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SCHEDULE 15-2
DESIGN AND CONSTRUCTION

PART 3
DESIGN AND CONSTRUCTION REQUIREMENTS – SYSTEMS

ARTICLE 1 INTRODUCTION

1.1 General Overview

(a) This Schedule 15-2, Part 3 – Systems is written using design standards typical of North America unless otherwise specified.

(b) Project Co shall declare and apply the selected standards consistently throughout the full range of the systems design.

(i) Project Co shall provide the systems in accordance with the requirements set out in this Project Agreement and any deviations or variances to the application of the selected standards shall be subject to approval by the City.

(c) Project Co shall provide the systems to include the ability to support the Expanded Trillium Line and expandability in the future.

(d) This section provides a description of the elements contained within the general heading of Systems. Project Co shall ensure that the systems include the following functional elements:

(i) S&TCS;

(ii) Communications systems

A. CTS;

B. PA/PIDS system;

C. CCTV system;

D. IAC system;

E. T&I system;

F. SCADA system;

G. Voice and Data Radio System; and,

H. Fare Collection (infrastructure only. Fare collection equipment provided by others).

(e) Project Co shall design the system elements to include training support elements including system simulation and control servers, operator workstations, and trainer workstations for the following systems:

(i) S&TCS; and,

(ii) TVS.

(f) The City shall test, integrate, Commission and maintain responsibility for all communications equipment upstream of the Confederation Line's Bayview Station all the way to the head-end management platforms at the TOCC and BCC.

(g) Project Co shall design, procure, test, integrate, Commission and maintain responsibility for the new S&TCS and TVS including the field equipment, servers, operator workstations and the head-end management platform to be installed in the TOCC and BCC.

(h) Project Co shall have access to install their equipment in the TOCC outside of Peak Period (as identified in Schedule 15-3 – Maintenance and Rehabilitation Requirements), outside of special event hours, or other critical times (Emergencies or security events) as determined by the City. Back room equipment that needs to be installed within the IT room can be installed anytime during the day as long as there is no impact to the day to day operations, i.e. power shutdown.

(i) Project Co shall coordinate all access to install their equipment into the BCC with the City.

1.2 Systems Element Summary

(a) S&TCS – detailed in Article 10 – Signalling and Train Control System, of this Part 3.

(i) Project Co shall design, procure and install the S&TCS head-end management platform. The head-end management platform for the S&TCS is the system architecture made up of both hardware and software that provides the command and control capability for the Expanded Trillium Line's new S&TCS. It includes new operator workstations in the TOCC, and BCC along with the graphical user interfaces connected to servers running industry standard operating systems, and the communications transmission infrastructure required to support operations, monitoring and alarm handling of the field equipment along the alignment. The City has reserved space in the TOCC and BCC equipment rooms for switches and servers as well as space in the TOCC and BCC operational theaters for user workstations to facilitate the transition of Train Control Operations from Montreal to the TOCC.

(ii) Project Co shall ensure that the S&TCS design is based on a proven ATC architecture supporting a wide range of operating environments as required for the SI.

(iii) Project Co shall ensure that the S&TCS is designed to maximize safety, reliability, operational flexibility and fault tolerance.

(iv) Project Co shall design the S&TCS to support the operational performance and service plan as described in Schedule 15-2, Part 1, Article 3 – Operational Performance Requirements.

(v) Project Co shall procure and install two new operator workstations for the S&TCS in the TOCC operational theater and one new operator workstation for the S&TCS in the BCC operational theater. Functions shall vary based upon the responsibility and access rights of the person who is logged on at that workstation at any given time.

A. The three workstations shall include visual displays, keyboards, telephones, head-set connection and headset, microphone, printer, and portable radio station.

(b) Communications systems - detailed in Article 2 – Communications Transmission System, of this Part 3.

(i) Project Co shall design the Expanded Trillium Line to include new and existing Stations and the New Walkley Yard. Project Co shall design the new Stations to receive communications systems as detailed in Article 2 – Communications Transmission System, of this Part 3. Project Co shall design the system so that all communications systems are remotely monitored and operated from the TOCC and the BCC.

(ii) The City shall purchase all required server licenses, software modifications, data storage, and any other systems expansion required to tie-in the new field equipment at the head-end Platform. Project Co shall integrate, test, and Commission all communications equipment in the field.

(iii) Project Co shall retrofit the Existing Trillium Line Stations with new communications systems as detailed in Article 2 – Communications Transmission System, of this Part 3. Project Co shall upgrade and replace all field equipment, cabling, and cabinet equipment as required to meet the new system requirements. Project Co shall install new communications equipment on Platform areas including PA Speakers, PIDS, CCTV, and Emergency telephones as required. Project Co shall assess existing conduit, power cabling, power systems, and cabinet/enclosures for reuse to support the new communications field equipment. No existing spares will be turned over for the Existing Trillium Line communications system

(iv) Project Co shall provide dual redundant hi-speed network nodes linked via a new fiber optic cable infrastructure that runs along the entire alignment including Airport Station, the Airport Link and to the Walkley MSF. Project Co shall tie-in to the Confederation Line CTS at Bayview Station. Project Co shall design and install a minimum 24 Strand fiber optic cable run from the fiber optic trunk cable to the CIHs, new Station communications cabinets and the New Walkley Yard.

1.3 Systems Engineering Principles

(a) Project Co shall design and implement all systems described in this Part following the Systems Engineering principles in accordance with the requirements set out in ISO/IEC 15288 and as described in Schedule 15-2, Part 1 – General Requirements.

(b) Project Co shall ensure that the systems engineering approach is applicable for all levels in the system hierarchy and for all disciplines.

(c) Submittal requirements are outlined in Schedule 10 – Review Procedure.

(i) Project Co shall implement a SEMP that outlines the engineering organization, the facilities needed and where they shall be located; the interaction between each of the engineering phases and what criteria is necessary to be completed prior to moving on to the next phase; each of the design phases and the requirements, processes and steps taken to successfully complete each; how technical issues shall be resolved; description of

implementation planning including training of users; and a description of how production shall be managed;

(ii) Project Co shall develop a Testing and Commissioning Plan in accordance with the requirements set out in Schedule 14 – Testing and Commissioning;

(iii) Project Co shall implement a Documentation Plan that outlines what documentation shall be produced and in accordance with schedule milestones either internal or external;

(iv) Project Co shall produce and provide the City with all Expanded Trillium Line Project asset data for incorporation into the CMMS; and,

(v) The City will provide the prescribed format to Project Co for development and incorporation of the Expanded Trillium Line Project asset data.

ARTICLE 2 COMMUNICATIONS TRANSMISSION SYSTEM

2.1 General Requirements

(a) Project Co shall design, install and test a closed loop fiber cabling infrastructure to connect the existing Stations, new Stations, New Walkley Yard and CIHs to the TOCC and BCC via a connection to the existing CTS at the Confederation Line's Bayview Station. An internet connection for the CTS is not required.

(b) Project Co shall coordinate with the City to establish the CTS connectivity to the TOCC and BCC. Project Co shall provide a minimum of two 48 strand fiber cables for the Expanded Trillium Line and connect to the Confederation Line's existing 48 strand fiber cables at the communication room at Bayview Station. The City shall reserve two strands within the Confederation Lines 48 strand fibre cable to provide connectivity from Bayview Station to the TOCC where the S&TC network equipment and head-end servers will be located. Out of each 48 strand fibre, a minimum of 24 strand fiber cables shall be provided for the exclusive use of the City. 24 of the 48 strands shall be brought to each Station on the Expanded Trillium Line and terminated on the fibre entrance cabinet. The remaining 24 strands shall be left as dark fiber for future use by the City. The City shall reserve one conduit in the E106 east conduit riser space and one conduit in the W110 west riser space for Project Co to pull the fiber cables into the communications room and terminate them at a new fibre equipment cabinet. Each fiber cable shall be pulled through a separate conduit for physical separation and route diversity.

(c) Project Co shall provide all field equipment, cabinets, and conduit/cabling Infrastructure at the stations, CIHs and along the alignment.

(d) The City shall reserve rack space at the TOCC for Trillium Line S&TC equipment including network switches and head-end servers in the data room.

(e) The City shall reserve spare rack #2 for Trillium Line equipment in the communications room at Bayview Station that will house the Project Co provided core network switch together with the Project Co provided fiber patch panel and fiber termination equipment required to connect the Trillium Line CTS to the Confederation Line's CTS. The new rack will be lockable and access restricted to Project Co staff for maintenance and system troubleshooting. Project Co shall make the physical connections from the new rack to the existing Confederation Line's CTS equipment cabinets.

(f) Project Co shall produce the design, procure (including Pre-delivery Testing), install, conduct PICO, SAT, SIT, Commission, and Maintain all communications field equipment from the new equipment installed at Bayview Station through all of the Expanded Trillium Line Stations.

(g) Project Co shall provide technical support to the City during system integration testing of the communications systems from the head-end management platform in the TOCC and BCC to the field equipment.

(h) Train Control data for the Expanded Trillium Line shall connect to the TOCC and BCC over the CTS see Article 10 – Signaling and Train Control, of this Part 3 for details.

(i) Project Co shall ensure the CTS is capable of providing automatic protection switching for link recovery in case of failure. Project Co shall design the CTS so that if a complete fiber optic cable

break should occur, the system shall perform a loop back operation, isolating the fault, and maintaining communications with all that remains connected to the network. Project Co shall design the CTS such that should a major node failure occur, the network shall automatically create and startup a new configuration without the node. Project Co shall design the CTS such that all restoration times shall be limited to a maximum of 50 milliseconds.

(j) Project Co shall provide the system of fiber optic Infrastructure including conduits or trenches, pull boxes, man holes and fiber optic splice enclosures required for the CTS extension.

2.2 Operational Requirements

(a) The TOCC, located at 875 Belfast Road, Ottawa, Ontario and the BCC, located at 805 Belfast Rd, Ottawa, Ontario, includes all of the systems and subsystems necessary to provide the command, control, and monitoring necessary for the delivery of the services with the exception of the Expanded Trillium Line S&TCS dispatch function and the Trillium Line TVS.

(b) The City shall purchase all required server licenses, software modifications, data storage, and any other systems expansion required to tie-in the new field equipment at the Confederation Line Belfast MSF head-end.

(c) Data from the new communications systems shall be transported back to the TOCC and the BCC for the integration by the City into the Confederations Line's head-end management platform.

2.3 Network Configuration

(a) Project Co shall design the CTS to include a WAN component and LAN component. Project Co shall design the LAN to provide local network traffic switching and aggregation of the network traffic at each Station, CIHs and TOCC/BCC for transport over the WAN.

(b) The City shall integrate the CTS equipment with the existing NMS located in the main communications room located in the TOCC. The City shall purchase any additional software required to accommodate the system extension. The City shall integrate, test, and Commission the expanded NMS.

2.4 Performance Requirements

(a) Project Co shall design the CTS expansion for the Project to include fibre optic and copper cable plant, network transmission equipment, and other equipment necessary for a complete communications network. Project Co shall provide a minimum of 50% spare port capacity for future City use of the CTS.

(b) Project Co shall design and install a high bandwidth and fault tolerant system. The system shall be of a compatible design with that of the existing City system and shall have no single point of failure. Project Co shall design the CTSA to be configured in a path-diverse topology in order to minimize single point failure. Project Co shall design the CTS network equipment to support fast (sub-50 milliseconds) automatic network recovery (self-healing) in the event of a network link failure.

(c) Project Co shall design the CTS to include redundant power supplies. Project Co shall design the CTS so that in the event of a power outage, the equipment shall remain operational for a

minimum of 4 hours through the use of uninterruptible power supplies. An additional 8 hours of power shall be provided through the use of generators.

(d) Project Co shall procure the specified CTS equipment to be compatible with the existing NMS which will allow the CTS equipment to be managed and monitored by the existing NMS in the TOCC and BCC.

(e) The core switches within the Stations shall have a minimum of 4 X 10Gbps ports to connect on the ring to the next Station on the loop and interconnect the core switches/routers.

(f) The core network switches/routers within the Station shall be interconnected using two 10 Gbps fibre interfaces. The switches shall be sized for the port density required within each Station including network connections on each core network switch/router for local critical equipment such as SCADA, VOIP gateways and CCTV NVRs, and PA network interfaces. All systems equipment with two network interfaces shall connect to a port on each of the core Station switches or access switches. If the core network switches/routers do not have the port density to support all network equipment in the Stations then additional access switches with high network interface ports shall be supplied to connect to CCTV cameras, and other equipment that only support single network connections. The access switches shall be connected to each of the core switches for redundancy. The core network switches located in each station shall support at a minimum the following features:

(i) Standard 19" rack mountable

(ii) Dual redundant hot swappable power supplies connected to the UPS and a separate electrical panel feed. Field replaceable fans

(iii) Local switch management

(iv) Minimum switch fabric non-blocking throughput of 40Gbps

(v) Provide switch aggregation or switch stacking

(vi) Support minimum 4 x 10 Gbps interfaces

(vii) Support minimum of 20 additional ports either SM or MM fibre or 10/100/1000 TX

(viii) Support the following network protocols:

A. G 8032 Ethernet Ring Protection and/or MPLS and/or SPB IEEE 802.1aq;

B. IEEE 802.1Q VLAN Tagging;

C. IEEE 802.3ad Link aggregation;

D. IEEE 802.1 Prioritizing;

E. IEEE 802.3w Rapid Spanning Tree;

F. IGMP V2, V3;

G. IEEE SBP Shortest Path Bridging;

H. IEEE 802.3af Power over Ethernet; and,

I. SNMP MIBs for remote management.

(ix) Port Security:

A. All ports shall be disabled unless specifically configured;

B. Port security can be set by MAC address, Sticky mac address, VLAN trunk; and,

C. Learned MAC address.

(x) Switch Security:

A. Switch shall require user and password to login; and,

B. Remote MIBs to support SNMP V3 for security.

ARTICLE 3 TELEPHONE AND INTERCOM SYSTEM

3.1 General Requirements

(a) Project Co shall design the T&I system to provide emergency and non-emergency voice grade communications. Project Co shall design the system such that telephones that are VoIP be routed through the existing Confederation Line's telephone system. Project Co shall design the T&I system such that the emergency telephone systems (emergency and elevator help) provide a direct connection to the TOCC. Project Co shall ensure that Staff telephones are deployed in specific locations in the Stations to support operations. Project Co shall ensure that maintenance telephones are deployed in the CIHs, vent plants and the New Walkley Yard and shall route through the existing Confederation Line's telephone system. The City shall expand the existing Confederation Line's PABX to support the new telephones and purchase new licenses and expansion modules as required. Project Co is not required to procure or install a new PABX.

(b) Project Co shall design, install, test and Commission all of the T&I system infrastructure hardware at the Expanded Trillium Line Stations including conduits and cables located in the field up to Bayview Station.

(c) Project Co shall provide the conduit and cabling infrastructure for the public telephones at the Expanded Trillium Line Stations but the instruments themselves shall be provided, connected and tested by a third party supplier.

3.2 Operational Requirements

(a) Project Co shall design, install, connect, integrate, test and Commission all station T & I equipment and all equipment necessary to connect the T&I system to the nearest network node for transport of voice communications back over the CTS to the TOCC and the BCC. Project Co shall design the T&I system to provide Emergency and non-Emergency voice-grade communications for the Project. Refer to Schedule 15-2, Part 4 - Stations for locations. The system shall include the following telephones:

(i) ETEL;

(ii) FTEL

(iii) HINT;

(iv) ICP Phones

(v) ITEL;

(vi) STEL;

(vii) MTEL;

(viii) HFI; and

(ix) Public Telephones (by others).

(b) The City shall upgrade the existing head-end management platform at the TOCC and BCC and the Confederation Line's existing PABX to accommodate the new T&I system equipment installed at the stations and the voice being brought back via the CTS.

3.3 Performance Requirements

(a) Project Co shall design the VoIP ETELs, STELs and ITELs to be routed through the Confederation Line's PABX to the City's existing PABX.

(b) Project Co shall ensure the Emergency and information telephone location/signage be properly identified to match the Confederation Line locations/signage. Emergency and information telephones shall be identical to existing phones including branding.

(c) Emergency telephones shall be rated for outdoor use, with IP66 rated enclosures, and vandal-resistant. Refer to Schedule 15-2, Part 4 – Stations for location information.

(d) Project Co shall design the Emergency telephones and elevator help telephones to interface with the CCTV system to automatically provide video of the area from where the call is being generated to the operator workstations at the TOCC and BCC, as defined by the Safety and Security assessment.

(e) Project Co shall provide service telephones at each vehicle gate of the Airport Emergency route crossing to facilitate communication with the TOCC for non-Emergency access to the crossing.

ARTICLE 4 PUBLIC ADDRESS SYSTEM/PASSENGER INFORMATION DISPLAY SYSTEM

4.1 General Requirements

(a) Project Co shall ensure all of the Expanded Trillium Line Stations are equipped with a PA/PIDS system to broadcast live and recorded announcements of arrivals, departures, general and Emergency/security information from the PA/PIDS console located in the TOCC and BCC. Project Co shall ensure the PA system provides uniformly distributed audio throughout public areas of the Stations. Project Co shall design the PA system to be synchronized with the Vehicle announcements for the Expanded Trillium Line to ensure that Station Platform announcements do not overlap/compete with onboard vehicle announcements.

(b) Project Co shall design, procure and install all necessary conduit, cabling, mounting bracket hardware at each of the existing stations and each of the new stations.

(c) Project Co shall procure, install, test and Commission the PIDS signs to accommodate message format being sent from TOCC and BCC.

(d) Project Co shall design each new Station with PIDS signs to provide up-to-date, specific, location-based, visual operational and safety-related messages for Passenger awareness. Project Co shall design the PIDS to be individually addressable and shall be accessed from the existing PA/PIDS console located in the TOCC and BCC. Project Co shall ensure that under normal operating conditions, information presented on the PIDS shall include, but not be limited to: date, time, arrival time and destination of the next two Trains, safety messages, Train delays, holiday schedules, and other ad-hoc messaging. Project Co shall ensure that in an Emergency condition, the PIDS display both pre-programmed Emergency announcements and simultaneous visual display of the PA system Emergency announcements.

4.2 Operational Requirements

(a) The City shall upgrade the Confederation Line's head-end management platform at the TOCC and BCC to accommodate the new signs installed on the Expanded Trillium Line.

(b) The City shall be responsible for all licenses and fees associated with new hardware and software procured for the Expanded Trillium Line System.

(c) Project Co shall design the PA/PIDS system to integrate with the existing GUI which shall serve as the means of interface between the system and the operator. The existing PA/PIDS servers are located at the Belfast MSF.

(d) Project Co shall design the PA/PIDS system to integrate with the Expanded Trillium Line Trains and systems in order to provide accurate countdown messages to the Platform displays and for Train arrival messages over the PA system.

4.3 Performance Requirements - PA

(a) Project Co shall design, procure, install and test the PA system at each of the new and existing stations including cabinets, speakers, microphones, amplifiers, DSPs, message storage equipment, etc.

(b) The City shall upgrade the Confederation Line's head-end management platform at the TOCC and BCC to accommodate the new PA system equipment installed on the Expanded Trillium Line.

(c) The City shall design and procure all appropriate head-end hardware/servers required to be installed in the Belfast MSF.

(d) The City shall procure all licenses and pay all fees associated with new head end hardware and head end software required for the Expanded Trillium Line System.

(e) Project Co shall design the PA system such that announcements are addressable to single and multiple zones within individual and/or groups of Stations. Separate zones with separate amplifying channels and speaker systems shall be accessible individually or in combination. The Project Co PA system design at Stations shall have up to five zones covering each Platform, mezzanine, and ancillary area.

(f) The Project Co PA system design and installation shall maintain a uniformly distributed sound level at least 10 dB above ambient Station operating noise level measured at 1.5m above floor. Stations SPL shall be not less than 60 dB plus or minus 30 degrees off axis, 1.5m above the floor, at Vehicle ambient noise level.

(g) The Project Co PA system design shall ensure that the automatic gain adjustment be provided based upon ambient noise levels captured by ambient noise sensors. The Project Co PA system shall adjust volume and clarity in proportion to the increase in noise level from a pre-set quiet level.

(h) Project Co shall design and install a PA system capable of playing pre-recorded messages in both English and French.

(i) Project Co shall design the PA system such that the component failures are minimized by redundancy. Project Co shall design a PA system with an availability (i.e. availability of all system hardware, cabling) greater than 99.9%.

(j) The Project Co PA system shall be fully supervised with failure annunciation at the TOCC and BCC of all major system components such as preamplifiers, power amplifiers, supervision detectors, and power supplies.

(k) Project Co shall design the PA system such that announcements from TOCC and BCC are delivered to the Station PA controllers over the CTS using TCP/IP. Each local PA Controller/DSP shall include a digital message store that will contain a digitally encoded set of pre-recorded messages and/or audio message "niblets" (e.g. .WAV files) that can be triggered from the TOCC/BCC or YCC via a short message code.

(l) Project Co shall design the PA system such that in the event of a power outage, the PA system shall remain operational for a minimum of four hours through the use of uninterruptible power supplies. An additional 8 hours of power shall be provided through the use of generators.

(m) The Project Co PA system design shall accept several competing inputs with successful transmission designated according to priorities as described in Clause 4.4 (d) below.

(n) The Project Co PA system design shall work in conjunction with the PIDS system to provide synchronous broadcasting of audio and visual pre-recorded announcements and to provide near-synchronous transmission of live announcements.

(o) The on-board system shall be capable of audio and visual messages on the Train in both English and French including accents on both upper and lower case letters as required

4.4 Performance Requirements - PIDS

(a) On each Platform, Project Co shall provide PIDS displays such that at least one display is visible and legible from any location along the Platform edge. Project Co shall ensure that Two-Platform Stations whether side or centre 90m in length have a minimum of two PIDS spaced no further than 30m apart. Longer Platforms may require additional PIDS. Project Co shall provide separate displays for each Platform edge on center Platforms. Project Co shall place displays to maximize visibility throughout the Platform area. Refer to Schedule 15-2, Part 4 – Stations for locations in accordance with ADOA requirements.

(b) The City shall integrate the Expanded Trillium Line's PA/PIDS system with the existing centralized message generator and dispatch functions at the existing PA/PIDS workstation in the TOCC and BCC to address individual zones, Stations, groups of Stations, or System-wide announcements for PIDS installed on the System. Project Co shall design the Expanded Trillium Line's Stations to have zones covering each Platform, mezzanine, and ancillary area that correspond with the PA system zones.

(c) Project Co shall integrate the PA/PIDS with the S&TCS to enable countdown messages at the stations on the PIDS and arrival messages on the PA system. Project Co shall design the PIDS with the capability of displaying messages in both English and French. Project Co shall design the PIDS such that all pre-programmed messages are provided in both languages.

(d) Project Co shall design the PIDS to accept several competing inputs with successful transmission designated according to assigned priorities. With the exception of item (i) below, message priority shall be controlled by the head and established as part of the message configuration in the order below:

(i) Trigger from locally initiated emergency PA messages (PID sign displays a default message);

(ii) TOCC/BCC initiated emergency messages entered by the TOCC/BCC operator;

(iii) Train event messages (Train approach, departure, station closure, etc.);

(iv) Informational messages (scheduled or ad-hoc); and,

(v) Arrival/departure time messages.

(e) If required by relevant codes and standards, Project Co shall provide local microphones at each Station that allows ESP to make the highest priority PA announcements at those Stations pre-empting any messages from the head-end. In Stations that require an ICP, a local microphone shall be located at the ICP. These Station initiated PA announcements shall trigger a default PID message (e.g. "live message") and inform the head-end PIS (via SCADA) on the microphone's

usage. This message priority scheme shall allow emergency messages to pre-empt other message categories, and for approach/departure and informational messages to be rotated. Train approach and departure PA announcements (and PID messages when Train approaches/departs) will take priority over general messages.

(f) Project Co shall design the PIDS to work in conjunction with the PA system to provide synchronous broadcasting of audio and visual pre-recorded announcements and to enable near-synchronous transmission of live announcements.

(g) The City shall integrate the PIDS into the existing head-end management platform to be fully supervised with failure annunciation at the TOCC and BCC of all major system components such as PIDS displays, Station controllers, and power supplies.

(h) The City shall ensure that all Expanded Trillium Line PIDS announcements are logged in a database on the existing head end PIDS system servers.

(i) Project Co shall design all PIDS to display Station date and time, which shall be synchronised with the existing central time server over the CTS.

(j) Project Co shall design the PIDS such that in the event of a power outage, PIDS equipment shall remain operational for a minimum of four hours through the use of uninterruptible power supplies. An additional 8 hours of power shall be provided through the use of generators.

(i) Project Co shall design the PIDS such that signs shall be blank when the sign is not operational.

(k) Project Co shall ensure that all PIDS signs shall be environmentally housed to prevent damage from moisture, dust, and vandalism and installed at a minimum height of 3.048m.

(l) Project Co shall design the PIDS to be rated for outdoor use, with IP66 rated enclosures, and vandal-resistant. Refer to Schedule 15-2, Part 4 – Stations for location information.

(m) Project Co shall provide functionality that enables the PIDS to provide real-time berthing location information to customers for arriving and departing 40m and 80m Trains. The PIDS shall direct Passengers to the appropriate waiting area when a 40m Train is arriving at an 80m Platform.

4.5 PID Signs

(a) Physical / Functional Attributes

(i) The overall size inclusive of housing shall be no larger than 1500mm (W) x 475mm (H) x 300mm (D), to accommodate space constraints along the Platforms. Refer to Schedule 15-2, Part 4 – Stations for location information.

(ii) The PID sign shall have a maximum weight of 70 Kg (for double-sided signs).

(iii) The PID signs shall feature the following characteristics:

A. Less than or equal to 8mm resolution pitch.

B. High contrast display using a monochromatic amber colour LED full matrix on a black glare-free background (590nm wavelength).

C. Ambient light adjustment - automated dimming of LEDs using ambient light sensors. E.g. in a darkened ambient light condition, LEDs would be dimmed to prevent eyestrain.

D. All outdoor PID signs shall be equipped with sunlight readable LED's (up to 5000 cd/m2 (nits) brightness level if required).

E. Wide viewing angle (minimum 120 degrees horizontal and vertical).

(b) Mechanical Attributes

(i) The PID sign shall be modular and designed for ease of service taking into consideration the clearances around the PID sign (reviewing adjacent architectural elements and spacing).

A. Keyed power switch and internal electronics accessible from the front top hinged doors, and;

B. Easily replaceable LED modules.

(ii) The PID housing shall be vandal and graffiti resistant with break, shatter proof, and scratch resistant display glass, resilient against dust, discoloration, atmospheric pollutants and salty dust.

(iii) PID signs should be able to sustain frequent cleaning using commercially available cleaning products approved by the manufacturer.

(iv) The PID housing shall be constructed of aluminum, galvanized steel and/or stainless steel.

(v) The PID housing components and fasteners shall be corrosion resistant.

(vi) The PID housing colour shall be provided by the City.

(vii) The PID signs shall be mounted from two HSS supports within which will run the power and data cables (installation by Project Co).

(viii) Under a regular scheduled maintenance program, the Design Life of the PID signs shall be 20 years.

(c) Electrical

(i) The main power supply shall be 90-132Vac, 1 phase, 60 Hz (110Vac nominal)

(ii) Data connection - the PID sign shall accept either UTP CAT6 or Fibre depending on the distance to the network switch.

(iii) The PID shall have CSA approval.

(iv) The cable routing and conduit design shall be performed by the Project Co.

(d) Data Communication

(i) Connectivity with the head end systems shall be through the CTS.

(ii) The PID signs shall be connected to PID controllers via a dedicated IEEE 802.3, which in turn shall interface with the CTS via dedicated IP switch ports in the Station's communications room.

(iii) A VLAN shall be created within the CTS that will segregate all PIDS traffic.

(iv) The PIDS shall use open standard communication protocol.

(v) Ethernet connection at 10/100 Mbps minimum using TCP/IP protocol.

(vi) Each PID shall have an addressable unique IP address.

(vii) Each PID shall have a unique alphanumeric ID.

(viii) Standard messages may be either sent from the head end system, or stored locally in the PID controller's local digital message store and be broadcast in response to instructions sent from the central equipment in the Belfast MSF.

(ix) The PID shall optionally have wireless WiFi 802.11b/g/n connectivity.

(x) The PIDS network shall be designed to handle an estimated network load of 100 kbps.

(xi) Each PID sign shall interface to a local network connected PID Controller (local digital message store) which shall communicate with the head-end PIDS to receive message content and in turn drive content to the PID signs. The PID sign controller shall be situated in the PID sign itself, or centrally in the Station communications room to manage all PID signs at the Station.

(e) PID Layout Design

(i) The PID shall be ADA compliant spacing (in term of character height) as given below:

A. Character separation: 10%.

B. Line spacing: 35%.

C. Stroke thickness: 10% - 30%.

D. Character width: 55%.

(ii) The PID signs shall be designed to display three lines of text with a minimum character height of 76mm.

(iii) The arrival/departure time screen display shall emphasize the top line of text (using a larger font and/or bolded).

(iv) The following examples describe an arrival/departure time screen display adhering to the given PID sign and character sizing constraints above:

A. 176 x 40 pixel active display; 7.62mm pixel; active area measuring roughly 1341mm x 305mm (~1481mm x 445mm overall area with 70mm border).

B. 11 pixels height top line (83.83mm) and bolded.

C. 10 pixels height second and third lines (76.2mm) in height.

D. 224 x 48 pixel active display; 6mm pixel; active display measuring roughly 1344mm x 288mm (1484mm x 428mm overall area with 70mm border).

E. 14 pixels height top line (84mm) and bolded,

F. 13 pixels height second and third lines (78mm) in height.

(f) The examples above can accommodate the 3-line arrival/departure time or a 3-line general announcement of up to 25 - 75mm mono-spaced characters - in practice, proportional characters shall be used which will accommodate more characters per line depending on message content.

(g) Failure Monitoring/Diagnostics

(i) The PID signs shall have built-in diagnostic capabilities and be monitored periodically by the PIS via a scheduled polling or subscribe/notify software architecture. The PID diagnostics and control shall include, but not limited to the following:

A. Power supply unit failure

B. High temperature warning. Temperature sensor(s) shall monitor the overall temperature in the PID sign case. In the event of a high temperature condition, the PID sign shall automatically shut off and an alarm generated.

C. Pixel failure (test). Each PID sign shall have embedded self-cycling pixel test.

D. Brightness level test.

E. Communication failure/Message time out (handled by the head-end PIS).

F. Remote power cycle / re-boot function.

(ii) Communications Failures

A. Each PID sign's network connection shall be monitored.

B. The PID shall be capable of displaying a default message such as time and date or a preconfigured message stored locally in the display. The message shall be activated by user-defined scenarios, including but not limited to, loss of communication with the head end system.

C. Locally stored default messages shall be displayed in the event that no content has been received from the PIS. If the communications fail (no heart beat message response), the display shall be blanked after a pre-set delay or shall default to a predetermined message stored locally (e.g. "Out of Service").

(iii) The head end PIDS shall log and timestamp all alarms/events.

(iv) The PID shall optionally have a local RS232/485/422 serial maintenance port for maintenance and diagnostic capabilities.

(h) Electrical and Cabling Design

(i) Project Co shall ensure that design is stamped & sealed by a Professional Engineer.

(ii) Racks

Project Co shall supply and install all rack cabling required for connections between equipment. All cabling and wires shall be traceable within the shop drawings of the equipment racks.

(iii) PID Sign Circuits

All PID sign network cabling shall be designed to be routed and terminated onto the patch cords in the back of the appropriate network equipment rack located in the Facility's communications room

(i) Cable Rating

(i) All cables called up in Project Co's installation design shall be CSA approved and meet the requirements of NFPA 130.

(ii) The insulation for all PIDS cabling installed shall be FT-4-ST1 as a minimum and specified with LSZH jacketing where cables are run through public areas.

4.6 Provision for City Provided Equipment

(a) Scope of Work

(i) Project Co shall provide the equivalent of one full height 480mm NEMA 4X weather-protected environmentally controlled cabinets at each Station on the Expanded Trillium Line for installation of City provided equipment.

(ii) Space shall be reserved in the cabinet for City provided equipment such as Public Art, Nexus/Directory/Entrance PIDS, HASTUS, and fare collection electronics.

(iii) Project Co shall install the conduits and cables from the cabinet for City provided equipment to the various device locations as defined in Schedule 15-2, Part 4 - Stations.

(iv) Project Co shall provide and install the cabling to connect the Public Art, Nexus/Directory/Entrance PIDS and HASTUS equipment installed in the cabinet for City provided equipment to the CTS.

ARTICLE 5 VOICE AND DATA RADIO SYSTEM

5.1 General Requirements

(a) Project Co shall procure the mobile radios for the Existing Vehicle Fleet, Expanded Trillium Line Vehicles, Maintenance equipment, and all required hand-held portable radios for Expanded Trillium Line maintenance activity. Project Co shall provide a total of 28 mobile radios for the Vehicles (one for each cab in each of 13 Vehicles and two spare mobile radios).

(b) The City shall install, integrate, test and Commission the two new radio dispatch consoles into the existing radio system at 875 Belfast for TOCC. The City shall install, integrate, test and Commission the one new radio dispatch console at 805 Belfast for the BCC.

(c) Project Co shall utilize the existing City of Ottawa public safety radio system.

(d) Project Co shall design, supply, test, integrate and Commission the new Voice and Data Radio System on-board the Vehicles. The Voice and Data Radio System shall include custom radio features that are required to implement on-board live PA announcements from the TOCC over the radio system as well as vigilance and alerted data alarms to the TOCC radio dispatch console over the radio system.

(e) Project Co shall be responsible for purchasing licenses and paying initial and on-going monthly fees for all Vehicle mobile radios and all Project Co required radios and equipment.

(f) The City shall develop the performance specifications and design criteria for the Voice and Data Radio System with its service provider to refine design requirements for radio coverage along the alignment.

(g) Project Co shall provide all cabling (coaxial, radiating, fiber, network, power) and all associated infrastructure to enable radio coverage in the 600m long Dow's Lake Tunnel, New Walkley Yard City spaces, and any new facilities along the alignment. For the purpose of redundancy, two radiating cables shall connect from the tunnel to a designated rack space in the Dow's Lake pump house.

(i) The radiating cables in Dow's Lake Tunnel shall connect from the Tunnel via a feeder coax cable to a designated rack space in the Dow's Lake pump house. The cabling, conduit and associated infrastructure shall be ready to enable the City to install and Commission radio repeater system in the tunnel and the pump house.

(ii) Actual cable specifications used shall depend upon link loss calculations; however Project Co shall install a minimum of two 1/2in coax cables, two 1/2in plenum rated coaxial cables and two 7/8in plenum rated radiating cables in the Dows Lake Tunnel including all required connection hardware such as coaxial power splitters/tappers, coaxial cable connectors and enclosures to house the tappers / splitters. One of the two 7/8 in cables shall be mounted on the western wall while the second cable shall be mounted on the eastern wall from the north portal to the south portal. The radiating cables shall serve as the signal source for the coverage enhancement.

(iii) For New Walkley Yard City spaces and new LRO facilities along the alignment, Project Co shall provision infrastructure space for a small antenna repeater system including

plenum rated coaxial cables, splitters, and a minimum of ten antennas to provide adequate coverage throughout the building.

(h) The City shall provide all active electronics to support the repeater system.

(i) Project Co shall provide the Voice and Data Radio System cabling and infrastructure to comply with NFPA 130 requirements.

5.2 Operational Requirements

(a) The City shall produce the design, test, and manage the systems integration and Commissioning of the Voice and Data Radio System into the TOCC and BCC.

(b) The City shall pay all associated access fees and on-going maintenance fees associated with the radios to be used by the City's operations personnel.

(c) The City shall integrate the Expanded Trillium Line's Voice and Data Radio System equipment with the existing voice recording system equipment located in the data room at the Belfast MSF to record all radio voice conversations. The City shall provide all necessary expansion to the existing voice recorder to accommodate the Expanded Trillium Line's Voice and Data Radio System.

5.3 Performance Requirements

(a) Project Co shall design, procure, install and test the Tunnel radio antenna system complete with directional antennas, radiating and coax cables, and mounting hardware and equipment necessary to propagate the necessary radio frequency coverage throughout the Tunnel areas for both voice and data radio.

5.4 Vehicle Onboard Radios

(a) Project Co shall procure, retrofit and test the Voice and Data Radio System radios on the Existing Vehicle Fleet with new radios and any other equipment required to make them fully functional. The new radios shall include firmware making them capable of transmitting vigilance and silent alarms, and PA announcements from the TOCC and BCC.

(b) Project Co shall procure, install and test the new Voice and Data Radio System radios and any other equipment required to make them fully functional onboard the New Vehicle Fleet. The new radios shall include firmware upgrades making them capable of transmitting vigilance and silent alarms and PA announcements from the TOCC and BCC.

ARTICLE 6 FARE COLLECTION

6.1 General Requirements

(a) Project. Co shall design, install, test and Commission the E&M infrastructure for the fare collection equipment including power outlets and conduit that connects the equipment cabinets to the designated Ticket Machine locations.

(b) Project Co shall provision the Power source within the Station electrical service for all fare collection equipment needs. Project Co shall design each Ticket Machine and each fare gate with one individual 15 amp circuit.

(c) Project Co shall design and provide data communication channels within the Station communications rooms or so that the fare vending equipment may communicate with the existing fare collection head end equipment and accounting personnel located within the TOCC and BCC.

(d) The City shall design, procure, install, integrate, test and Commission all fare collection equipment (fare gates, Ticket Machines, data cabling and servers). Refer to Schedule 15-2, Part 4 – Stations for location and quantity information.

(e) Project Co shall procure and install an interposing relay at each Station that when a fire alarm is initiated from the fire detection and alarm system to the interposing relay, it will cut power to the fare gates. By cutting power, the gates shall default open allowing customers to safely exit the facility.

6.2 Operational Requirements

(a) Ticket Machine, power and data requirements:

(i) Project Co shall provide slab conduits to bring UPS protected power cabling from the Station power panel to the Ticket Machine. Refer to Schedule 15-2, Part 4 – Stations for locations and electrical details.

(ii) Project Co shall provide slab conduits from the communications room/cabinet to allow for data cabling to the Ticket Machines locations. Project Co shall ensure that no conduits or ducts are exposed.

(b) Fare Gates, power and data requirements:

(i) Project Co shall provide power for the fare gates by a single circuit breaker protected line delivered by slab conduit to the base of each fare gate.

(ii) Project Co shall ensure that no conduits or ducts are exposed.

ARTICLE 7 CCTV SYSTEM

7.1 General Requirements

(a) Project Co shall provide a CCTV system that serves both operational and security needs of the Project. The CCTV system shall allow operations, security staff and ESP the ability to monitor elements of the system remotely from the TOCC and BCC.

(b) Project Co shall design the CCTV system with operational views of the Platforms that are made accessible to Operators on the Expanded Trillium Line through a wireless data connection to allow the Operator the ability to safely operate and monitor the Vehicle doors. Project Co shall undertake a risk and safety assessment of the System and shall install CCTV equipment and / or any other security devices as an outcome of the assessment.

(c) The City shall integrate the Expanded Trillium Line's CCTV system with the existing head-end management platform to ensure that the OC Transpo Rail Controllers have supervisory control of the CCTV system. The City shall integrate the Trillium Line's CCTV system with the existing head-end management platform to ensure that the TOCC and BCC Controllers and Special Constables Unit Communications Officers each have access and the ability to view and the ability to control video from the CCTV system. The CCTV workstations have been provided in the TOCC and BCC as part of the Confederation Line Project.

(i) Project Co shall not be required to procure these workstations as part of the Trillium Line Project;

(ii) Project Co shall design, install, connect, integrate, test and Commission all station and facility CCTV equipment including cameras, cabinets, NVRs and all equipment necessary to connect the CCTV system to the CTS for transport of video back to the Belfast MSF.

(d) Project Co shall ensure that all NVR's be connected to the CTS and able to transmit all required live and recorded video to the TOCC and BCC while multiple users are using the system at one time.

(e) Project Co shall design and install all of the station CCTV System Infrastructure hardware including mounting brackets, conduit and cables.

(f) Each Station shall have at least two NVRs to ensure redundancy. Each camera shall be assigned to a recording device via the VMS to balance the load on each NVR. Cameras located within the same area shall be recorded on a different NVR. The video storage capacity varies by Station. The NVR shall be capable of recording up to 200 channels however the system shall be designed to limit 50 cameras per recorder. All NVRs shall be the same model but with different hard drive sizes based on the total storage per NVR storage unit. Storage capacity shall be based on 30fps frame rate and native resolution of the camera being recorded for 31 days.

(g) The total capacity of the NVR at each Station shall be based on the number of cameras at each station. Common factors affecting the NVR size shall include video compression, resolution, frame size and frame rate of cameras connected to the NVR.

(h) Project Co shall provide commercially available, high quality cameras from reputable and established manufacturers. The cameras shall be fixed cameras and PTZ cameras. Cameras shall use 6.35mm or 8.5m CMOS type sensors and be able to operate in all expected light levels down to a level of <2 lux. The cameras shall be able to switch to black and white mode in low light conditions (below 0.1 lux).

(i) The cameras shall be:

A. High resolution fixed cameras, 1 MP, 3.3-12mm lens – Platforms, concourses, ETELs, escalators, elevator landings, stairs, communications equipment rooms/cabinets, bike racks, Tunnel portals and egress entrance/exits, yard perimeter fences and intrusion monitoring, monitoring of Train movements.

B. High resolution fixed cameras, 1 MP, 2.5-6mm lens – elevators.

C. High resolution fixed WDR cameras, 1 MP, 3-9mm – Platforms, Platform edges/Train doors, TSAs, Ticket Machines, fare gates.

D. Super high resolution fixed cameras, 2 MP, 3-9mm – external cameras for exterior of Stations and viewing large areas.

E. High resolution PTZ cameras, HD, 1.3 MP, 4.3-129mm – Platforms, PPUDO, parking lot and yard, yard perimeter fences and intrusion monitoring, monitoring of Train movements.

F. Identification cameras, 3-6mm - New Walkley Yard vehicle entrance.

7.2 Operational Requirements

(a) Project Co shall design the CCTV cameras to meet the following requirements:

(i) Provide CCTV in keeping with CPTED principles, including but not limited to CCTV coverage of entrances to washrooms, designated bicycle parking areas, Platforms, Train doors, corridors, and stairways;

(ii) CCTV cameras shall cover every door of the Train servicing the Station and general circulation areas, all entrances to Stations/Platforms and fare equipment; and,

(iii) CCTV coverage shall include all exterior areas of each Station including MUPS, Station plazas and general circulation areas.

7.3 Performance Requirements

(a) Project Co shall design a CCTV system capable of determining intrusion into restricted areas through the use of sensors and/or video analytics. The CCTV system shall interface to the ETELs and access control system so that any events are automatically recorded at higher frame rates and resolution.

(b) Project Co shall ensure that recorded video is capable of being reviewed and downloaded from the on-board Vehicle CCTV system while at a station or at the New Walkley Yard and

transmitted to the Belfast MSF for storage of the video for up to 3 years. Project Co shall design the CCTV system based on a distributed video storage architecture; some data shall be captured and stored at Stations, some shall be captured and stored on Trains. Project Co shall ensure that data will be stored in local NVRs at each Station and in Trains with minimum 1080P and 30 fps at H.264 compression. The NVR retention period should be programmable/adjustable up to a maximum of 31 calendar days but will be programmed to meet the current Policy requirements. The City shall expand the storage servers up to 3 years and system management servers installed in the data room at the Belfast MSF. The City shall specify, procure, install, integrate, test and Commission any additions/modifications to the existing Belfast MSF head-end equipment (VMS server and workstations); to accommodate any MSF expansion.

(c) Project Co shall provide CCTV coverage for the areas outlined in this Article based on Good Industry Practices, for example as described in the most recent edition APTA Standards Development Program Recommended Practice CCTV (APTA IT-CCTV-RP-001-11).

(d) Project Co shall design a CCTV system that complies with MFIPPA and the current Surveillance System for Transit Network Access and Privacy Policy dated 2016.

(e) Project Co shall provide a CCTV system comprised of network based fixed, HD fixed, and HD PTZ digital cameras, along with associated power supplies, cabling, network media converters, video storage devices, viewing stations and control panels, all of which is managed by the IPVS. The CCTV sub-system shall provide records for post event review and analysis. Project Co shall ensure that cameras are to be rated for the environment installed, including day/night capabilities, heater/blower, appropriate housing, NEMA 4X (IP-66) rated and IEC 62262 IK10 impact resistant enclosures.

(f) Project Co shall ensure that camera locations are strategically selected to ensure the views are clear, unobstructed, and not impaired by Structures, signage, foliage, intense lights, or any other obstacles. During installation, testing and Commissioning of the CCTV system, if camera views are blocked from viewing the intended coverage area, Project Co shall adjust the camera to a provide a clear view of the intended coverage area. Project Co shall ensure that camera views of the fare collection area shall be arranged to provide images of the customer's frontal interface with the Ticket Machines.

(i) Project Co shall design the CCTV system such that Fixed Cameras are installed to monitor the following locations:

A. Platform edges including Train doors;

B. ETELs located in TSAs;

C. Elevator cab and landings, escalator and stair landings;

D. Public and employee washroom entrances;

E. Tunnel access and egress entrance/exits;

F. Fare collection equipment;

G. Restricted areas (equipment room entrances for public to non-public areas, electrical rooms, communications equipment rooms, mechanical rooms);

H. Bike racks; and,

I. Tunnel portals.

(ii) Project Co shall design the CCTV system such that PTZ and/or fixed cameras are provided to monitor the following locations:

A. Concourse level corridors/Passenger circulation areas;

B. Station Platforms (bus and Train);

C. Coiling grills at some Stations;

D. PPUDOs; and,

E. Exterior station areas including MUPS, Station Plazas and general circulation areas.

F. IAC controlled doors

(iii) Project Co shall design the CCTV system such that high resolution cameras with low lux capabilities be installed to monitor Tunnel entrances.

(g) The City shall integrate the CCTV system with the Emergency telephone systems. The City shall integrate the CCTV system such that upon activation of Passenger Emergency telephones or elevator help telephones, the CCTV system at the TOCC and BCC shall automatically display the CCTV camera with the best view of the telephone area. The City shall ensure that the displays shall appear at both Rail Controllers consoles and the Special Constables Unit Communications Officers consoles.

(h) The City shall integrate the CCTV system with the IAC system. The City shall integrate the CCTV system to be capable of automatically displaying a view of the activated access control device, either via fixed camera or PTZ pre-set, upon activation of an IAC system alarm or use, whether authorized or unauthorized. The City shall be capable of including or excluding automatic display of video coverage of any device, type of device, specific event, or general event type as needed.

(i) The City shall integrate the CCTV system to the MSF storage system for long term storage. Each alarm shall be assessed and if the video is required, a record will be created to the long term storage device by authorized Transit Staff.

(j) The City shall integrate the CCTV system with the existing head-end management platform such that recordings are digitally watermarked to detect tampering. The City shall integrate the CCTV system into the existing head-end management platform such that access to recordings shall be restricted to OC Transpo personnel only.

(k) Project Co shall design the CCTV system to ensure that the resolution and clarity of captured images is maintained under a range of lighting conditions from darkness through bright sunlight while ensuring optimal picture quality.

(l) Project Co shall design the CCTV system to provide spare recording capacity to allow for the addition of up to 40% video inputs for future expansion.

(m) The City shall integrate the Expanded Trillium Line's CCTV system into the existing head-end management platform such that an administrator can dynamically specify resolution and frame rate variation at a particular camera location for monitoring that location while not affecting the recording parameters.

(n) Project Co shall design and install the CCTV cameras with de-icing and lens clearance protection. Project Co shall ensure that all cameras have a unique identity and provide a means of detecting image loss.

(o) Project Co shall design the CCTV system such that the system shall store all recorded images in an accepted industry standard format.

(p) Project Co shall design and implement the CCTV system such that in the event of a power outage, CCTV equipment shall remain operational for a minimum of four hours through the use of UPS. An additional 8 hours of power shall be provided through the use of generators.

(q) Project Co shall design and install the CCTV cameras located in public areas in vandal resistance environmental enclosures. Refer to Schedule 15-2, Part 4- Stations for location information.

(r) Project Co shall design the CCTV system and install the cameras such that they never directly view the sun. Project Co shall ensure that the field of view of cameras shall be adequately illuminated either by natural light or by luminaires. Project Co shall design the CCTV system such that within the field-of-view, particular care shall be taken to avoid extremes of light, shadow and reflection from extreme glazing.

ARTICLE 8 SCADA SYSTEM

8.1 Scope of Work

(a) Project Co shall design and install a wayside SCADA system that provides supervisory control of the support systems. The existing head end systems servers are located at the Belfast MSF and manage all system controls and indications for the System. The wayside SCADA system shall integrate to the existing GUI and include the ability to filter out unnecessary indications and alarms according to user preference. SCADA system functions shall include:

(i) BMS – Project Co shall design the BMS system to monitor Station mechanical and electrical equipment and report to the existing MSF head-end. Refer to Schedule 15-2, Part 4, Article 5 – Mechanical Design Criteria for details;

8.2 General Requirements

(a) The Confederation Line SCADA head-end equipment consists of master terminal equipment, including servers and workstation GUIs, to control, monitor, gather data and communicate with field equipment. The SCADA system shall ensure that each point be sequentially scanned point by point under normal conditions and the status of all points shall be continuously transmitted to the existing SCADA head-end in the TOCC and BCC.

(b) Project Co shall design, procure, install, connect, integrate, test and Commission all station SCADA interconnection equipment including RTUs and all equipment necessary to connect the BMS (station mechanical and electrical equipment) and SCADA system to the CTS for transmission of controls from the TOCC and BCC and indications and alarms from the Stations. Any additional RTUs required as part of the new S&TCS shall be provided and installed by Project Co.

(c) The City shall upgrade the Confederation Line's existing head-end management platform on the servers located in the data room at the Belfast MSF to accommodate the new SCADA system equipment installed at the Stations and Facilities on the Expanded Trillium Line.

(d) The City shall design, procure, install, test and Commission all head-end management platform hardware required in the BCC at the Belfast MSF.

(e) The City shall procure and pay all licenses and on-going fees associated with new hardware and software required for the expansion of the Existing Trillium Line headend management platform.

(f) Project Co shall design the SCADA system to ensure that signals transmitted from the RTUs to the processors at the TOCC and BCC shall be processed to provide monitoring information for all required subsystems, generate commands to be transmitted back to the RTUs, provide information for displays and alarm processing at the control consoles, and store information and historical data for future processing.

(g) The City shall upgrade the existing Confederation Line's head-end management platform to ensure that for each new Expanded Trillium Line remote location, the system shall display the following items on the SCADA monitoring workstations in the TOCC and BCC:

(i) Current system and subsystem status;

(ii) Control panel status;

(iii) Remote control RTU functions;

(iv) Alarm handling and fault resets; and,

(v) Historical event logging.

(h) The City shall update the existing SCADA system head-end management platform to ensure that schematic, one-line, pictorial, and alphanumeric displays of the Expanded Trillium Line SCADA system can be generated, altered, or deleted online by existing GUI.

(i) Project Co shall design the SCADA system for ease of expansion and alteration in an economical and efficient manner to protect for future System expansion.

(j) Project Co shall design and install, all Station, Facility and BMS SCADA infrastructure hardware including mounting brackets, conduit and cables.

8.3 Control and Monitoring Requirements

(a) The City shall integrate the Trillium Line's new SCADA equipment into the existing head-end management platform. The City shall integrate the Expanded Trillium Line's SCADA equipment with the existing head-end management platform to ensure that the system provides indications from field equipment to the TOCC and BCC and controls from the TOCC and BCC to field equipment.

(b) Project Co shall design the SCADA system to ensure that each remote monitored location provide a local HMI for local alarm annunciation and system control.

(c) Project Co shall design the SCADA system to ensure that each communications cabinet/ signal case report status of intrusion detection and fire alarm to the TOCC and BCC's SCADA head-end management platform.

(d) Project Co shall design the SCADA system to monitor the following operational items:

(i) Passenger Elements

A. Elevator status: on, off, maintenance, fault;

B. Platform PID status: on, off, fault;

C. Public Address status: on, off, fault;

D. Platform lighting status: on, off, fault;

E. Emergency Telephones: active; off; fault;

F. Intrusion detection alarms; and,

G. Other emergency alarms.

(ii) Wayside Elements

A. Bungalow door status: open, closed;

B. Switch heater control: low – medium – high; on/off;

C. Switch heater status: on, off, fault;

D. Dow's Lake Pump house critical alarms;

E. Dow's Lake tunnel high water alarm;

F. Dow's Lake radio repeater status: on, off, fault;

G. GIDS alarms;

H. Tunnel Ventilation;

I. Escalators (where located);

J. Platform heating (where located);

K. Station power & backup generators; and,

L. Other critical infrastructure alarms.

(iii) Other Elements

A. Incoming utility power.

8.4 SCADA Configuration

(a) Project Co shall design the SCADA system to ensure that the RTUs provide the interface between the field equipment and the CTS, which includes the CTS.

(b) Project Co shall design the SCADA system to ensure that the SCADA RTUs utilize an Ethernet connection via the CTS to communicate with the existing TOCC and BCC head-end equipment. Error correction and detection schemes shall be used utilizing an industry standard (such as CCITT CRC-16) and, at a minimum shall:

(i) Detect all errors of up to 16 continuous bits; and,

(ii) Detect at least 99% of all error bursts greater than or equal to 16 bits.

(c) Project Co shall design and implement the SCADA system to ensure that the wiring and cabling between the RTU and field devices are uniform in type, routing, and connection locations. Project Co shall design the SCADA system to ensure that the following field interface requirements be met:

(i) Signals between the RTU and CIHs/cases shall terminate at one centralized location.

(ii) RTU terminations shall include test points and rapid disconnect.

(iii) All wires and cables shall be labeled using a logically consistent labeling convention consistent with the existing system labeling.

8.5 Development and Configuration Tools

(a) Project Co shall ensure that the SCADA system be designed such that no action or lack of action by the users or any malfunction of the SCADA subsystem equipment can cause an unsafe condition. Project Co shall design the SCADA system to ensure that should the system become completely inoperative, for any reason, the System shall continue to operate normally and safely.

8.6 Remote Terminal Units

(a) Project Co shall ensure that the requirements for the SCADA RTUs are provided as follows:

(i) Solid-state, microprocessor-based with logic elements and auxiliary components configured on easily replaceable plug-in modules.

(ii) Provide interchangeability of modules; all RTUs shall be of a common design.

(iii) Operate normally unattended. RTU logic and configuration data shall reside in non-volatile memory.

(iv) Perform self-tests upon power up and on command from local test equipment and from the TOCC and BCC. Self-tests shall also be performed by input/output subsystems and input/output cards.

(v) Provide for Maintenance of input/output circuits (including disabling power to output circuits) and safe replacement of input/output cards while power is applied. Possess the capability to continue operation in outdoor weather conditions with 0 to 95% humidity (non-condensing).

(vi) Operate within a power supply range of plus or minus 5% of its nominal value and a frequency range of plus or minus 1% of its nominal value.

(vii) Support local initialization and troubleshooting with either a local control panel or workstation or portable test equipment.

(viii) Be modular in design to provide expansion of performance and capacity by adding subsystem modules. This shall include the ability to add a minimum of 20% more input/output subsystem modules.

8.7 Operational Requirements

(a) Project Co shall design that the SCADA system to ensure that RTUs operate in a full-duplex mode in which each continuously scans and reports the status of indicators and commands.

(b) Project Co shall ensure that the SCADA system RTUs be designed to continue operations with the loss of communication to head-end as a result of either communication equipment failures or

head-end equipment failures. Project Co shall ensure that upon return to service of failed equipment, the SCADA system shall automatically resume normal monitoring and management of that equipment.

(c) Project Co shall ensure that the SCADA system RTUs are designed to continue operation in the electromagnetic environment where they shall be located, such as CIH, traffic cabinet and communications equipment cabinets.

8.8 Interface Requirements and Data Exchange

(a) Project Co shall design the SCADA system RTUs to support discrete inputs and outputs via relay contact closures (or optically isolated sold-state equivalents such as silicon controlled rectifiers). Project Co shall ensure that all discrete inputs to the RTU shall be of the same type. Project Co shall ensure that all discrete outputs by the RTU shall be of the same type. Project Co shall ensure that the following SCADA system RTU input and output requirements are met:

(i) Digital inputs to the RTU shall be from Form C relay contacts. The sensing voltage DC power supply shall be in the RTU domain.

(ii) Input and output signals shall be electrically isolated from the RTU.

(iii) RTU shall generate outputs via relays. Relays and transient suppression circuits shall be provided. RTU interface relays and relay contacts shall have a MTBF, at rated loads, of 5,000,000 cycles or more.

(iv) RTU outputs shall be momentary contact closures with a time duration that is stable and adjustable.

(v) RTUs shall prevent unintended action such as energizing output circuits upon power-up and power-restore.

(vi) A serial digital data interface may be used between the RTU and other processor-based devices, such as Train-to-wayside communications. All serial interfaces to RTUs shall be optically isolated.

8.9 Performance Requirements

(a) Project Co shall design the SCADA system to ensure that the elapsed time from the first possible detection by an RTU or equivalent field device of an alarm or change of state, until display at the TOCC and BCC shall not exceed 2.0 seconds, unless otherwise approved.

(b) Project Co shall design the SCADA system to ensure that when a user enters a command for any individual device control, the RTU shall generate the associated output signal, in the field, in no more than 2.0 seconds, unless otherwise approved. In the event a device equivalent to an RTU is used, the network shall deliver the command to the equivalent device in no more than 2.0 seconds, unless otherwise approved.

(c) Project Co shall design the SCADA system to ensure that the specified SCADA system equipment have the ability to integrate into the existing system without degrading performance and security of the system. Project Co shall design the SCADA system to ensure that the HMI

hardware shall have TCP/IP with 10/100Mbs connectivity for network communication. Project Co shall design the SCADA system to ensure that the SCADA system HMI software comply with the Open Process Control standards to assure interoperability of the data servers between different RTU platforms.

ARTICLE 9 INTRUSION ACCESS CONTROL SYSTEM

9.1 General Requirements

(a) Project Co shall design the IAC system to control access and provide for detection of intrusion into non-public or otherwise restricted areas in Stations and along the alignment. Project Co shall design the IAC system to ensure that intrusion sensors sound an audible alarm locally and trigger an automatic alarm notification to the workstation GUI in TOCC and BCC for unauthorized entry or tampering to IAC equipment.

(b) Project Co shall design the IAC system to ensure that the major access control equipment in Facilities include smart card readers, request-to-exit detectors, door contacts, electrified lock sets, and ACPs. ACPs shall be connected to the local network switch associated with the CTS. Project Co shall design the IAC system to ensure that card readers and ACPs be designated matching products or equivalent to ensure system compatibility with the existing IAC system.

(c) Project Co shall design the IAC System to ensure that all access-controlled doors in Stations and the New Walkley Yard are monitored by the CCTV system.

(d) Project Co shall design, install, connect, integrate, test and Commission all station IAC equipment including door hardware, door control units, intelligent system controllers, power supplies, Ethernet switches, routers, equipment cabinets, fiber distribution panels and all equipment necessary to connect the IAC system to the CTS for transport of data back to the TOCC and the BCC. All IAC system field devices for the Expanded Trillium Line shall be compatible with the existing IAC system management platform at the TOCC and BCC. The IAC system shall use the same access control cards as used on the Confederation Line.

(e) The City shall upgrade the Confederation Line's head-end management platform at the TOCC and BCC to accommodate the new IAC system equipment installed on the Expanded Trillium Line.

(f) The City shall design and procure all appropriate head-end management platform hardware required to be installed in the Belfast MSF as a result of the Expanded Trillium Line.

(g) The City shall be procure all licenses and pay all fees associated with new hardware and software procured for the Expanded Trillium Line system.

(h) Project Co shall design, install, test and Commission all IAC infrastructure hardware including mounting brackets, conduit and cables.

(i) Project Co shall provide a method to detect and identify any persons or objects that infringe into the guideway from the end of Station Platforms or intrusion at a portal.

    (i) Project Co shall ensure that the gates at the end of the platforms utilize contact closure switches monitored by the SCADA system.

    (ii) Project Co shall design, install, test and Commission a portal intrusion detection system to be used at tunnel portal entrances to monitor for intrusions by humans or other large objects into the tunnel.

A. Project Co shall design the portal intrusion detection system to ensure that it is capable of being monitored by the SCADA or IAC system.

(iii) Project Co shall ensure that upon activation of the portal intrusion detection system, an automatic 25 km/h speed restriction shall be applied to all Vehicles operating with the vicinity of the intrusion.

(iv) Project Co shall design the portal intrusion detection system to ensure that train Operators are provided with an indication at the portal entrance that an intrusion has been detected.

9.2 Operational Requirements

(a) Project Co shall design the IAC system to ensure that the system provide controlled access and detect intrusion of the following:

(i) Public to non-public doorways;

(ii) CIH;

(iii) Station communication cabinets and/or communications rooms;

(iv) Elevator machine rooms;

(v) Escalator machine rooms;

(vi) Electrical equipment rooms;

(vii) Vent plants;

(viii) Mechanical rooms;

(ix) Crew/Operational Rooms;

(x) Platform End Gates;

(xi) ICP; and,

(xii) Additional areas listed in Schedule 15-2, Part 5, Article 8 – Communication, Control and Security Systems.

9.3 Performance Requirements

(a) Access Cards – Project Co shall design the IAC system to ensure that access cards be provided as follows:

(i) Access cards shall be provided by The City to approved staff for entry into the CIHs, and vent plants. This system shall be compatible with the Confederation Line IAC system.

(b) Project Co shall design the IAC system to ensure that access authorization be verified based on data submitted from any credential and retained in the system controller database, granting access by releasing electronic door locks once all correspondence is deemed accurate.

(c) Project Co shall design the IAC system to ensure that all access decisions/credential transactions be processed locally at the card reader interface board as it receives data from the system controller, minimizing network traffic while also providing real-time access determinations.

(d) Project Co shall design the IAC system to ensure that all cardholders have access based on Facility, card reader, time, and day. Project Co shall design the IAC system to allow access levels to be defined and to be applied to any or all cardholders. Project Co shall design the IAC system to ensure that access authorization be denied by credential holder, time of day, group of staff, shift, and any additional characteristics that are identified by the system controller database.

(e) Project Co shall design the IAC system to ensure that provisions be made for remote signalling of the door opening to an IAC panel.

(f) Project Co shall design the IAC system to ensure that the system provide a means to bypass zones for facilities/locations where certain alarm zones are not 24 hour zones and be capable of being armed and disarmed from the TOCC and BCC.

(g) Project Co shall design the IAC system to ensure that the system incorporate an interface to the fire alarm panel to allow override of door locks for free egress in an emergency situation. Refer to Schedule 15-2, Part 4 – Stations for additional information.

(h) Project Co shall design the IAC system to ensure that the system can be interfaced with the CCTV system to allow the display of video upon activation of an IAC alarm or use of an access control device at the TOCC and BCC.

(i) Project Co shall design the IAC system to ensure that in the event of a power outage, IAC equipment shall remain operational for a minimum of four hours through the use of uninterruptible power supplies. An additional 8 hours of power shall be provided through the use of generators.

(j) Project Co shall design the IAC system to ensure that the system shall be fully distributed system architecture, with access control and event processing undertaken by intelligent controllers, and shall be designed with the following capabilities:

(i) Support multiple card readers for access control, alarm input devices, and control outputs.

(ii) Designed for multi-tasking, capable of maintaining system operations while other applications are being performed in the host computer.

(iii) Prepare, process, and display video photo identification badges.

(iv) Equipped with a control panel to allow staff to open or close selected doors remotely. The panel shall have indicating lights to show door positions.

(v) Designed for 24-hour per day, 7 days a week operation.

(vi) Generate reports based upon system configuration database as well as historical system activity.

ARTICLE 10 SIGNALLING AND TRAIN CONTROL SYSTEM

10.1 Codes, Standards and Manuals

(a) The works shall comply with the criteria contained in this Article, and all standards, regulations, policies, Applicable Law, guidelines or practices applicable to the Project, including but not limited to each of the following Reference Documents:

(i) AREMA, Communications and Signal Manual;

(ii) Transport Canada Grade Crossing Standards;

(iii) Manual of Uniform Traffic Devices for Canada (MUTCD-C);

(iv) Ontario Electrical Safety Code;

(v) EN 50121-1, Railway Applications – Electromagnetic Compatibility;

(vi) EN 50125-3, Railway Applications - Environmental conditions for Equipment – Part 3: Equipment for Signalling and Telecommunications;

(vii) EN 50126, Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS);

(viii) EN 50128, Railway Applications – Communication, Signaling, and Processing systems – Software for Railway Control and Protection Systems;

(ix) EN 50129, Railway Applications – Communication, Signalling and Processing systems – Safety Related Electronics for Signalling;

(x) EN 50155, Railway Applications – Electronic Equipment used on rolling stock;

(xi) EN 50159-1, Railway Applications – Communication, Signalling and Processing Systems;

(xii) EN50238, Railway Application – Compatibility between rolling stock and train detection systems

(xiii) IEEE Std. 1475, IEEE Standard for the Functioning of Interfaces Among Propulsion, Friction Brake, and Train-borne Master Control on Rail Rapid Transit Vehicles;

(xiv) IEEE Std. 1478, IEEE Standard for Environmental Conditions for Transit Rail Car Electronic Equipment;

(xv) IEEE Std. 1483, IEEE Standard for Verification of Vital Functions in Processor-Based Systems Used in Rail Transit Control;

(xvi) MIL-HDBK-217F, Handbook of Reliability Prediction of Electronic Equipment;

(xvii) MIL-HDBK-472, Maintainability Prediction; MIL-STD-470B, Maintainability Program Requirements for Systems and Equipment;

(xviii) MIL-STD-471A, Maintainability Verification/Demonstration/Evaluation;

(xix) MIL-STD-810F, Test Method Standard for Environmental Engineering Considerations and Laboratory Tests; and,

(xx) Railway Association of Canada – Railway Signal & Traffic Control Systems Standards.

(b) The entire S&TCS, including the inspection and test program, shall be in full compliance with all of the listed standards, regulations, and codes as relevant to each component of the S&TCS. .

10.2 Scope of Work

(a) The existing S&TCS on the Existing Trillium Line is based on an ABS system with Track circuits and an overlaid ATP system. The ATP system consists of intermittent inductive automatic train stop devices referred to as the Indusi system. The Indusi system uses two magnets - one providing an over-speed warning device; the other acting as a positive train stop used to address a Signal Passed at Danger. The magnets are mounted on the outside of the rail at fixed distances from the signal, and used as a coupling device to activate the on-board ATP braking system. The Indusi system is considered obsolete and shall be eliminated. In order to achieve the City's operational objectives, Project Co shall replace the existing S&TCS with a new modern advanced S&TCS in accordance with this Article.

(b) The new S&TCS shall provide a "Grade of Automation" as defined in the IEC 62290-1 at Level 1 (manual operation with ATP).

(c) The new S&TCS shall provide continuous speed supervision and speed enforcement throughout the alignment to prevent derailments due to over speeds and to prevent signals passed at danger. Further, the onboard system shall provide Operators with information through a Train Operator's display linked to master timetable, and including but not limited to:

(i) Train Crew identification;

(ii) Train identification;

(iii) Maximum safe speed and current speed;

(iv) Movement authority limits (i.e. distance to go, next stop, next signals;

(v) Enforcement warnings and activation (i.e. STOP signal violation, overspeed, etc.);

(vi) Dwell countdown timer and punctuality status (early, on time, late);

(vii) Door control indications including which side is enabled;

(viii) Onboard S&TCS high-level alarms, faults and messages;

(ix) Door control indication including which side is enabled; and,

(x) Onboard S&TCS high-level alarms, faults, and messages.

(d) In the event of failure of the onboard S&TCS system, or for operation on non-equipped Track it shall be possible to operate the Train in cut-out mode. While cut-out is selected, the S&TCS System shall be prevented from controlling the Train.

(e) The new modern advanced S&TCS shall be designed by the Project Co to address the primary goal of automatically stopping or slowing down a train before certain accidents occur including:

(i) Train-to-Train collisions;

(ii) Derailments caused by excessive Train speed; and,

(iii) Train movements through misaligned Track switches.

(f) In order to achieve this primary goal, the S&TCS shall be designed to:

(i) Determine a Train's block occupancy, direction and speed;

(ii) Receive and analyze Track data;

(iii) Provide advance warning of movement authority limits, speed limits and Track conditions; and,

(iv) Engage the Train brakes and bring it to a controlled stop without the Operator's assistance.

(g) Project Co shall develop the performance specification, produce the design, procure, conduct Pre-delivery Testing (including FAT), install, conduct PICO, SAT, SIT, Commission and Maintain the new S&TCS head-end management system, including back office equipment, servers, and user workstation within the TOCC and BCC.

(h) Project Co shall design the new S&TCS system for the Expanded Trillium Line to be capable of:

(i) Providing ATP through enforcement of all civil speed restrictions and adherence to maximum curvature speeds based upon the entire Mainline Track alignment;

(ii) Providing ATP for Trains passing cab signals or wayside signals set to stop Train movement through engagement of on board automatic braking of the Train;

(iii) Enabling a continuous cab signaling for Train movement control with additional wayside signals available at signal controlled interlockings;

(iv) Facilitating the complex passing movements in and out of South Key Station;

(v) Facilitating passing movements through all the passing sidings through timetable-based signal controls; and,

(vi) Facilitating entrance and exiting of Vehicles between the New Walkley Yard and the Mainline Tracks by means of signal controlled interlockings.

(i) The City shall reserve and allow Project Co access to four spare fibres in each of the Confederation Line's redundant 48 strand fibre optic cables at the TOCC and BCC to connect the Expanded Trillium Line's new S&TCS headend equipment to the new field equipment.

(j) The City shall provide Project Co access to the building's cable/conduit pathways for Project Co to install LAN equipment for connecting the Expanded Trillium Line's new S&TCS head-end servers to the new Expanded Trillium Line's new S&TCS operator workstation located in the TOCC and BCC.

(k) The City shall allow Project Co access to spare fiber within its existing Confederation Line's 48 strand fiber optic cables at Bayview Station to connect the Expanded Trillium Line's CTS to the Confederation Line's CTS.

(l) The City shall reserve rack space in one of its equipment rooms at the TOCC to install the primary head-end server and the BCC to install the backup head end server for the new S&TC System. Space has been reserved in the TOCC and BCC to facilitate the transition of Train Control Operations from Montreal.

(i) Project Co shall design a new S&TCS to include a real-time head end GUI for Controllers to be able to easily monitor, control, and dispatch Trains as necessary throughout the day. The display shall provide and consolidate Train locations, switch status and positions, Train routes and signal block occupancy, equipment status and signal bungalow status, critical alarms, and, all standard Train Control and dispatch functions in a consolidated two monitor display configuration.

(ii) Project Co shall design a system that is fully integrated with all the field equipment and control of all required rail system elements including switch heaters, switch and signal controls, route setting, diamond controls (Walkley & Ellwood), yard signal and switch controls, Tunnel lunar light status, and any other functions that would reasonably be required to safely and efficiently operate the Expanded Trillium Line System.

(iii) Project Co shall design the system to provide automatic route and signal setting based on a timetable mode in order to manage the arrival/departure times of Trains at Stations and to coordinate the movements by Trains through the passing sidings. The system shall be possible to edit/change timetable schedules and to adjust timing parameters such as Station dwell times. The current signal system allows automatic route setting but provides no other higher-level functions such as Station departure indicators. The current signal system does not coordinate departure timing from adjacent Stations to enable fully coordinated Operator passing movements, i.e. maximum siding travel speeds without stopping. Project Co shall provide a new Train Control System (signals, cab controls, other) that manages Train Station arrivals, Station departure times (departure indicators or other methodology to be proposed by Project Co), and fully coordinates movements through passing sidings and junctions in order to minimize the probability of a Train stopping on the mainline. The system shall be capable of integration with OC Transpo's scheduling system.

(iv) Project Co shall design the system to allow for manual route setting to accommodate staging Vehicles in the morning; reduction of Trains at night; removal of Trains from service; and, degraded mode and recovery operations.

(v) Project Co shall design the system capable of being configured to detect and report on passed stop signals (Rule 439 violations) to the TOCC and BCC. The integrated system shall enable other performance alarms including vigilance violation alarms, Train Emergency brake applications, Operator Emergency alarms, and Train over speed conditions. Refer to Schedule 15-2, Part 8, Clause 1.17 for descriptions of vigilance violation alarms.

(vi) Project Co shall design the system to include a playback system that enables playback of Vehicle movements, signal status, and other key status indicators for a minimum of 120 calendar days. It shall be possible to create records of specific events for review at a later date.

(vii) Project Co shall design the system capable of facilitating administration of CROR Track occupancy permits and other positive protection controls for Maintenance staff accessing the corridor through recording of permits/activity in electronic forms which are linked to required signal controls. System shall also facilitate recovery and positive protection requirements for Trains following system events or issues, e.g. dropped signals, shared block occupancy, reversing movements, etc. Integrated DOB, GBO, event logging, and other operations reporting shall be included.

(viii) Project Co shall design the system to log and report all Vehicle movements to enable recording and capturing of all Station departure times, Station arrival times, dwell times, travel times, headways, and Station-Station travel times. The data shall be provided in a standard report format on a daily basis and shall also be available in a CSV file format for post-processing. Accuracy of the data shall be +/- 5 seconds.

(ix) Project Co shall design the system to report all Vehicle movements against a standard timetable in order to be able to measure and report on actual versus scheduled departures and late arrivals (early, on time, and late). The data shall be provided in a standard report format on a daily basis and shall also be available in a CSV file format for post-processing. Accuracy of the data shall be +/- 5 seconds. The system shall provide other reports as necessary to support the performance management system.

(x) Project Co shall design the system to provide a current Train graph (fleet position and time) and historical Train graph to enable analysis and reporting.

(xi) Project Co shall design the system to integrate with the PA/PIDS system in order to enable current and next three Train arrival countdown messages, PA Train arrival messages, and other standard passenger information triggers.

(xii) Project Co shall provide a real-time data feed to the City's PIDS and the City's ATIS. The system shall provide information to customers which includes but is not limited to current and next three train arrival countdown messages, GPS or equivalent Train location information, Station elevator status, Station open/close status, general Train punctuality status, Passenger counting information, and other common customer transit reporting elements. Project Co shall provide the server data feed to the City's systems to enable third-party real-time reporting of system status. The data feed shall be open data constructed in an XML format and will be designed to be interoperable with SIRI or other applicable standards. In order to facilitate timely integration with the City's

systems, Project Co shall submit the ATIS data format, data contents, and data server architecture to the City in accordance with Schedule 10 – Review Procedure.

(xiii) Project Co shall procure all licenses and pay all fees associated with new hardware and software procured for the Expanded Trillium Line.

A. The S&TCS shall be based on a proven ATC architecture supporting a wide range of operating environments as required for the SI.

B. The S&TCS shall be designed to maximize safety, reliability, operational flexibility and fault tolerance.

(xiv) OC Transpo schedulers will build a Train service plan (headway, dwell times, etc..) for the scheduled service using the S&TCS headend software or software tool provided by Project Co, with a view to feeding this information back into HASTUS for crewing purposes. HASTUS is used by OC Transpo personnel to schedule operator shift assignments and work blocks. The current Existing Trillium Line schedule and timetable is created in HASTUS. This includes continued fine tuning of regular schedules as well as the scheduling of special service days, shutdowns, etc.

(xv) Once the Train schedule has been imported into HASTUS and processed by the scheduler, a HASTUS generated operator schedule shall be exported to the S&TCS to enable matching of Operators & Operator work assignments with specific Trains. Controllers shall have the ability to query Train information in the S&TCS software to identify the designated shift assignment, work block, and assigned Operator.

(xvi) On the Train assignment, operator shift assignment, operator work block, and Train arrival information shall be aggregated by Project Co supplied systems onto a simple screen or electronic display provided by Project Co in the Train Operator rooms identified in Schedule 15-2, Part 4, Clause 2.6 (a) (v) and (vi).

(xvii) HASTUS and other equipment Operator management systems shall be supplied, installed, and tested by the City. The City shall develop and input schedule, Operator assignments into these systems.

(xviii) The S&TCS (or other Project Co system) shall drive information required for the screen controller to display the desired information. File exchange shall occur in CSV format or other format to be finalized during design.

(xix) It is envisioned that as a minimum, the S&TCS head-end system shall be used to trigger Station countdown messages on the PIDS at the Stations (format to be confirmed), ATIS updates via an open data feed (XML), the automatic passenger count system, and an interface to the performance reporting system. The format shall be defined by Project Co.

(m) Project Co shall design the system to support the operational performance and service plan as described in Schedule 15-2, Part 1, Article 3 – Operational Performance Requirements.

(n) Project Co shall have access to the City's fiber optic network but shall otherwise be responsible for providing the network equipment for a fully segregated S&TCS network into the TOCC and

BCC. Cabling work shall be completed in engineering hours but patching may be possible during normal business hours.

(o) The City shall coordinate all access to the TOCC, BCC and Equipment Rooms as required by Project Co.

(p) Project Co shall design the system such that the distance from the Train stop location on the Platform, to the end of the Track at all Terminal Stations shall be a maximum of 22.5m.

(i) Project Co shall ensure all SI including the S&TCS is designed to support this maximum dimension while still meeting all requirements.

(ii) Project Co shall be fully responsible for any additional work, system modifications, regulatory approvals that may be required to ensure this maximum dimension is not exceeded.

(q) Project Co shall provide an S&TCS for the mainline that is capable of launching Trains from the New Walkley Yard to the mainline and exiting Trains from mainline to the New Walkley Yard at all times. The switch used to enter and exit the New Walkley Yard shall be controlled from the TOCC and BCC by means of an interlocking with wayside signals available for non-cab signal equipped Vehicles. The interlocking shall include a local control panel within the main signal bungalow that can be used to control the switch and Train movements if the TOCC and BCC are not available.

(r) Project Co shall provide a separate S&TCS for New Walkley Yard that is capable of yard operation as described under Schedule 15-2, Part 5 – New Walkley Yard.

(s) If required for the NRC Spur Line, Project Co shall provide a HGCWD for Lester Road in accordance with Transport Canada Grade Crossing Standards and as noted herein.

(i) Requirements

A. Project Co shall perform a complete grade crossing Site evaluation to determine the design updates required to the existing HGCWD system located at Lester Road. The crossing shall be equipped with all new HGCWD equipment as part of the S&TCS. The grade crossing protection solution shall include at a minimum the installation of new flashers, cantilevers, gates, crossing controller, and all associated equipment required to operate the crossing equipment.

B. Project Co shall verify the crossing equipment layout design will ensure that all components of the HGCWD meet the physical characteristics of the new overhead Bridge and the future roadway extension. Project Co shall verify that the physical locations of the HGCWD equipment comply with the visibility and sight line criteria as required by the Transport Canada Grade Crossing Standards and the City.

C. Project Co shall ensure that all of the equipment installed at the Lester Road crossing operates as specified in further detail elsewhere herein in accordance with Clause 10.13(b).

D. The right of way at Lester Road is always for the Train as there is no means to stop the Train. Train stop signals shall not be required for the Lester Road crossing. The adjustments required to the Track circuits are those adjustments required to account for the widened Lester Road crossing area.

(t) Project Co shall provide an interface to the S&TCS for the Airport Emergency services access road as noted herein.

(i) Project Co shall design the S&TCS System to include the interface and equipment necessary to operate the Airport security fence sliding gate and simultaneously request the S&TCS to stop all approaching Trains to the crossing. This shall include the installation and interface of the Yelp Emergency vehicle detection and activation system.

(ii) Although there will be no HGCWD system flashers or crossing gates to be provided at this private crossing, Project Co shall provide and install all required crossing warning signage in accordance with the Transport Canada Grade Crossing Standards.

(iii) Project Co shall verify that the line of site for viewing approaching Trains in both directions from the crossing is unobstructed and compliant with requirements of the Transport Canada Grade Crossing Standards.

(iv) Project Co shall ensure that all of the equipment installed at the Airport Emergency services access road crossing operate as specified in further detail elsewhere herein under Clause 10.13 (c).

(v) Project Co shall provide CCTV coverage of the airport Emergency access road crossing.

(u) Project Co shall supply and Maintain all necessary equipment including, hardware, software, spare parts and any additional items required for Operation and Maintenance of S&TCS.

(v) Project Co shall provide functionalities and equipment to support all modes of operation in all relevant areas. Upon loss of remote control, local control intervention shall be required in failure or abnormal circumstances.

(w) Project Co shall ensure that all Revenue Vehicles shall be equipped with S&TCS equipment meet the requirements set out in the Output Specification.

(x) Project Co shall assess the need for equipping Maintenance Vehicles with S&TCS onboard equipment; otherwise they shall be considered non-equipped vehicles.

(y) Project Co shall design S&TCS for the safe operation of the Trains, Maintenance Vehicles, non-communicating Trains, and non-equipped vehicles throughout the Expanded Trillium Line at all times.

(z) Project Co shall provide all necessary wayside signs required for manual operation of Trains and work zones.

(aa) Project Co shall provide Maintenance planning tools for S&TCS to support the asset management planning.

(bb) Project Co shall provide training equipment in order to allow training of Maintenance staff, including troubleshooting, fault finding, and system updates.

(i) Project Co shall maintain the training equipment to be consistent with System operating functions and features.

(cc) Project Co shall provide remote diagnostic capability and portable test units for S&TCS equipment.

(dd) The new S&TCS for Trillium Line shall not be required to cover the NRC Spur Track. The adjustments required to the Track circuits at this location are those adjustments required to account for the widened Lester Road crossing area.

10.3 General Requirements

(a) Project Co shall design all elements of the S&TCS to be failsafe and maximize the safety and security of all personnel, Passengers, and equipment.

(b) Project Co shall design the S&TCS for the Operation and control of all equipped Revenue Vehicles.

(c) Project Co shall design the S&TCS to accommodate the safe Operation of the Maintenance vehicles.

(d) Project Co shall design the S&TCS to allow additional equipment for expandability and extendibility without replacement of previously provided equipment. This shall not prevent minor hardware and software upgrades.

(e) Project Co shall modify or replace the existing Vehicle on-board ATP equipment, to support cab signaling.

(f) Project Co shall provide and install new on-board ATP equipment for the new Vehicles.

(g) Project Co shall design an S&TCS that is based on modern technology, standard off the shelf equipment that has been in service on another similar property for a minimum of five years.

(h) Project Co shall design an S&TCS that is reliable, maintainable and provide the highest degree of safety for both riders and Vehicle.

(i) Project Co shall design an S&TCS that provides broken rail detection, speed limit enforcement, and absolute stop enforcement.

(j) Project Co shall design the S&TCS, for the Trillium Line Extension compliant to the recommended safety level requirements as specified within the AREMA Communication and Signal (C&S) Manual Section 17, Quality Principles. Project Co shall consider and provide the SIL for each Safety Critical function in reference to EN 50128/EN 50129. The final determined level of safety for the S&TCS shall be submitted in accordance with Schedule 10 – Review Procedure.

(k) Project Co shall design and install the S&TCS to endure reasonable electromagnetic interference without causing or being affected by such inference. The S&TCS shall take into account the following:

(i) Project Co shall produce a Track circuit design that does not permit from any source, power equipment, communication systems, On-board Vehicle equipment or any local Utility power lines to interfere with its operation.

(ii) If AF Track circuits are utilized they shall be designed in such a manner to minimize interference and crosstalk to a level that will not cause an unsafe condition.

(iii) Shielded wire, and twisted wire shall be utilized for EMI noise reduction.

(iv) Surge protection against lightning and other sources shall be provided.

(v) Proper grounding techniques shall be utilized throughout the S&TCS.

(l) Project Co shall design the S&TCS to include the following minimum expandability and extendibility criteria:

(i) additional Tracks;

(ii) additional interlockings;

(iii) additional Vehicles;

(iv) additional Station/Stops; and,

(v) technology refresh (i.e. hardware and software).

(m) Project Co shall design the S&TCS to be capable of adapting to the foreseen conditions and constraints such as failures, Emergencies, weather conditions, abnormal conditions and interruptions. The S&TCS shall be Project Co's responsibility to identify and mitigate them while ensuring safe and reliable Operations at all times.

(n) Project Co shall design the S&TCS to optimize the Train movements and operational speed in accordance with vertical and horizontal Track alignment.

(o) Project Co shall design an S&TCS capable of reading and reacting to the inputs from supervisory and control systems as required.

10.4 Functionalities

(a) Project Co shall design the S&TCS to include an ATP system.

(i) All elements of the new S&TCS shall be provided with the same level of functionality, safety, protection, and redundancy as acceptable on the current system regardless of the assignment of functions among hardware or the terminology used.

(ii) Project Co shall provide as a minimum the following S&TCS functionality:

A. Presence detection of Train vehicles within specific block sections of each segment that are based upon the minimum required safe braking distances;

B. Safe separation of following Train vehicle movements, while maintaining the required headway between them;

C. Determination and display of the appropriate signal aspect indications required for Train routing and changes in speed;

D. Enforcement of adherence to speed restrictions and reaction to signal overruns through application of automatic braking.

E. Interlocking switch machine control and indications;

F. Switch machine heater (hot air blower) control and indications; and,

G. Activation of HGCWD in accordance with the Transport Canada Grade Crossing Standards.

(b) Project Co shall design the S&TCS with an interlocking system as follows.

(i) Interlocking functions shall maintain vital fail-safe protection against collisions, derailment, conflicts and other hazardous conditions.

(ii) Interlocking system shall be designed in conformance with the latest AREMA Communications & Signals Manual.

A. Interlocking system shall be a type of VMIS or CBI or similar industry accepted technology.

(iii) Interlocking system shall be a system with interface to other subsystems of S&TCS (e.g. onboard, wayside, the TOCC, and the BCC).

(iv) Interlocking system shall be available in the event of major failure of other subsystems of the S&TCS.

(v) Interlocking system shall be designed to support not only Trains and Maintenance Vehicles but also to support non-communicating Trains and non-equipped vehicles along the Right-of-Ways.

(vi) Track circuits shall be used within interlockings to provide Train detection. Vital interlocking logic shall include control of traffic direction between interlockings. Traffic direction status shall be vitally maintained through power interruption and failures.

(vii) Project Co shall provide as a minimum the interlocking system functionality:

A. continuous Train detection throughout the interlocking;

B. switch position control and indication;

C. route call/set;

D. approach locking/release;

E. route locking/release;

F. route conflict protection;

G. switch locking/release;

H. overlap locking/release;

I. section locking/release;

J. route override (e.g. call-on); and,

K. field blocking (e.g. Track, signal, switch, route).

10.5 Control

(a) TOCC/BCC Head end Management Platform

(i) The TOCC and the BCC shall serve as the command and control center for the Expanded Trillium Line. Controls and indications required for all wayside signals, Track circuits, switch machines, switch hot air blowers, house alarms, local control panel operations, power availability, and microprocessor status, and shall be transmitted to/from the TOCC and BCC via the fiber optic communication network.

(ii) Project Co shall procure and install the hardware and software required at the TOCC and BCC in coordination with the City.

(iii) Project Co shall design the S&TC head end management platform whereby the GUI displayed on one dispatcher's console can be displayed on another dispatcher's console as long as the required sign in credentials are entered.

(iv) Project Co shall design the S&TC head end management platform whereby the GUI displayed on a dispatcher's console can be displayed at the TOCC and BCC supervisor's console as long as the required sign in credentials are entered.

(v) The City shall integrate the S&TC system into the TOCC and BCC's operational theatre to facilitate the display of the workstation GUI onto the video display wall when required.

(vi) The S&TC head end management platform shall be able to perform all control and monitoring functions required to safely operate the Expanded Trillium Line.

(vii) Project Co shall design the S&TC system head end management platform to include redundant (primary and backup) servers with full fail-over capability. If the primary servers fail for any reason, the system shall fail over to the backup server without manual intervention.

(viii) During the fail-over from the primary to the backup server, an alert shall be sent notifying the console operator that a server has failed and the failover has successfully occurred. Acknowledgment of the alert shall be required from the operator's console/workstation.

(ix) Once the S&TC system primary server has been successfully restored, the system shall be designed to automatically initiate a transition from the backup server to the primary server.

(x) During the transition from the backup to the primary server, an alert shall be sent notifying the console operator that a server has been restored and the transition has successfully occurred. Acknowledgment of the alert shall be required from the operator's console/workstation.

(b) Wayside signals

(i) Project Co shall design the S&TCS with a wayside signals at all Train entrance points to the interlocking and at end of each platform to support any operational requirements including departure indicators. The signal arrangement shall follow the Existing Trillium Line CROR signal configuration.

(ii) Project Co shall design the S&TCS with wayside signals for trains leaving station platform locations.

(iii) Project Co shall design the S&TCS such that wayside signals are mounted with the vertical center of the signal head approximately 2.6m above TOR.

A. Built in ladders shall be provided on high signal masts to permit the changing of aspect lamps.

(iv) Project Co shall design the S&TCS with signal heads and all associated equipment located outside the Trains' clearance envelope.

(c) Central Instrument Houses

(i) Project Co shall design all interlockings to be controlled from VMIS or CBI based system contained within a CIH.

(ii) Project Co shall locate the CIH within the interlocking area at a location to minimize the cable lengths to the interlocking wayside devices. Additional remote houses or cases shall be utilized to accommodate manufacture equipment limitations on cable lengths. CIH's shall be prefabricated units that have been prewired and tested at the factory.

(iii) Project Co shall design the CIH to be secured in accordance with Safety Certification and System Security Certification requirements.

(iv) Project Co shall design CIH with doors with locks. The doors shall also have an emergency bar on the inner side of the door which shall bypass the lock and open the door.

(v) Project Co shall design the CIH to primarily house all microprocessor systems, relays, electronic switch controllers, etc. necessary to control the interlocking from the TOCC and BCC or from the local control panel within the CIH. Additional relays and supporting equipment may be located within the additional remote houses or cases.

(vi) Project Co shall design the local control panel with switch controls, signal controls and Track and switch indications and switch heater status shall be provided. Project Co shall design the controls to select local or TCSS control, and local automatic or local manual control shall be provided.

(vii) Project Co shall design a CIH that is resistant to corrosion and weather damage.

(viii) Project Co shall design a CIH that is insulated to a level that minimizes heating and cooling loads for the HVAC and heating systems.

(ix) A single phase feed shall be provided with appropriate step down transformer(s) and distribution panels for signal power and for bungalow power outlets, lighting, HVAC etc.

(x) A transfer switch and an outside connection for a portable Emergency generator and pad for placement of that generator shall be provided.

(xi) Power for vital signal systems shall not be grounded.

(xii) A battery backup system, as described herein, shall be provided to power all signal and ATP systems including fixed block detection and switch operation.

(xiii) HVAC and heating systems shall be provided with sufficient capacity to maintain room temperatures between 15ºC and 22ºC.

(xiv) The CIHs shall be grounded. All racks in the CIH shall be connected to the earth ground bus.

(xv) Where high density termination blocks are used in signalling equipment located within the CIH, the types used shall:

A. Allow for circuit isolation without disconnecting wires from the terminal blocks;

B. Provide crimped terminations on wires to provide strain relief at the wire insulation;

C. Provide cable identification; and,

D. Provide evidence of environmental testing to EN50125-3 Environmental conditions for equipment, *Equipment for Signalling and Telecommunications*. Special attention shall be paid to the clearance and creepage requirements and lightning suppression for entrance rack terminations.

(d) Switch Machines and Switch Heaters

(i) Dual Control Powered switch machines provided shall:

A. Have capability to be remotely controlled from TOCC and BCC;

B. Have heaters to prevent internal condensation;

C. Have a lockable hand throw lever used for manual mode of operation; and,

D. Have a record of reliable operation in heavy traffic/transit operation.

(ii) Switch heaters shall be provided to prevent ice and snow from building up and immobilizing the switch points and switch rods. Switch heaters shall:

A. Be controlled by the TOCC and BCC with local manual control available for Maintenance and troubleshooting;

B. Have sufficient thermal rating and appropriate controls to operate successfully in the climatic conditions outlined in Schedule 15-2, Part 1, Article 4 – Design and Construction;

C. Report the status of the switch heater (ON/OFF) for each switch to the local control panel and to the TOCC, the BCC; and,

D. Shall cause an alarm indication to the TOCC, the BCC and the local control panel upon failure of switch heaters status to correspond to command status.

(iii) If electric switch heaters are used:

A. A switch heater case shall be provided at each interlocking or group of interlockings to distribute power to each switch heater;

B. A main circuit breaker and disconnect shall be provided at each switch heater case; and

C. The power for the switch heater for each switch shall be separately current protected.

(iv) If gas heaters are used:

A. Flameout and ignition failure shall be provided; and

B. A safety analysis of gas heaters as well as the gas delivery or storage systems shall be provided.

(v) If hot air blowers are used:

A. Hot air blower powered by electric shall meet same requirements as electric switch heaters listed herein.

B. Hot air blower powered by gas or propane shall meet the same requirements as gas heaters listed herein.

C. Air pressure flow switch shall be such that ignition is disabled until adequate pressure is developed.

D. High temperature protection shall be such that automatic shut-off for either thermostat failure or temperature exceeding 420 degrees Fahrenheit. Heater operation shall only be restored by manual reset.

E. Loss of Flame protection such that the ignition module closes the gas valve if after 10 seconds, no flame is sensed or if flame detection is lost for more than 1 second during normal operation.

(vi) Switch machine controls shall provide overload protection and automatic recycling in case of obstructions.

(e) Signal Cable

(i) The design and manufacture of all signal cables shall meet the requirements of AREMA 10.3.17 for armoured cable.

(ii) Signal Cable used in Tunnels shall be provided with a low smoke zero halogen jacket.

(iii) If audio frequency Track circuits are provided, the twisted pair or pairs for each impedance bond shall be run in a separate cable from the cable for any other impedance bond. The use of multi twisted pair cables feeding multiple impedance bonds shall be prohibited.

(iv) Signal wires from cables shall be terminated with compression lugs.

(f) Signal Cases and Junction boxes

(i) Signal cases, junction boxes, and switch heater cases shall be constructed of stainless steel, aluminum or fibreglass with locking doors and neoprene door seals.

(ii) All cable wires shall be terminated on AAR terminal boards with links and double nut locking. Gold nut links shall not be used in unheated cases and junction boxes.

(iii) Signal cases and junction boxes shall be earth grounded.

(g) Signal Battery Backup System

(i) Project Co shall provide a battery backup system for the S&TCS that is capable of providing a minimum of four hours of backup power after the primary source of power is not available. An additional minimum of eight hours of supplementary backup power shall be provided by an external generator.

(ii) If batteries are used:

A. The battery bank system shall be constantly recharged by the primary power source. Therefore when the primary power source is out, the batteries are no longer recharged but will continue to provide power until the batteries are

exhausted. An external generator shall provide the second backup source of power.

B. Battery banks shall be provided with redundant chargers.

C. Battery charger filtering shall be sufficient that the ripple requirements of attached processor systems can be met even when batteries are not attached.

D. Batteries provided shall be selected for the required capacity and minimal degradation of capacity with age and suitable for the environmental conditions outlined in Schedule 15-2, Part 1, Article 4 – Design and Construction.

E. Batteries shall not be lead acid.

(iii) If a UPS is used:

A. The UPS system shall provide a minimum of four hours operating time as the first backup source of power when the primary source of power is out. An external generator shall provide the second backup source of power for a minimum of eight hours.

B. The UPS equipment shall meet all CEC requirements and other applicable industry standards.

(iv) Project Co shall size the batteries, UPS, and generator to provide sufficient backup power to handle all of the S&TCS components operating at the maximum power withdrawal requirements.

(v) If the generator is "shared" with other systems, the power output of the generator shall handle all of the S&TCS components operating at the maximum power withdrawal requirements, in addition to the maximum power withdrawal requirements for the other shared systems.

(vi) Project Co shall create and add a test procedure to the test plan for the backup system including testing of the generator.

(h) Broken Rail Protection

(i) A broken rail protection subsystem shall be provided by Project Co as part of the Trillium Line Extension new S&TCS.

A. The broken rail protection system shall be capable of providing direct input to the S&TCS or transmit data collated by alternative rail condition monitoring method to update the S&TCS to automatically apply any necessary speed restrictions required to prevent Trains from passing over Tracks where potential broken rails have been detected.

B. If Track circuits are used for this purpose, the use of insulated joints shall be kept to a minimum.

C. If an alternative to a broken rail detection system is proposed it shall be subject to the following constraints:

(i) The environmental temperature of the Track and associated Track system shall be monitored. The frequency of rail monitoring/testing shall be increased after experiencing >= 20 degree Celsius thermal swings in 12 hours or less;

(ii) The frequency and type of monitoring shall be commensurate with the type of Track used, its construction methods and the Track bed;

(iii) The seismic activity in the area shall be monitored. The frequency of rail monitoring /testing shall be increased after experiencing seismic activity that would exceed the design of the Track and Track bed or compromise structural integrity of the rail or stability of the Track bed.

(iv) The Track conditions shall be reported to the City at a minimum of every month. This report shall detail temperature change and any seismic activity during that time period.

(v) A fastening system that restricts the longitudinal and lateral movement of the rail following a break shall be provided.

D. Project Co shall demonstrate that the alternative broken rail protection system has been assessed through a Safety and FMEA analyses. Any required mitigations or design changes shall be implemented before Trial Running.

E. The broken rail protection system requirement applies to all Mainline Tracks and Airport Link Spur Tracks. It shall also apply to other Tracks (New Walkley Yard) if warranted by the Safety and FMEA analyses.

(ii) All aspects of the final proposed broken rail protection system shall be subject to review and approval by the City prior to procurement and installation.

10.6 Performance

(a) General

(i) The S&TCS shall be available as per Clause 10.9 or this Part 3.

(ii) The S&TCS shall provide the capability of automatic recovery when a part of the signaling system is temporarily unavailable due to a fault or error that is self-correctable without the need for direct attention by qualified signal maintenance personnel. Upon correction of the fault or error, the system shall be able to automatically restart to restore and re-establish contact with the rest of the signaling system. However, any such fault or error shall place any effected vital subsystems of the S&TCS in their most restrictive mode or status of operation until the fault or error is no longer an issue.

(iii) The S&TCS shall provide the capability of manual recovery when a part of the signaling system is unavailable due to a fault or error that is only correctable with direct attention

by qualified signal maintenance personnel. Upon correction of the fault, the system would require a manual restart in order to be able to restore and re-establish contact with the rest of the signaling system. Any such fault or error shall place all effected vital subsystems of the S&TCS in the most restrictive mode or status of operation until the fault or error is no longer an issue.

(b) Headway

(i) The S&TCS shall be capable of maintaining the same 12 minute operating headway for Trains during peak hours as the Existing Trillium Line.

(ii) The S&TCS shall be capable to operate at a minimum headway, as mandated by the safe Train separation in accordance with the ATP function.

10.7 Failure Management

(a) Project Co shall seek to ensure no single point of failure, or no common cause failures are creating any hazardous situation to the S&TCS.

(b) The S&TCS shall be designed to be fault tolerant through modular design, redundancy and resiliency, otherwise fall back to a fail-safe state.

(c) The S&TCS shall provide alarm indications of abnormal/failure conditions, including data recording and reporting.

(d) The S&TCS alarms shall be categorized and prioritized in coordination with the Operator and the TOCC/BCC.

(e) All essential equipment of S&TCS shall be battery backed up or powered by UPS.

(f) The S&TCS shall not cause loss of Revenue Service operation in the event of a single or common cause failure.

(g) The S&TCS shall be capable of transferring control from the TOCC and BCC to a local control area via manual commands and overrides in case of partial failure of network or equipment/functions.

(h) The S&TCS shall provide the capability of transferring control from TOCC and BCC to local Controllers, while the TOCC and BCC or connection to TOCC and BCC control center is not operational.

(i) When the failed elements at TOCC and BCC are recovered, the S&TCS shall provide the capability of transfer of control from the local control back to TOCC and BCC.

(j) The S&TCS shall be capable of switchover from a failed element to a functioning one when a redundant element is available with no impact to service.

(k) All major S&TCS elements shall be monitored for malfunctions, failures, FLS issues and cyber security intrusions. This shall include both an incident message display and audible alarms.

(l) The S&TCS shall be capable of turn back operation at special Trackwork locations via local control room even if TOCC and BCC is not available.

10.8 Safety

(a) General Requirements

(i) The S&TCS shall be designed to the fail-safe principles for bidirectional operation for semi-exclusive and exclusive ROW

(ii) The S&TCS shall ensure that the Train operation is safe and it shall remain in a safe state under any System or functional failures.

(iii) All potentially unsafe failure modes shall be detected and reported by the S&TCS.

(b) Safety Standards and Submittals

(i) The S&TCS shall meet the safety requirements of EN50126, EN50128 and EN50129 in accordance with Schedule 15-2, Part 1 – General Requirements.

10.9 Availability and Reliability

(a) General Requirements

(i) The reliability shall be determined and measured based upon hardware failures of the S&TCS equipment.

(ii) The availability shall be determined and measured based upon service affecting failures and functional failures of the S&TCS.

(b) Availability and reliability standards

(i) Availability and reliability calculation for the S&TCS shall be performed by using internationally recognized industry standards, such as MIL-HDBK-217F, and verified by using real service-proven data provided by Project Co with appropriate rational.

(c) Availability and reliability demonstration

(i) The S&TCS availability and reliability shall be demonstrated during demonstration period.

10.10 Maintainability

(a) General Requirements

(i) The S&TCS shall be designed to be accessible by maintainers with minimum relocation of equipment.

(ii) The S&TCS shall be designed to be capable of replacing of redundant elements of S&TCS without affecting the intended function.

(iii) S&TCS shall provide remote diagnostic capability and portable test units with the following features:

A. built-in test and diagnostic capability;

B. built-in status and failure indication capability; and

C. central fault monitoring and alarm management capability.

(iv) Project Co shall provide and have available an adequate number of spare S&TCS equipment to maintain the service requirements.

(b) Maintainability Standards

(i) The S&TCS shall meet the reliability and availability requirements of an internationally recognized industry Standards such as, but not limited to MIL-STD-470B, MIL-STD-471A and relevant guidelines in MIL-HDBK-472.

10.11 Security

(a) General Requirements

(i) The S&TCS shall provide secure access to its functionalities and equipment.

(ii) The S&TCS shall provide secure data transfer, storage and retrieval through cyber security.

10.12 Environment

(a) The S&TCS shall meet all of the environmental requirements of regionally recognized industry Standards such as, but not limited to AREMA, IEEE 1478 and test method of MIL-STD 810F.

(b) The S&TCS onboard equipment shall meet the requirements of EN 50155 and the environmental conditions outlined in Schedule 15-2, Part 1, Article 4 – Design and Construction.

10.13 Highway Grade Crossing Warning Devices

(a) General

(i) HGCWD shall include flashing lights, crossing gates, bells, signal masts, cantilever structures, signs, approach and island Track circuits, foundations, conduit, cabling, equipment enclosures, crossing logic and associated materials, lightning/surge protection equipment, equipment appurtenances and subsystems as required for a complete safe, and reliable system.

(ii) HGCWD shall be designed and installed to meet requirements of the Transport Canada Grade Crossings Standards.

(iii) Grade crossing equipment shall meet the requirements of AREMA Communication and Signal Manual and the standards of the operating railroad.

(b) Crossing Operation

(i) Control logic and indications for the crossing shall be located in the designated crossing house.

(ii) The crossing approach limits shall be based upon the maximum approach speed and minimum required warning time. The actual activation of the crossing shall be controlled by a constant warning system based upon the actual speed of the approaching Train.

(iii) The Grade crossing warning device sequence shall begin with activation of all of the flashing lights when a Train is detected approaching the crossing. All flashing lights at the crossing, including gate lights, shall flash in synchronization to form the standard railroad crossing alternating pattern. The light on the tip of the gate shall remain solid, while others are flashing.

(iv) All bells shall emit sound while the lights are flashing and continue to sound until the gate arm has returned to within 10 degrees of its vertical position.

(v) The gate arm shall begin to descend five seconds after the crossing warning system's signal lights begin to flash, and shall reach its horizontal position at least five seconds before the arrival of the Train. Caution shall be taken to eliminate any quick decent of the gate arm.

(vi) All gates shall remain in the down position as long as any Train or rail vehicle occupies any section of the highway-rail grade crossing Track circuit limits. Once there are no other Trains detected on the approach and the entire Train has completely exited the crossing limits, the lights shall stop flashing, the bells shall stop ringing, and the gates shall rise back to the upright position. Caution shall be taken to eliminate any quick ascents of the gate arm.

(c) Special Crossing Operations

(i) The Airport Emergency services access road at-grade railway crossing shall include special operational requirements as described in this Part 3. Project Co shall coordinate these operational requirements including design, procurement, installation, and testing of the crossing with the City and the OMCIAA:

(ii) No flashers and gates shall be provided at this location, however a standard crossing Train detection system shall be implemented to operate the sliding security gates and allow access through the at-grade crossing.

(iii) All operational and control components of the crossing shall be designed to operate as a “fail-safe” system, such that any failure of a specific component or function shall place the crossing in a fail-safe mode of operation. The fail-safe mode of operation shall not permit the sliding gates to open for the Emergency vehicles unless an override is conducted by the TOCC or BCC.

(iv) The sliding security gates shall be constantly monitored by the S&TCS to be detected as fully closed. Any time the gates are detected as opened, the TOCC and BCC shall stop all

approaching Trains by placing the approach signal to stop. There shall be two modes of requesting access to the grade crossing and for the sliding gates to be opened:

A. Emergency vehicles shall request activation through the YELP audio system. The TOCC and BCC shall be notified of the Emergency vehicle request activation. The S&TCS shall operate the sliding gates in the procedure noted herein.

B. Non-Emergency vehicles or vehicles without the YELP system, shall request activation through an authorized phone or radio call to the TOCC and BCC. The S&TCS shall operate the sliding gates in the procedure noted herein.

(v) Sliding Gate Opening Procedure

A. The S&TCS shall check to see if any Trains are already within the approach to the at-grade crossing. Trains shall be considered to be within the approach when the Train is past the point at which the Train can safely stop prior to the crossing, based on maximum approach speed and safe braking criteria.

B. If train is detected already within the approach, the sliding gates shall remain closed until the Train has passed the crossing. Once the Train is confirmed past the crossing and the stop signal for other Trains has been confirmed, the sliding gates shall open and the Emergency vehicles can proceed across the Tracks.

C. If no Trains are detected already within the approach, then any other approaching Trains are stopped prior to the crossing. Once the stop signal for Trains has been confirmed, the sliding gates shall open and the Emergency vehicle can proceed across the Tracks.

D. Upon official notification by radio or phone call to the TOCC and BCC that the request for the grade crossing access is no longer required, the S&TCS shall close the sliding gates. Once the sliding gates are detected and confirmed to be fully closed, the S&TCS shall release Trains stopped for the crossing. The first Train stopped prior to the crossing shall proceed at reduced speed until past the crossing. Afterwards all future Train movements shall be returned back to normal operations and associated speeds.

(d) Materials and Fabrication

(i) HGCWD equipment and materials, shall be designed, manufactured and installed in accordance with the latest version of Transport Canada Grade Crossing Standards, Manual of Uniform Traffic Devices for Canada (MUTCD-C) and AREMA, Communications and Signal Manual.

(ii) Project Co shall coordinate procurement and installation of the security fencing gate equipment required for the Airport Emergency access road crossing with the City and the OMCIAA.

ARTICLE 11 CORROSION CONTROL

11.1 Reference Documents

(a) Project Co shall provide corrosion control systems compliant with the criteria contained in this Article, and all standards, regulations, policies, Applicable Law, guidelines or practices applicable to the Project, including but not limited to each of the following Reference Documents:

(i) CAN/CSA A23.1/A23.2 Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete. Canadian Standards Association;

(ii) CAN/CSA A3001 Cementitious Materials for Use in Concrete;

(iii) CAN/CSA C22.1 Canadian Electrical Code Part I Safety Standard for Electrical Installations;

(iv) CAN/CSA C22.2 Canadian Electrical Code Part II General Requirements;

(v) CAN/CSA C22.3 No. 4-1974(R2004) Control of Electromechanical Corrosion of Underground Metallic Structures;

(vi) ACI SP-77 Sulphate Resistance of Concrete. American Concrete Institute;

(vii) ACI 201.2R Guide to Durable Concrete;

(viii) ACI 222R Protection of Metals in Concrete Against Corrosion;

(ix) ACI 318 Building Code Requirements for Structural Concrete and Commentary

(x) ACI 439 4R Report on Steel Reinforcement;

(xi) ASTM C 452 Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate. ASTM International;

(xii) ASTM C876 Standard Test Method of Half Potentials of Uncoated Reinforcing Steel in Concrete;

(xiii) ASTM C1152 Standard Test Method for Acid-Soluble Chloride in Mortar and Concrete;

(xiv) ASTM C1218 Standard Test Method for Water-Soluble Chloride in Mortar and Concrete;

(xv) ASTM D512 Standard Test Methods for Chloride Ion In Water;

(xvi) ASTM D-516 Standard Test Method for Sulfate Iron in Water;

(xvii) ASTM G-51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing;

(xviii) ASTM G-57 Standard Test Method for Field Measurement of Soil Resistivity using the Wenner Four-Electrode Method;

(xix) NACE SP0187 Design Considerations for Corrosion Control of Reinforcing Steel in Concrete;

(xx) NACE SP0290 Impressed Current Cathodic Protection of Reinforcing Steel in Atmospherically Exposed Concrete Structures;

(xxi) TCRP Report No. 155 Track Design Handbook for Light Rail Transit Chapter 8, Corrosion Control;

(xxii) Publication No. FHWA-NHI-00-044-2000 Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes. National Highway Institute, Federal Highway Administration, U.S. Department of Transportation;

(xxiii) NFPA-130 Standard for Fixed Guideway Transit and Passenger Rail Systems; National Fire Protective Association; and

(xxiv) Ontario Electrical Safety Code

11.2 Scope of Work

(a) This Article describes the Design Criteria for corrosion control.

(b) Project Co shall protect all new Structures and Facilities from corrosion, including the mitigation of stray current for the future electrification of the Expanded Trillium Line. Requirements for existing Structures shall be as per Clause 11.3 (x) (A) of this Part 3. As a minimum, the following new Structures shall be protected from stray current corrosion:

(i) Earl Armstrong Grade Separation;

(ii) Ecological Crossing;

(iii) Rail Bridge over Lester Road;

(iv) Rail Bridge over Hunt Club Road;

(v) Pedestrian Underpass North of Hunt Club Road;

(vi) Pedestrian Underpass North of South Keys Station;

(vii) Ellwood Diamond Grade Separation

(viii) Elevated Guideway to OMCIA Terminal;

(ix) Rail Bridge over Uplands Drive;

(x) Rail Bridge over Airport Parkway;

(xi) Bowesville Road Grade Separation; and

(xii) Limebank Road Grade Separation

11.3 General Requirements

(a) Summary

(i) The corrosion control criteria are separated into three categories: (1) stray current corrosion control, (2) soil corrosion control, and (3) atmospheric corrosion control. Project Co shall meet the following objectives for each of these categories in the order of priority shown below:

A. Obtain City approval where required;

B. Ensure continuity of Operations by eliminating corrosion-related failures;

C. Maximize Design Life of System facilities by avoiding premature failure due to corrosion;

D. Minimize annual Operation and Maintenance costs associated with material deterioration;

E. Minimize the deleterious effects to facilities belonging to others caused by stray earth currents from transit operations; and

F. Minimize cost of installed corrosion control elements.

(b) A project corrosion control and stray current mitigation coordination report shall be required by Project Co to address the corrosion control mitigation technologies to be employed, the coordination with the discipline designers, and the coordination with adjacent Utilities. Project Co shall produce and complete the Corrosion Control and Stray Current Mitigation Coordination Report no later than 120 days following Commercial Close.

(c) A NACE certified corrosion specialist or cathodic protection specialist with a certification in cathodic protection and 10 years of experience on transit systems with a similar level of complexity as this Project, shall serve as the responsible professional and shall approve and coordinate all elements of the corrosion mitigation measures for the Project.

(i) Corrosion control measures shall be coordinated by Project Co with the other relevant disciplines including Track, signaling and Train Control, communications, EMI/EMC, facilities, safety, civil, structural, geotechnical, electrical, and mechanical.

(ii) Corrosion control systems provided by Project Co for the Expanded Trillium Line shall be expandable without major reconfiguration, reconstruction, or duplication of equipment.

(d) Soil Corrosion Control

(i) Soil corrosion control requirements apply to systems or measures installed to mitigate corrosion caused by soil, rock and groundwater.

(ii) The designs required to mitigate soil corrosion control shall be implemented with the submission of the PFDD level of the first utility or structure design and completed within the Project duration for each identified Utility or Structure.

(iii) Project Co shall be responsible to obtain adequate soil/rock samples and ground water samples in areas of anticipated extensive below grade Construction at the reinforced concrete structures listed above in Section 11.2 b. The soil/rock samples shall be analyzed for resistivity (or conductivity), moisture content, pH, chloride and sulphate ion concentrations and for the presence of sulphides.

(iv) Project Co shall coordinate with the geotechnical engineering firm to obtain soil samples at a minimum of 10% of boring locations for chemical analysis testing to include moisture content, pH, concentration of chlorides, concentration of sulfates, presence of sulfides, and saturated resistivity to assess corrosivity.

(v) Project Co shall obtain in-situ soil resistivity measurements, in accordance with IEEE81, using the Wenner 4 electrode method at all structure locations listed above for comparison to the geotechnical sample chemical analysis.

(e) Stray Current Corrosion Control

(i) The minimum requirements apply to measures installed with fixed facilities.

(ii) Stray current corrosion control design shall be initiated within 30 days after Commercial Close and completed within the Project duration for each identified Utility or Structure.

(iii) A baseline stray current survey shall be performed for post-construction to establish proper installation of electrical continuity and test station installation.

(f) Atmospheric Corrosion Control

(i) Atmospheric corrosion control requirements apply to systems or measures installed to mitigate corrosion caused by local climatological conditions including condensation, temperature cycling, industrial and vehicle emissions, salt spray by motor vehicles and snow and air pollutants.

(ii) The requirements to be applied to all areas where atmospheric corrosion may be anticipated, are selection of materials of proven durability, protective coatings both barrier and sacrificial, sealants to prevent moisture intrusion and prohibiting the use of dissimilar metals.

(iii) Project Co shall ensure that the Bridge Design is not affected by the contamination from adjacent road de-icing or dust suppression, which includes but may not be limited to the following compounds:

A. Sodium Chloride (NaCl);

B. Calcium chloride (CaCl2);

C. Magnesium chloride (MgCl2);

D. Potassium chloride (KCl);

E. Brines used in road de-icing/salting; and

F. The salt portion of abrasive mixtures and additives commonly used in road salts (ferrocyanides).

(g) Coatings

(i) Coatings specified for corrosion control of buried metallic or concrete facilities shall satisfy the following requirements:

(ii) Minimum thickness as recommended for the specific system, but not less than 380 microns in accordance with NACE International SP0169 and the manufacturers recommendations;

(iii) A chemical or mechanical bond to the metal or concrete surface; pressure-sensitive systems shall not be permitted; non-bonding systems may be permitted in special instances, after review by the City;

(iv) Minimum 15-year performance record for the intended service;

(v) Mill application wherever possible, with field application of a compatible system; and,

(vi) Mechanical characteristics capable of withstanding installation abuse during handling and earth pressure after installation for the Design Life of the System.

(h) The design of cast-in-place concrete Structures shall be based on the following provisions with a minimum Design Life as outlined in Schedule 15-2, Part 1, Article 4 – Design and Construction:

(i) Use Type I cement. ASTM C452-75 and ACI Publication SP-77 Sulfate Resistance of Concrete shall be used as guidelines for evaluating the sulphate resistance of concrete mixes with non-standard cement types;

(ii) Water/cement ratio and air entrainment admixture in accordance with the structural requirements to establish a dense, low permeability concrete. Refer to applicable sections of ACI 201.2R Guide to Durable Concrete;

(iii) Maximum chloride concentration of 250 ppm in the total mix (mixing water, aggregate, cement, and admixtures). The concrete mix shall be such that the water soluble and acid soluble chloride concentrations, at the concrete/ reinforcing steel interface, do not exceed 0.15 and 0.2 percent by weight of cement, respectively, over the life of the Structure. Refer to applicable sections of ACI 222R Corrosion of Metals in Concrete;

(iv) Concrete cover over reinforcing steel shall comply with appropriate codes and provide a minimum of 50mm of cover on the soil/rock side of reinforcement when pouring within a form and a minimum of 75mm of cover when pouring directly against soil/rock; and

(v) The need for additional measures, as a result of localized special conditions, shall be determined on an individual basis.

(i) Support Pilings

(i) The following shall be applicable only to support piling systems which are to provide permanent support. Pilings used for temporary support do not require corrosion control provisions.

(ii) Designs based on the use of metallic supports exposed to the environment, such as H or soldier piles, shall include the use of a barrier coating. The need for special measures, such as cathodic protection, shall be determined on an individual basis, based on type of Structure, analysis of soil borings for corrosive characteristics and the degree of anticipated structural deterioration caused by corrosion.

(iii) Reinforced concrete piling, including fabrications with prestressed members, shall be designed to meet the following minimum requirements:

A. A minimum Design Life as outlined in Schedule 15-2, Part 1, Article 4 – Design and Construction.

B. Water/cement ratio and cement types in accordance with applicable codes.

C. Chloride restrictions for concrete with non-prestressed members shall be in accordance with applicable codes.

D. Chloride restrictions for concrete with prestressed members shall be in accordance with applicable codes, with exception that the concrete mix shall be such that the water soluble and acid soluble chloride concentrations, at the concrete/prestressed steel interface, do not exceed 0.06 and 0.08 percent by weight of cement, respectively, over the life of the Structure; and

E. A minimum of 75mm of concrete cover over the outermost reinforcing steel, including prestressing wires, if present.

(j) Concrete-filled steel cylinder columns, where the steel is an integral part of the load bearing characteristics of the support structure, shall be designed considering the need for special measures, such as increased cylinder wall thickness, external coating system, and/or cathodic protection. The design shall be determined on an individual basis, based on type of Structure, analysis of soil borings for corrosive characteristics and the degree of anticipated structural deterioration caused by corrosion.

(k) Stray Current Corrosion Control

(i) For Tunnel Structures

A. Reinforcing steel in underground trackway structure inverts shall be made electrically continuous. Minimum requirements for the reinforcing steel from the top of rail down shall include the following:

B. Welding of all longitudinal lap splices in the top layer of first pour reinforcing steel.

C. Welding of all longitudinal members to a transverse (collector) member at intervals not exceeding 152 meters and at electrical (physical) breaks in the longitudinal reinforcing steel, such as at expansion joints.

D. Electrical interconnection of first pour reinforcing steel to second pour reinforcing steel at all collector bars through use of insulated copper cables or steel straps. Longitudinal steel in the second pour shall be made electrically continuous by tack welding all lap splices.

E. Test facilities shall be installed at each end of the structure and at every collector bar. Facilities shall consist of insulated copper wires, conduits, and enclosures terminated at an accessible location.

F. Precast segmented concrete ring tunnel construction shall meet the requirements in Section 3.l and the following or be reviewed on an individual basis to determine alternative criteria when they cannot be practically modified to meet the provisions specified below:

G. Embedded steel reinforcing members shall be constructed without special provisions for establishing electrical continuity.

H. Connecting hardware between adjacent rings and ring segments shall be constructed without provisions for establishing electrical continuity between segments.

I. Any metallic components which will be exposed to the soils/groundwaters shall be coated with a fluidized bed epoxy resin system or coal tar epoxy system.

J. Application of a coal tar epoxy coating system to the external surfaces of each precast panel.

K. Steel liner tunnel construction shall be reviewed on an individual basis to determine the need for special measures, such as increased liner thickness, external coating system, and/or cathodic protection.

(ii) For Elevated Guideway and Bridge Structures using column and bearing assemblies, tie and ballast

A. This section applies to Elevated Guideway and Bridges that use a column and bearing assembly, but with tie and ballast Track construction. Welding of reinforcing steel in the deck is not required for this configuration.

B. A waterproof, electrically insulating membrane (with protection board on top of the membrane) shall be provided over the entire surface of the deck that shall be in contact with the ballast. The membrane system shall have a minimum volume resistivity of 1×10^{12} ohm-cm.

C. Electrical isolation of reinforcing steel shall be provided in deck/girders from columns, abutments, and other grounded elements. Isolation can be established through the use of insulating elastomeric bearing pads, dielectric sleeves and

washers for anchor bolts and dielectric coatings on selected components. Use of bearings shall take into account the appropriate electrical grounding to ensure that stray current does not pass through the bearing race.

(iii) For Elevated Guideway or Bridge Structures using column and bearing assemblies, direct fixation.

A. This section applies to Elevated Guideway and Bridges that use a column and bearing assembly that can be electrically insulated from deck or girder reinforcing steel and shall have insulated Trackwork Construction.

B. Provide a fusion bonded epoxy coating to all reinforcing steel and provide a wire mesh current collector mat or provide electrical continuity of top layer reinforcing steel in the deck/girder by welding all longitudinal lap splices.

C. If the top layer of reinforcing steel is made electrically continuous, electrically interconnect all top layer longitudinal reinforcing steel by welding to transverse collector bars installed at breaks in longitudinal reinforcing steel, such as at expansion joints, hinges, and at abutments. Connect collector bars installed on each side of a break with a minimum of two cables.

D. If the top layer of reinforcing steel is made electrically continuous, provide additional transverse collector bars at intermediate locations to maintain a maximum spacing of 150m between collector bars.

E. Provide a ground electrode system at each end of the Structure and at intermediate locations to maintain a maximum spacing between ground electrode systems of 457m. The number, location, and earth resistance of the ground electrode system shall be determined on an individual structure basis.

F. Provide test facilities at each end of the Structure and at intermediate locations to maintain a maximum spacing of 152m between test points. The test facilities shall house test wires from the collector bars and ground electrode system, if present.

G. Provide electrical isolation of reinforcing steel in deck/girders from columns, abutments, and other grounded elements. Isolation can be established through the use of insulating elastomeric bearing pads, dielectric sleeves and washers for anchor bolts and dielectric coatings on selected components.

(iv) For Elevated Guideway and Bridge Structures using bents and girders, tie and ballast

A. This section applies to Elevated Guideway and Bridge Structures that use bent type supports with reinforcing steel extending into the deck/girders, but with tie and ballast Track construction.

B. Provide electrical continuity of the column/bent steel by fillet welding appropriate reinforcing to at least two vertical column bars. Make these connections to each of the two vertical bars at the top and bottom of the

column/bent. The use of sacrificial reinforcing steel bars shall be considered to eliminate degradation of structural steel bars by welding.

C. Provide electrical continuity of the deck longitudinal bars by fillet welding all lap splices or fillet welding sacrificial reinforcing steel bars and wire tying the structural bars together and to the welded reinforcing steel.

D. Electrically interconnect column/bent steel to deck/girder steel by fillet welding at least two vertical column bars to collector bars installed at bents or fillet welding sacrificial reinforcing steel bars between column/bent and deck.

E. Electrically interconnect column/bent steel to footing steel when column/bent steel penetrates the footing. Fillet weld at least two vertical column/bent bars to footing reinforcing steel.

F. Electrically interconnect pre or post tensioned cables to continuous longitudinal reinforcing steel by fillet welding a cable between each anchor plate and the longitudinal reinforcing steel.

G. Provide test facilities at each hinge and expansion joint and at every other column/bent, starting with the first column/bent from an abutment. Test facilities at hinges and expansion joints shall house bonding cables from adjacent collector bars on each side of the hinge/joint.

H. Facilities at columns/bents shall house two wires from vertical column/bent steel and from the collector bar at the top of the bent.

I. Provide a waterproof, electrically insulating membrane (with protection board on top of the membrane) over the entire surface of the deck that shall be in contact with the ballast. The membrane system shall have a minimum volume resistivity of 1×10^{12} ohm-cm.

(v) For Elevated Guideway and Bridges using bents and girders, direct fixation.

A. This section applies to Elevated Guideway and Bridge Structures that use bent type supports with reinforcing steel extending into the deck/girders.

B. Provide electrical continuity of top layer reinforcing steel in the deck/girder by welding all longitudinal lap splices.

C. Electrically interconnect all top layer longitudinal reinforcing steel by welding to transverse collector bars installed at bents and on each side of breaks in longitudinal reinforcing steel, such as at expansion joints, hinges and at abutments (deck side only). Connect collector bars shall be installed on each side of a break with a minimum of two cables.

D. Provide electrical continuity of all column/bent steel by welding appropriate reinforcing to at least two vertical column bars. Make these connections to each of the two vertical bars at the top and bottom of the column/bent.

E. Electrically interconnect column/bent steel to deck/girder steel by welding at least two vertical column bars to collector bars installed at bents.

F. Electrically interconnect column/bent steel to footing steel when column/bent steel penetrates the footing. Weld at least two vertical column/bent bars to footing reinforcing steel.

G. Electrically interconnect pre or post tensioned cables to continuous longitudinal reinforcing steel by welding a cable between each anchor plate and the longitudinal reinforcing steel.

H. Provide test facilities at each hinge and expansion joint and at every other column/bent, starting with the first column/bent from an abutment. Test facilities at hinges and expansion joints shall house bonding cables from adjacent collector bars on each side of the hinge/joint. Facilities at columns/bents shall house two wires from vertical column/bent steel and from the collector bar at the top of the bent.

I. If electrical continuity of the reinforcing steel is not provided, other methods of stray current control may be employed such as the use of epoxy coated reinforcing steel and stray current collector mats with test facilities.

(vi) For Elevated Guideway and Bridge Structures using concrete deck/exposed steel, tie and ballast

A. This section applies to Elevated Guideway and Bridge Structures that use a reinforced concrete deck with exposed steel superstructure and have insulated Trackwork with tie and ballast Track construction. Welding of reinforcing steel in the deck is not required for this configuration.

B. Provide a waterproof, electrically insulating membrane (with protection board on top of the membrane) over the entire surface of the deck that shall be in contact with the ballast. The membrane system shall have a minimum volume resistivity of 1×10^{12} ohm-cm.

C. Provide electrical isolation of reinforcing steel in the deck and superstructure steel from columns, abutments and other grounded elements. Isolation can be established through the use of insulating elastomeric bearing pads, dielectric sleeves and washers for anchor bolts and dielectric coatings on selected components.

D. If electrical isolation of reinforcing steel in the deck and superstructure steel from columns, abutments, and other grounded elements cannot be obtained, then electrical continuity of metallic components within these latter elements shall be established by appropriate welding and bonding procedures.

(vii) For Elevated Guideway and Bridges using concrete deck/exposed steel, direct fixation.

A. This section applies to Elevated Guideway and Bridge Structures that use a reinforced concrete deck with exposed steel superstructure and shall have

insulated Trackwork construction. This type of construction precludes the electrical insulation of deck reinforcing steel from superstructure steel.

B. Provide electrical continuity of top layer reinforcing steel in the deck/girder by welding all longitudinal lap splices.

C. Electrically interconnect all top layer longitudinal reinforcing steel by welding to transverse collector bars installed at breaks in longitudinal reinforcing steel, such as at expansion joints, hinges, and abutments. Connect collector bars installed on each side of a break with a minimum of two cables.

D. Provide additional transverse collector bars at intermediate locations to maintain a maximum spacing of 150m between collector bars.

E. If the total structure length exceeds 3km provide a ground electrode system at each end of the structure and at intermediate locations to maintain a maximum spacing between ground electrode systems of 457m. The number, location and earth resistance of the ground electrode system shall be determined on an individual structure basis.

F. Provide test facilities at each end of the structure and at intermediate locations to maintain a maximum spacing of 150m between test points. The facilities shall house test wires from the collector bars and ground electrode system, if present.

G. Provide electrical isolation of reinforcing steel in the deck and superstructure steel from columns, abutments and other grounded elements. Isolation can be established through the use of insulating elastomeric bearing pads, dielectric sleeves and washers for anchor bolts and dielectric coatings on selected components.

H. If electrical isolation of reinforcing steel in the deck and superstructure steel from columns, abutments and other grounded elements cannot be obtained, then electrical continuity of metallic components within these later elements shall be established by appropriate welding and bonding procedures.

I. If electrical continuity of the reinforcing steel is not provided, other methods of stray current control may be employed such as the use of epoxy coated reinforcing steel and stray current collector mats with test facilities.

(viii) Retaining Walls

A. The longitudinal bar overlaps in both faces of the wall, including the top and bottom bars in the footing, shall be tack welded to insure electrical continuity. Longitudinal bars in the footing shall be made electrically continuous to the longitudinal bars of the walls. Collector bars, bonding cables and test facilities shall be installed.

(ix) Conduit shall be non-metallic, unless metallic facilities are required for specific engineering purposes or by code.

(x) Existing Bridge Structures

A. Stray current corrosion control for existing Bridge Structures shall be addressed at the time of electrification of the Expanded Trillium Line and is not included in this Project Scope.

(xi) Corrosion control coatings

A. Coatings shall have established performance records for the intended service and be compatible with the base metal to which they are applied.

B. Coatings shall be able to demonstrate satisfactory gloss retention, color retention, and resistance to chalking over their minimum life expectancies.

C. Coatings shall have minimum life expectancies, defined as the time prior to major Maintenance or reapplication, as determined by the manufacturer's standard.

(xii) Metallic-Sacrificial Coatings

A. Acceptable coatings for carbon and alloy steels for use in crawlspaces, vaults, or above grade shall be as follows:

B. Zinc (hot-dip galvanizing or flame sprayed);

C. Aluminum (hot-dip galvanizing or flame sprayed);

D. Aluminum-zinc;

E. Cadmium and electroplated zinc (sheltered areas only); and

F. Inorganic zinc (as a primer).

(xiii) Organic Coatings

A. Organic coating systems shall consist of a wash primer (for galvanized and aluminum substrates only), a primer, intermediate coat(s), and a finish coat. Acceptable organic coatings, for exposure to the atmosphere, shall be as follows:

B. Aliphatic polyurethanes;

C. Vinyl copolymers;

D. Fusion-bonded epoxy polyesters, polyethylenes, and nylons;

E. Acrylics, where not exposed to direct sunlight;

F. Alkyds, where not exposed to direct sunlight; and

G. Epoxy as a primer where exposed to the atmosphere or as the complete system where sheltered from sunlight.

(xiv) Conversion Coatings

A. Conversion coatings, such as phosphate and chromate coatings, shall be used as pre-treatments only for further application of organic coatings.

B. Ceramic-Metallic Coatings (Cermets): this hybrid-type coating system shall be acceptable for use on metal panels and fastening hardware.

(xv) Sealants

A. Crevices shall be sealed with a polysulfide, polyurethane or silicone sealant.

(l) Barrier Coating System

(i) One of the following barrier coating systems shall be used where corrosion protection is required but appearance is not a primary concern:

A. Near white blast surface according to NACE NO. 2/SSPC-SP 10;

B. Commercial blast surface according to NACE NO. 3/SSPC-SP 6;

C. Near white blast surface according to NACE NO. 3/SSPC-SP 10; or

D. Apply the coatings according to manufacturer's specifications.

E. Use one of the following barrier coating systems where corrosion protection and good appearance is needed.

(ii) One of the following barrier coating systems shall be used where corrosion protection is required and appearance is a primary concern:

A. Near white blast surface according to NACE NO. 2/SSPC-SP 10;

B. Near white blast surface according to NACE NO. 2/SSPC-SP 10;

C. Commercial blast surface according to NACE NO. 3/SSPC-SP 6;

D. Commercial blast surface according to NACE NO. 3/SSPC-SP 6;or

E. Apply the coating according to manufacturer's specifications.

ARTICLE 12 CELLULAR SYSTEM

(a) Cellular System Infrastructure

(i) Project Co shall provide all cabling (coaxial, radiating, fiber, network, power) and all associated infrastructure to enable cellular coverage in the Dow's Lake Tunnel. The cabling and associated infrastructure shall be ready to enable the City to install and Commission radio repeater system in the Tunnel and the pump house.

(ii) The City shall develop the performance specifications and design criteria for the cellular system with its service provider in order to refine final design requirements for coverage in the tunnel. The City shall provide all the active repeater equipment for the coverage.

(iii) Project Co shall incorporate into their design (design reviews, drawings, system integration) the radiating cable (and accessories) and ensure that all electrical, mechanical, physical interfaces are reviewed and approved.

(iv) Project Co shall install and test a minimum 3/4in radiating cable in Dows Lake Tunnel at a height adjacent or near to the vehicle passenger windows. The radiating cable, including mounting hardware shall be provided Project Co.

(v) Project Co shall provide a 1/2 in coaxial feeder cable from the Tunnel to the pump house and provided a dedicated rack space in the pump house.

(vi) Project Co shall provide fiber connections and power connections in the tunnel to support repeater units, as required, to be installed by the City. Project Co shall approve the mounting detail for the repeater units in the Tunnel.

(vii) Project Co shall provide appropriate number of conduits (for fibre and coax) from the Tunnel to the pump house, where the cellular base station will be located.

(viii) Project Co shall provide the cabling and infrastructure to comply with NFPA 130 requirements.