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SCHEDULE 15-2
DESIGN AND CONSTRUCTION REQUIREMENTS

PART 3
SYSTEMS

ARTICLE 1 INTRODUCTION

1.1 General Overview

(a) This Part 3 is written using design standards typical of North America unless otherwise specified.

(b) DB Co shall declare and apply the selected standards consistently throughout the full range of the Systems designs.

(i) DB 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) DB Co shall ensure that each system design includes the ability to support the extension and system expandability.

(d) DB Co shall ensure that equipment from selected vendors is implemented consistently from the same vendors throughout the Confederation Line Extension.

(e) This section provides a description of the elements contained within the general heading of systems. Systems include the following functional elements:

(i) Traction Power System;

(ii) OCS;

(iii) Revenue Vehicles; the City to procure all Revenue Vehicles required for the extension;

(iv) Maintenance Vehicles; the City to procure all Maintenance Vehicles required for the extension ;

(v) Communications

(f) DB Co shall develop the performance specifications, produce the design, supply and test the Signalling and Train Control System.

(g) DB Co shall design, procure, install, test and commission the S&TC infrastructure items required to support the overall S&TCS implementation. The S&TC system will be an

extension of the Existing Confederation Line system and as such shall be consistent with the existing system in design approach, architecture and technology. The S&TC shall, as far as possible, deploy the identical functions, features and equipment. Changes to the existing design shall be limited to those specifically required for the extensions to the guideway and associated facilities, including any new hazards or requirements

(h) DB Co shall produce the specifications, develop the interfaces and manage the integration testing and Commissioning of the communications Systems listed below.

(i) CTS;

(ii) PA/PIDS system ;

(iii) CCTV System

(iv) IAC System

(v) Telephone and Intercom System

(vi) SCADA System

(vii) Voice Radio Communications (including BTS hotel, conduits along the alignment, fibre along the alignment, conduits at Stations, fibre & coax cable at Stations, leaky coaxial cable in Tunnel and equipment in communications equipment rooms)

1.2 Systems Element Summary

(a) TPSS – detailed in Article 13 – Traction Power System, of this Part 3.

(i) DB Co shall design the Traction Power System that supplies a dual end fed DC voltage into the OCS.

(ii) DB Co shall ensure that the TPSS be placed alongside the Guideway at locations dictated by the Train performance criteria, maintenance consideration, available property and availability of utility power connection. Refer to Schedule 15-2, Part 4, Article 2 – Architectural Design Criteria, for TPSS location restrictions.

(iii) DB Co shall ensure that the TPSS be modular in design. Equipment within the TPSS shall be easily accessible for performing maintenance.

(iv) DB Co shall ensure that the design and positioning of the TPSS take into account any environmental and aesthetic constraints resulting from their chosen locations.

(v) DB Co shall ensure that The TPSS conform to EMI & EMC requirements set forth in Article 11 – EMI/EMC of this Part 3.

(vi) DB Co shall minimize stray current through compliance with the corrosion requirements set forth in Article 12 – Corrosion Control, of this Part 3.

(vii) DB Co shall ensure that the Utility feed to TPSS be obtained at the utility transmission voltage level.

(viii) DB Co shall ensure that the System include built-in redundancy to maintain normal revenue Train operations with a single point of failure, sub-transmission systems shall be designed with two cable circuits, each capable of carrying the full-load current.

(ix) DB Co shall ensure that a computerized analysis be performed to develop an optimum Traction Power System configuration defining TPSS locations, equipment ratings and cable sizes. DB Co shall ensure that the design meet specified systems performance under normal and degraded operation conditions. DB Co shall produce and submit the report to the City for review and comment.

(x) DB Co shall ensure that the System design take into consideration personnel and equipment safety requirements, proper clearances, and required lockout functions, controls, warning alarms, and other equipment operating functions.

(b) OCS – detailed in Article 14 – Overhead Contact System, of this Part 3.

(i) DB Co shall provide an OCS to supply Traction Power to Revenue Vehicles and Maintenance Vehicles throughout the Confederation Line.

A. The OCS shall consist of the messenger and contact wires which are supported from poles, portals, cross-spans, bridge supports and tunnel supports as required. The contact wire shall be installed at constant height with respect to the Track and shall be suspended from the messenger wire by means of hangers.

B. The OCS design shall include the selection of support structure spacing along tangent and curved Track, and the messenger and contact conductor tensions. The design shall optimise the selection of these parameters to achieve the most complete and functional design while the pantograph does not leave the contact wire under the most onerous conditions of operation.

C. The OCS shall be designed to have a low visual impact, high reliability, provide safe operation and maintenance and operate within the environment installed.

(c) Signalling and Train Control System – detailed in Article 10 – Signalling and Train Control System, of this Part 3.

(i) DB Co shall ensure that the S&TCS be based on a proven ATC architecture supporting a wide range of operating environments.

(ii) DB Co shall ensure that the S&TCS be designed to maximize the safety, reliability, operational flexibility and fault tolerance.

(iii) DB Co shall ensure that the S&TCS support operational performance and service plan as described in Schedule 15-2, Part 1, Article 3 – Operational Performance Requirements.

(d) DB Co shall provide all field cables. DB Co shall provide all civil infrastructure (conduits duct banks, inserts, etc.) and installation required to support the S&TCS design. DB Co shall terminate and test all cabling.

(e) EMC/EMI – detailed in Article 11 – EMI/EMC, of this Part 3.

(i) All supplied equipment and systems within the DB Co System Infrastructure shall meet the EMC/EMI requirements set out in Article 11 – EMI/EMC, of this Part 3.

(f) DB Co shall ensure that all systems elements be designed, implemented and configured as required to support the future implementation of PEDs at all Underground Stations.

(g) DB Co shall produce and provide a register to the City with all Confederation Line Extension Project asset data for incorporation into the CMMS developed as part of the Existing Confederation Line. DB Co shall provide the CMMS data for the East Extension and the West Extension six months prior to Substantial Completion.

(h) The City will provide the prescribed format to DB Co for development and incorporation of the asset data.

(i) Radio Systems

(i) In Article 2 – Communications Transmission Systems, of this Part 3, the term "train to wayside wireless" includes all three of the train to wayside radio systems being constructed as part of the Confederation Line West Extension and Confederation Line East Extension and described below.

(ii) A Voice Data Radio (P25) system is being provided for Project wide communications and ESP use. The scope of work with regards to the locations of DB Co responsible items has been included in Article 5 – Voice/Data Radio System, of this Part 3.

(iii) In Clause 8.8 (a) (vi.), of this Part 3, the term "train to wayside" is being used to include the Voice/Data (P25) Radio System and the HSDR system.

(iv) A wireless radio system is being included as part of the CBTC system, as outlined in Article 10 – Signalling and Train Control System. The location of all radio system components included as part of this system is included as part of the CBTC system design and installation.

(v) A High Speed Data Radio System is being provided for data communications between the vehicles and the wayside infrastructure, as outlined in Article 17 – high Speed Data Radio System, of this Part 3. The actual locations of the wayside devices shall be determined during the design phase.

1.3 Systems Engineering Principles

(a) All the Systems described in this Part 3 shall be designed and implemented following the Systems Engineering principles (as set out in ISO/IEC 15288 and as described in Schedule 15-2, Part 1 – General Requirements) and the S&TCS will be consistent with **[REDACTED]** as described in the **[REDACTED]**. The Systems Engineering and Systems Integration Management processes shall ensure that systems expanded, or provided, by DB Co will interface with Existing Confederation Line systems to create a fully integrated expanded system.

(b) This systems engineering approach shall be applicable for all levels in the system hierarchy and for all disciplines.

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

(d) DB Co shall:

(i) Implement a SEMP that outlines the engineering organization, the facilities needed and where they will 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 design phases and the requirements, processes and steps taken to successfully complete each; how technical issues will be resolved; description of how external interfaces will be developed and managed; implementation planning including training of users; and a description of how production will be managed; the SEMP shall include the plan & process for requirements review and approval as well as how issues will be resolved between the City and DB Co.

(ii) DB Co shall develop and implement a comprehensive Grounding and Bonding Plan that outlines how all elements (above ground and underground Stations, Track, TPSS, OCS, bridges and overhead structures, etc.) of the System are grounded and bonded. The plan shall describe how the elements of the Confederation Line shall be grounded and bonded to ensure an electrically safe design and to prevent adverse stray current conditions that could impact the overall operational state of the System and surrounding non-system elements. The plan shall be submitted to the City for review and comment.

1.4 RAM Targets

(a) DB Co shall provide equipment/subsystem equipment to meet the following RAM targets:

(i) General

A. For the requirements pertaining to this Clause 1.4, a re-use of equipment from the Existing Confederation Line will be deemed compliant. DB Co shall provide the respective information for reliability and MTTR for the intended re-use equipment from the Existing Confederation Line. DB Co shall demonstrate to the City that the equipment to be re-used from the Existing Confederation Line for the Confederation Line East Extension and Confederation Line West Extension is from the same supplier, with the same model number, and has been accepted for use on the Existing Confederation Line. In the case that equipment cannot be re-used from the Existing Confederation Line due to actual or planned obsolescence, DB Co shall be entitled to use a more recent and equivalent model recommended by the equipment supplier, provided it meets or exceeds the specifications of the original equipment and is compatible with the existing interface.

B. MTTR – For the purpose of the prescribed requirements in this Clause 1.4, the design MTTR shall be used for analysis and demonstrated at the First Article Inspection or at a site demonstration, if a First Article Inspection is not required.

C. All workstations (excluding keyboard, monitor, mouse) shall have a minimum MTBF of 50,000 hours.

i. MTTR < 0.5 hours.

D. All servers shall have a minimum MTBF of 50,000 hours.

i. MTTR < 0.5 hours.

E. Network switches shall have an MTBF of 500,000 hours.

i. MTTR < 0.5 hours.

F. Station Controllers for emergency sound system/CCTV/PIDS (as applicable) shall have a minimum MTBF of 120,000 hours.

i. MTTR < 1.0 hours.

G. Elevators shall have an Availability of > 97%.

i. Availability is calculated as total operational time (in hours) divided by the total number of downtime (in hours) plus total operational time (in hours).

ii. A% = total operational time / (total operational time + total downtime).

iii. MTTR < 4 hours.

H. Escalators shall have an Availability of > 97%.

i. Availability is calculated as total operational time (in hours) divided by the total number of downtime (in hours) plus total operational time (in hours).

ii. A% = total operational time / (total operational time + total downtime).

iii. MTTR < 4 hours.

I. Switch Heater (gas for yard and electric for mainline):

i. Each switch heater shall have an MTBF of 2000 operational hours with an MTTR of 1 hour.

(ii) Communications Equipment

A. CCTV:

i. Each camera shall have a minimum MTBF of 120,000 hours.

ii. MTTR < 0.5 hours.

B. NVR shall have a minimum MTBF of 50,000 hours.

i. MTTR of 0.5 hours.

C. PA / PIDS:

i. Each speaker shall have a minimum MTBF of 120,000 hours.

ii. Each display shall have a minimum MTBF of 50,000 hours.

iii. MTTR < 0.5 hours.

D. ETELs and FTELs:

i. Each outdoor phone shall have a minimum MTBF of 50,000 hours.

ii. Each indoor phone shall have a minimum MTBF of 130,000 hours.

iii. Each intercom shall have a minimum MTBF of 130,000 hours

iv. MTTR < 0.5 hours

(iii) S&TCS:

A. Wayside Radio Unit Assembly:

i. Includes radio, antenna and peripherals and shall have an MTBF greater than 50,000 hours.

ii. MTTR < 0.5 hours.

B. Zone Controllers:

i. Each single checked redundant (2oo2) zone controller shall achieve an MTBF greater than 16,000 hours.

ii. MTBSAF of 50,000 hours.

iii. MTTR < 0.5 hours.

C. Switch Machine:

i. Each switch machine shall achieve an MTBF of 200,000 hours.

ii. MTTR < 2 hours.

D. Transponder Tags:

i. Each tag shall achieve an MTBF of 3,000,000 hours.

ii. MTTR < 0.5 hours.

(iv) Traction Power:

A. TPSS:

i. Switchgear shall have an MTBF of 20,000 hours, MTBSAF of 50,000 hours and an MTTR of < 4 hours.

ii. Transformer/Rectifier Unit MTBF of 20,000 hours, MTBSAF of more than 250,000 hours and an MTTR of < 4 hours.

B. UPS Equipment provided for applicable system power supply back-up:

i. UPS assembly shall have an MTBF of 25,000 hours, MTBSAF of 250,000 hours and an MTTR of 0.5 hours.

C. OCS:

i. DB Co shall provide an MTBF and MTBSAF analysis for the Overhead Contact System (inclusive of poles, mounts, messenger and contact wire, tensioners, mounts, etc.) to demonstrate that the design meets or exceeds the performance of the Existing Confederation Line.

ii. MTTR < 8 hours.

ARTICLE 2 COMMUNICATIONS TRANSMISSION SYSTEM

2.1 General Requirements

(a) The CTS shall serve as communications backbone to provide data, voice and video communications between the TOCC, BCC, Moodie LMSF, Belfast MSF, the Stations and wayside facilities.

(b) DB Co shall ensure that the CTS design provide hi-speed fibre optic communications transmission for the various Confederation East/West communications subsystems, including, CCTV, PA, PIDS, telephone & intercom, IAC, fare collection, FLS, radio, Train to wayside wireless and SCADA systems. Train Control data for the Confederation Line communication shall be on a separate wireless network, see Article 10 – Signaling and Train Control System, of this Part 3, for details. The CTS design shall also include any fibre required for the voice radio system and the cellular network in the Tunnels and for any parts of the Works.

(c) DB Co shall ensure that the CTS design for Confederation Line shall include integration of the proposed CTS with the existing CTS.

(d) DB Co shall ensure that the CTS design be capable of providing automatic protection switching for link recovery in case of failure.

(e) DB Co shall ensure that if a complete fibre optic cable break should occur, the system shall perform a loop back operation, isolating the fault, and maintaining communications with all equipment that remains connected to the network. Should a major node failure occur, the network shall automatically create and startup a new configuration without the node.

(f) DB Co shall ensure that all restoration times shall be limited to a maximum of 50 milliseconds.

(g) DB Co shall provide the system of ductwork, conduits, pull boxes, man holes and fibre optic splice enclosures required for the CTS extension. DB Co shall ensure that manholes can be secured and allow access only to authorized persons.

(h) DB Co shall ensure the system of ductwork, conduits, pull boxes and manholes to be provided along the mainline to transport the CTS cables is physically separated by providing a system along both sides of the alignment that connects with the Existing Confederation Line infrastructure.

(i) DB Co shall design, manage the interfaces, supply and install, the CTS civil infrastructure both outside and inside the Stations including conduits, pits, foundations, buildings and cabinets.

(j) DB Co shall provide rack space at underground Stations for cellular service equipment.

(k) The mainline CTS system of ductwork and conduits shall include manholes strategically located throughout the alignment to facilitate connection of fibre cables from the Stations to the TPSS.

(l) DB Co shall design, manage the systems interfaces, procure, install, conduct PICO and SAT of the CTS facility to facility fibre optic cable.

(m) DB Co shall terminate fibre runs into the fibre entrance cabinets in Station communications rooms and from there to CTS rack patch panels.

(n) DB Co shall design, manage the systems interfaces, procure, install, conduct PICO and SAT of the CTS stations to wayside fibre cable.

(o) DB Co shall design, manage the interfaces, supply (including Pre-delivery Test), install, terminate, conduct PICO and SAT on the fibre runs from fibre entrance cabinets in Station communications rooms to any CTS wayside patch panels and from FECs to CTS rack patch panels.

(p) DB Co shall design, supply (including Pre-delivery Test), install, conduct PICO, SAT and commissioning of all CTS cable terminations.

2.2 Operational Requirements

(a) The existing TOCC, located at 875 Belfast Road, Ottawa, Ontario (referred to as 875 Belfast herein), includes all of the systems and subsystems necessary to provide the command, control and monitoring necessary for the delivery of the services. The existing communications elements managing these functions are located either in the Belfast MSF communications room or in TOCC.

(b) The City will purchase all required server licenses, data storage, and any other system expansion equipment required to connect the new CTS field equipment to the equipment located in the Belfast MSF.

(c) The City will integrate, test, and commission all OLRT Stage 2 communications equipment at the TOCC and BCC head-ends.

2.3 CTS Core Network Switch/Router Requirements

(a) The core network switches/routers 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.

(b) 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 inch 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 single mode or multimode 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 shall 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.

(c) DB Co shall design the new extension's CTS to include a WAN component and LAN component. The LAN shall provide local network traffic switching and aggregation of the network traffic at each Station, TPSS, and the Moodie LMSF, for transport over the WAN.

(d) The City shall configure the existing network hardware to accept the expanded CTS. The City shall configure the existing network software to accept the expanded CTS.

(e) The City shall update the existing head-end management platform and verify the CTS connectivity from the field equipment to the TOCC, BCC, MYCC and BYCC. This is the network equipment (switches, routers, etc.) that make up the active CTS equipment along the main line.

2.4 Performance Requirements

(a) DB Co shall ensure that the CTS expansion for the Project shall include fibre optic cables, network transmission equipment, and other equipment necessary for a complete communications network.

(b) DB Co shall provide, as a minimum, cable sizes and quantity of strands that match what has been installed on Stage 1. DB Co shall also provide a minimum of 50% spare fibre/copper cable and port capacity for future expansion of the CTS.

(c) DB Co shall design the network expansion to be 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.

(d) The City shall be responsible for protecting and maintaining the existing optical fibre feeds on the Confederation Line until Substantial Completion. The WAN shall be configured in a path-diverse topology in order to minimize single point failure. WAN network equipment shall support fast (sub-50 milliseconds) automatic network recovery (self-healing) in the event of a network link failure.

(e) DB Co shall ensure all CTS equipment include redundant power supplies. In the event of a power outage, the equipment shall remain operational for a minimum of 24 hours through the use of uninterruptible power supplies, generators, and/or other backup power equipment.

(f) DB Co shall ensure that all new equipment be compatible with the existing NMS and shall be managed and monitored by the NMS.

(g) The City shall be responsible for the integration into the TOCC & BCC. The existing NMS shall automatically discover all new network devices and network connections within the CTS. In the event of a network failure, the NMS shall perform root cause analysis to pin-point location of failure.

(h) The CTS shall be designed such that these component failures are minimized by redundancy. The availability of the Confederation Line system (i.e. availability of all system hardware, cabling) equipment shall be greater than 99.9%.

2.5 City Traffic Operations Communications Infrastructure

(a) DB Co shall supply and install a twenty-four strand single-mode fibre optic cable for dedicated use by the City along the whole length of the Confederation Line alignment, including 17 break-out points (with the breakout point at Carling (Lincoln Fields) serving as the junction point for the lines to Moodie and Baseline) and manholes throughout the alignment; seven of these shall be on the East extension, and ten shall be on the West extension.

(b) DB Co shall supply and install fibre cable rated for the environmental considerations and shall meet all regulatory requirements regarding installation along a transit corridor.

(c) DB Co shall ensure at each break-out point, a concrete encased 100mm duct shall deviate from the mainline and connect to breakout manholes. The fibre cable shall run from the main duct to the manhole and return to the main duct. The location of manholes will be determined based on consultation with the City, but shall be located outside of the Confederation Line ROW, and shall be as close as practicable to the locations proposed in Table 3-2.1. The manholes shall be designed to meet current City specifications for traffic maintenance holes. The manholes shall be located at street level and provide sufficient clearance from obstacles to allow City staff to access the manhole.

Table 3-2.1: Proposed Breakout Points for Traffic Operations Fibre

Confederation Line Breakout Points	**Lat**	**Long**	**Description**
Confederation Line East Extension			

Blair Rd	45.433117	-75.607537	Southwest corner of the 174 WB Off ramp & Blair Rd
Montreal Road	45.45106	-75.584471	Southeast corner of the 174 WB Off ramp & Montreal Rd (North side of the Jersey Barrier)
Jeanne D'Arc	45.468264	-75.545546	Northwest Corner of the 174 EB On/Off ramp & Jeanne d'Arc
Orleans Blvd	45.47328	-75.534117	Southwest corner of the 174 & Orleans Blvd Overpass
Place D'Orleans	45.479667	-75.517476	Southeast corner of the 174 & Champlain Overpass. Northeast corner of the Champlain & Place d'Orleans Drive Intersection
Tenth Line	45.486967	-75.503442	Southwest Corner of the Tenth Line & 174 WB Off ramp Intersection
Trim Rd	45.494774	-75.482003	Southwest Corner of the 174 & Trim Intersection
Confederation Line West Extension			
Tunny's Pasture	45.404002	-75.734266	Northeast Corner of the Scott & Holland Intersection (Manhole existing as part of Stage 1 LRT)
Island Park	45.399004	-75.745968	Southeast corner of the Confederation line and Island Park. Northeast corner of the Island Park & Scott Intersection
Scott Street	45.394975	-75.755324	Northeast corner of the Scott & Churchill intersection
Woodroffe N	45.377793	-75.774967	North corner of the Richmond & Woodroffe Ave N Intersection
Carling Rd	45.364693	-75.783757	Northeast Corner of the SJAM Parkway On Ramp & Carling Ave

Baseline Rd	45.351552	-75.763422	Northwest corner of the Baseline & Woodroffe Intersection.
Pinecrest	45.350655	-75.790239	Southeast corner of the Pinecrest & 417 WB Off ramp Intersection
Richmond Rd (West)	45.347805	-75.803548	Southwest corner of the Richmond & Bayshore Intersection
Holly Acres	45.344746	-75.814196	Southeast corner of Holly Acres & Transitway Intersection
Moodie	45.343011	-75.842018	Northeast Corner of Moodie & Corkstown Intersection

(d) DB Co shall ensure that the fibre have 10m of slack for each direction of travel coiled within each manhole.

(e) DB Co shall ensure that the installed fibre not have any splice points within the duct and shall be one unbroken cable from breakout point to breakout point.

(f) Where the Confederation Line splits (south to Baseline Road and west to Moodie Drive) the fibre shall be installed in both branches, with the breakout point at Carling Road serving as the junction point for both of the branches. The City shall be responsible for any splicing and/or termination work at the junction.

2.6 City Traffic - Intelligent Transportation System Devices

(a) DB shall provide 120/240 VAC and Traffic Signal Disconnect with Cabinet External Meter (EB99) (DWG NO T31-M date Dec 2010) along with Disconnect Pad Foundation (DWG NO. T26 Rev. date March 2012) at each of the 14 locations (4 for Traffic Engineering; 10 for Traffic Management) identified in Table 3-2.2 below.

(b) DB Co shall relocate affected devices at current locations if required due to Roadway modifications. Some devices shall be relocated irrespective of Roadway modifications. The City shall have final approval of identified device locations.

Table 3-2.2: Proposed Locations for Power, Disconnect Cabinets and Pads

Owner	**Device**	**Location**	**Current Connection**	**Scope**	**Extra Scope**
Traffic Engineering	Camera 234	NE corner of Hwy 174 EB	Hydro &	Relocate existing if	N/A

Owner	Device	Location	Current Connection	Scope	Extra Scope
Group		on/off ramp & Blair Rd intersection	wireless	required due to Roadway modifications	
	Camera 235	NE corner of Hwy 174 WB off ramp & Blair Rd intersection	Hydro & wireless	Relocate existing if required due to Roadway modifications	N/A
	Camera 200	Hwy 174 Transitway overpass, near SE corner of bridge deck	Solar & wireless	Relocate existing if required due to Roadway modifications	Provide Hydro power.
	Camera 199	Hwy 174 WB (north side), ~505m east of Montreal Rd	Hydro & DSL	Relocate existing if required due to Roadway modifications	N/A
	Camera 198	Hwy 174 EB (south side), ~25m east of Jeanne d'Arc Blvd	Hydro & DSL	Relocate existing if required due to Roadway modifications	N/A
	Camera 197	NW corner of Champlain St & Place d'Orleans Dr intersection	Hydro & DSL	Relocate existing if required due to Roadway modifications	N/A
	Camera 72	Hwy 174 WB (north side),	Hydro & DSL	Relocate existing if required due	N/A

Owner	Device	Location	Current Connection	Scope	Extra Scope
		~85m east of Trim Rd		to Roadway modifications	
	Wavetronix B	Hwy 174 EB (south side), ~240m east of Blair Rd	Solar & Cell	Relocate existing if required due to Roadway modifications	Provide Hydro Power.
	Wavetronix C	Hwy 174 EB (south side), ~1075m east of Blair Rd	Solar & Cell	Relocate existing if required due to Roadway modifications	Relocate to Hwy 174 EB (south side), ~1185m east of Blair Rd. Provide Hydro power.
	Wavetronix D	Hwy 174 EB (south side), ~940 west of Montreal Rd	Solar & Cell	Relocate existing if required due to Roadway modifications	Provide Hydro Power.
Traffic Management Group	BlueToad 655	Hwy 174 EB (south side), ~245m west of Jeanne d'Arc Blvd	Solar & Cell	Relocate existing if required due to Roadway modifications	N/A
	Wavetronix 3	Hwy 174 WB (north side), ~505m east of Montreal Rd	Solar & Cell	Relocate existing if required due to Roadway modifications	N/A
	FVMS: 174 EB for Jeanne d'Arc Blvd	Hwy 174 EB (south side), ~1635m west of Jeanne d'Arc Blvd	Solar & Cell	Relocate existing if required due to Roadway modifications	Provide Hydro Power.

Owner	Device	Location	Current Connection	Scope	Extra Scope
	FVMS: 174 WB for Montreal Rd	Hwy 174 WB (north side), ~1635m west of Jeanne d'Arc Blvd	Solar & Cell	Relocate existing if required due to Roadway modifications	Provide Hydro Power.
	FVMS: 174 WB for Trim Rd	Hwy 174 WB (north side), ~525m east of Trim Rd	Hydro & Cell	Relocate existing if required due to Roadway modifications	N/A
	FVMS: 174 EB for Montreal Rd	Hwy 174 EB (south side), ~1185m east of Blair Rd	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.
	FVMS: 174 WB for Blair Rd	Hwy 174 WB (north side), near south end of Shefford Rd	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.
	FVMS: 174 EB for Champlain St	Hwy 174 EB (south side), on west side of embankment for Orleans Blvd overpass	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.
	FVMS: 174 WB for Jeanne d'Arc Blvd	Hwy 174 WB (north side), on east side of embankment for Orleans	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.

Owner	Device	Location	Current Connection	Scope	Extra Scope
		Blvd overpass			
	FVMS: 174 EB for Tenth Line Rd	Hwy 174 EB (south side), ~440m east of Champlain St	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.
	FVMS: 174 WB for Champlain St	Location: Hwy 174 WB (north side), ~520m west of Tenth Line Rd	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.
	FVMS: 174 EB for Trim Rd	Location: Hwy 174 EB (south side), ~900m east of Tenth Line Rd	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.
	FVMS: 174 WB for Tenth Line Rd	Hwy 174 WB (north side), somewhere along Parkrose Pvt	N/A (Future Devices)	N/A (Future Devices)	Provide Hydro power.

ARTICLE 3 TELEPHONE AND INTERCOM SYSTEM

3.1 General Requirements

(a) DB Co shall design a telephone and intercom system that provides emergency and non-emergency voice grade communications.

(b) DB Co shall design the telephone and intercom system to ensure that all telephones route through the Confederation Line's existing telephone system. The emergency intercom systems (emergency and elevator help) shall provide a direct connection to the TOCC and BCC.

(c) DB Co shall ensure that staff telephones be deployed in specific locations in the Stations to support operations.

(d) DB Co shall supply and install maintenance telephones in the communications equipment rooms, elevator/escalator machine rooms, EERs, TPSS, CIH, and vent plants and shall route through the existing Confederation Line's telephone system.

(e) DB Co shall coordinate the expansion of the telephone system with the City. The City shall expand the telephone system to support the new telephones with the new licenses and expansion modules.

3.2 Operational Requirements

(a) DB Co shall design, manage the interfaces supply, install, conduct PICO, SAT, SIT and commissioning of the telephone and intercom system. Refer to Schedule 15-2, Part 4 – Stations for locations including the equipment cabinets and racks. The telephone system shall include the following types of 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) DB Co shall perform static subsystem test of the of the telephone systems.

3.3 Performance Requirements

(a) The City shall perform all addition/modifications to the Existing Confederation Line telephone System head-end equipment at the TOCC and BCC.

(b) DB Co shall install ETELs a minimum of every 30m on Platforms and a minimum of every 30m in TSA.

(c) DB Co shall install ETELs at each Station entrance, along the concourse areas and in general passenger circulation areas including concourse areas and corridors.

(d) DB Co shall ensure that Emergency telephones and staff telephones be VoIP and be routed through the existing PBX.

(e) DB Co shall ensure that the ETELs be of identical construction and branding as the Existing Confederation Line. ETEL are identified in accordance with Schedule 15-2, Part 4, Appendix D – Signage and Wayfinding Cyrville Station (Segment 5) IFC package.

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

(g) DB Co shall design, supply, and install the telephone systems E&M infrastructure including conduits, mounting brackets, etc.

(h) Emergency telephones and elevator help telephones shall interface with the CCTV system to automatically provide video of the activated telephone and area to the TOCC, BCC, MYCC and BYCC receiving a call from these phones. A minimum of two fixed cameras shall view the areas so that cameras cannot be purposely panned away from possible incidents.

(i) ETEL Alarm Monitoring

  (i) The ETELs located on Platforms shall have an off-hook auxiliary relay installed in the ETEL enclosure. This auxiliary relay shall be hard wired to the Station's SCADA system. This shall enable the SCADA system to send commands to the CCTV system to control CCTV cameras close to the ETELs to capture video and display it on a workstation monitor when the ETEL is being used. The ETELs located in the TSA shall be monitored by a fixed camera at all times. For Emergency situations, when the call button is activated an alarm shall be sent to the SCADA system from the auxiliary relay. This causes the nearby PTZ cameras to pan towards the area providing two views of the area. These functions shall be performed by the SCADA system, cameras shall then be displayed on the video wall in the TOCC and BCC.

(ii) The ETELs located elsewhere on the Platform or in the concourse area of the Station shall be monitored by either a fixed camera at all times or by a nearby PTZ camera which shall be homed to that area when the push button on that particular ETEL is pressed.

(j) Elevator Help Intercoms

(i) The EHFI and faceplate shall be provided by the elevator supplier. An analog EHFI shall be deployed in each elevator cab of all Stations on the Confederation Line connected to a VOIP terminal adapter over CAT 3 cable, provided within the elevator travelling cable. Customers using the elevator shall be able to communicate with the TOCC and BCC by the push of a button when and if they feel threatened.

(ii) All EHFIs shall be connected to an interface panel in their designated elevator room connected via the elevator travelling cable. From the terminal adapter in the elevator room they shall be routed back to the nearest communications room by a fibre optic cable or an Ethernet cable depending on the distance between both rooms and the length of the travelling cable. In the communications room, EHFIs shall be terminated in the same patch panels used for ETELs. The EHFI include a LED on the faceplate to indicate "Help is on the way" that can be controlled remotely using a DTMF code to illuminate the LED. The EHFI phones' DTMF codes shall be configured using the embedded HTTP web configuration tool or through a TFTP file. The EHFI units shall be flush-mounted at an accessible height, and shall be equipped to be accessible to Passengers with hearing and/or visual impairments. The EHFIs shall be rated for outdoor use and are vandalism-proof.

(k) EHFI Alarm Monitoring

(i) Similar to ETELs, EHFIs shall be equipped with an auxiliary relay, which shall be connected to the Station SCADA system for monitoring purposes via the interface panel. The auxiliary relay shall be activated when the red HELP button is pressed.

(ii) Each EHFI shall be monitored by a fixed CCTV camera located in the cab. When the help button is pressed, CCTV shall start recording at a higher frame rate and video from this camera shall be fed to the video wall in the control room at the TOCC and BCC.

(l) Information Telephone

(i) ITELs shall be used by the public for assistance with any issues related to tickets, or any other non-Emergency purposes. These ITELs shall be installed on the fare paid side of the fare gates within the utility cabinets. ITELs shall be used by customers for information and to communicate with customer service for issues such as fare information, Ticket Machine errors, and if they need any non-

Emergency assistance. ITELs shall be programmed to connect directly to the customer service personnel. ITELs shall be power over Ethernet VoIP based hands free units. They shall be powered by power over Ethernet and shall be a different color than the Emergency phones to avoid confusion between both types of telephones. ITELs shall function outdoors and be able to withstand the local climate conditions. They shall be provided with the equipment necessary to assist Passengers with visual impairment. ITELs shall be connected using CAT6 to the CTS rack's patch panel in the communications room of the Station. From there, they shall be routed through the CTS back to the City's PABX.

(m) ITEL Alarm Monitoring

(i) Alarm alerts shall not be necessary when ITELs are used by customers as these phones are expected to be used for non-Emergency purposes; however, the personnel in the TOCC and BCC shall be able to monitor these devices by using existing fixed cameras or nearby PTZ cameras in case these phones are used for an Emergency purpose.

(n) Maintenance Telephones

(i) MTELs shall be located in all technical rooms (electrical rooms, communications rooms, elevator machine rooms, SER, etc.). In addition to these technical rooms, MTELs shall be installed at the LMSF, and within all TPSS for maintenance staff to communicate with each other and OC Transpo staff as necessary. Similar to the STELs, each MTEL shall be supplied with a wall mounting bracket. Staff using these phones shall be able to call any other STEL or MTEL by dialing the extension of a particular telephone. These phones shall have a dial pad to dial numbers. These phones shall have conference calling and call forwarding capabilities. The MTELs shall be power over Ethernet VoIP based telephones with speed dial programming capabilities that shall allow staff to utilise the short dialing feature of the programmable telephones. They shall be routed to a new PABX located in the Belfast MSF.

(o) MTEL Alarm Monitoring

(i) There is no alarm monitoring for maintenance telephones.

(p) Staff Telephones

(i) STELs shall to be installed in specific locations such as the TOCC, BCC, MYCC, BYCC and staff multipurpose rooms. STELs help OC Transpo staff communicate via Confederation Line telephones for Confederation Line operations support. Each telephone shall be supplied with a wall mounting bracket. STELs located in the TOCC, BCC, MYCC and BYCC shall sit on the console desktops. Staff using these phones shall be able to call any other STEL or MTEL by dialing the extension of a particular telephone. These phones shall have a dial pad to dial

numbers. These phones shall have conference calling and call forwarding capabilities. The handset shall be a power over Ethernet VoIP based telephone with speed dial programming capabilities that shall allow staff to utilise the short dialing feature of the programmable telephones. They shall be routed through the City PBX via the CTS.

(q) STEL Alarm Monitoring

(i) There is no alarms monitoring for STELs.

(r) HFI

(i) HFIs shall to be installed in the Moodie LMSF yard, the LMSF Building, and at main entrances to the site. HFIs shall be provided for use by maintenance staff for communication with the MYCC. HFIs are power over Ethernet VOIP based telephones and pre-programmed to call a specific number at the MYCC. HFIs shall be rated for outdoor operations and shall be wall mounted at accessible heights.

(s) HFI Alarm Monitoring

(i) There will not be any active monitoring available for HFIs, but HFIs located beside level crossings and near external doors or entrances shall be visible from PTZ cameras located nearby.

(t) Circuit Wiring

(i) The telephone wiring between the communications room and telephone devices (ETELs, STELs, ITELs, MTELs, HFIs, etc.) shall use CAT6E cables for power over Ethernet connections. For intercoms requiring fibre (e.g. in the Moodie LMSF where the unit is more than 90m from a network switch), an industrial grade media converter shall be installed in the intercom housing and powered with a 48VDC power supply which requires a 120VAC input. The CAT6E cables (from switch or media converter) shall be connected to telephone wall jacks to accommodate a connection with the RJ-45 plugs of the telephone sets.

(u) IP Connectivity

(i) Each telephone shall be configured to have a unique IP address and caller ID. The caller ID shall help locate a telephone if it has an error, or in the event of an alarm monitoring event.

(ii) Telephones shall be assigned an IP address for their location. Circuit wiring for EHFIs in elevators shall be run from the Communications Room to interface with the panel in the elevator room. A two core cable shall be run along the elevator travelling cable for alarm monitoring.

(v) AODA Compliance

(i) All the telephones which shall be used by patrons to communicate with OC Transpo staff, such as, ETELs, ITELs, EHFIs and HFIs shall be AODA compliant. The telephones shall have an amplifier producing sound at approximately 88db to help hearing impaired customers. To help visually impaired customers, all of the above mentioned public accessible telephones shall have their function written in Braille on the phone. The ETELs, ITELs, EHFIs and HFIs shall be equipped with an LED indicator marked as "Help is on the Way" in English and French. The LED shall be connected to the telephones auxiliary relay that is controlled by a digital phone that supports DTMF codes. The telephone shall be programmed with a selectable code of up to 25 characters that enables the LED. The phone shall be configured for the LED to stay on for a predetermined time, or to stay on permanently until the code is resent.

ARTICLE 4 PA SYSTEM/PASSENGER INFORMATION DISPLAY SYSTEM

4.1 General Requirements

(a) DB Co shall design all Confederation Line Extension Stations with a PA system to broadcast audio announcements of arrivals, departures, general and emergency/security information from a microphone or headset connected to the PA/PIDS console located in the TOCC, BCC, MYCC and BYCC. DB Co shall design the PA system to provide uniformly distributed audio throughout public areas of the Stations. The PA system shall be synchronized with the Vehicle announcements for the Confederation Line so that announcements on the Vehicle do not occur at the same time as announcements on the Platforms.

(b) PIDS shall be capable of displaying text in both English and French including accents in upper and lower case letters.

(c) Each new Station shall be equipped with PIDS signs to provide real time, specific, location-based, visual operational and safety-related messages for customer awareness. The PIDS shall be individually addressable and shall be accessed from the existing PA/PIDS console located in the TOCC and BCC. 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 Train (one arrival time per line), safety messages, Train delays, holiday schedules, and other ad-hoc messaging. In an Emergency condition, the PIDS shall display both pre-programmed Emergency announcements and simultaneous visual display of the PA system Emergency announcements.

(d) DB Co shall design, supply, install and test the PA E&M system infrastructure including conduits, mounting brackets, etc.

(e) DB Co shall design, manage the interfaces, procure, install, conduct PICO, SAT, SIT, and commissioning of the Station PA system.

(f) DB Co shall provide the Station speakers/microphone and Station rack with connectivity to the TOCC and BCC via the CTS.

(g) DB Co shall produce the design, supply (including Pre-delivery Test), install test and coordinate with the City during the Systems integration, testing and Commissioning of the Station PA system.

(h) DB Co shall provide the relevant technical staff, tools and test equipment to support the City during Systems integration, testing and Commissioning of the PA system.

4.2 Operational Requirements

(a) DB Co shall ensure that the PA/PIDS System Station equipment interface to the existing PA/PIDS servers at the Belfast MSF.

(b) The City shall expand the existing head-end equipment including system servers and voice recorder(s) as required to accommodate the new Station equipment.

(c) DB Co shall provide one new PA/PIDS console at the TOCC.

(d) The City shall ensure that the PA/PIDS system integrate with the existing GUI which shall serve as the means of interface between the system and the operator.

4.3 Performance Requirements - PA

(a) DB Co shall ensure that the PA system announcements be 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. Stations shall have up to five zones covering each Platform, mezzanine, and ancillary area.

(b) DB Co shall ensure that the PA system maintain a uniformly distributed sound level at least 10 dB above ambient Station operating noise level measured at 1.5 m above floor. Stations SPL shall be not less than 60 dB plus or minus 30 degrees off axis, 1.5 meter above the floor, at Vehicle ambient noise level. The PA system in the in the Stations shall also provide a STI of 0.6.

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

(d) DB Co shall ensure that the PA system be capable of playing pre-recorded messages in both English and French.

(e) DB Co shall ensure that the PA system be designed such that the component failures are minimized by redundancy. The availability of the system (i.e. availability of all system hardware, cabling) shall be greater than 99.9%.

(f) DB Co shall ensure that the PA system be fully supervised with failure annunciation at the TOCC, BCC, MYCC and BYCC of all major system components such as preamplifiers, power amplifiers, supervision detectors, and power supplies.

(g) DB Co shall ensure that the PA announcements from TOCC shall be delivered to the Station PA controllers over the CTS using TCP/IP protocol.

(h) DB Co shall ensure that the in the event of a power outage, the PA system shall remain operational for a minimum of 4 hours through the use of uninterruptible power supplies, generators, and/or other backup power equipment.

(i) DB Co shall ensure that the PA system be designed to accept several competing inputs with successful transmission designated according to assigned priorities. DB Co shall coordinate with OC Transpo to determine priority levels. The system shall be prioritized for TOCC, BCC, MYCC, and BYCC communications consoles, Station PA microphone in the ICP, and pre- recorded announcement devices.

(j) The PA system shall be prioritized for TOCC communications consoles, Station microphones, fire alarm panels, and pre-recorded announcement devices.

(k) DB Co shall ensure that the PA system work in conjunction with the PIDS system to provide synchronous broadcasting of audio and visual pre-recorded announcements and to provide synchronous transmission of live announcements.

(l) DB Co shall ensure that the PA system be synchronized with in-Vehicle PA systems for the Confederation Line to prevent audible delays between the two systems while a Vehicle is at the Station.

(m) DB Co shall ensure that the PA system announcements shall be recorded on the existing City voice recorder at 875 Belfast.

(n) The voice recording system may need to be expanded to accommodate the additional PA system requirements.

(o) The City shall design the PA system to be capable of expansion to accommodate additional equipment and licenses as required.

4.4 Performance Requirements - PIDS

(a) DB Co shall design, manage the interfaces, supply, install, conduct PICO, SAT, SIT and commission the PIDS.

(b) DB Co shall design, supply and install the PIDS E&M infrastructure including conduits, mounting brackets, etc.

(c) DB Co shall install, conduct PICO and SAT of the PID signs.

(d) Due to the unique physical characteristics of the signage, DB Co shall procure and install Station racks with connectivity to the TOCC and BCC via the CTS.

(e) On each Platform, DB Co shall install PIDS displays such that at least one display is visible and legible from any location along the Platform edge. DB 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. DB C shall install separate displays for each Platform edge on center Platforms. DB Co shall place displays to maximize visibility throughout the Platform area. Refer to Schedule 15-2, Part 4 – Stations for locations.

(f) The City shall integrate the PA/PIDS system with the existing centralized message generator and dispatch functions at the existing PA/PIDS workstation in the TOCC & BCC to address individual zones, Stations, groups of Stations, or System Infrastructure-wide announcements for PIDS installed on the System.

(g) DB Co shall ensure that Stations have zones covering each Platform, mezzanine, and ancillary area that correspond with the PA system zones.

(h) DB Co shall ensure that the PIDS have the capability of displaying messages in both English and French. All pre-programmed messages shall be provided in both languages.

(i) DB Co shall ensure that the PIDS be designed to accept several competing inputs with successful transmission designated according to assigned priorities. DB Co shall coordinate with OC Transpo to determine priority levels. The system shall be prioritized for TOCC, BCC, MYCC, and BYCC communications consoles, an automatic pre-defined emergency PIDS message triggered from the Station PA microphone in the ICP, and pre-recorded announcement devices.

(j) The City shall ensure that the PIDS is integrated with the PA system to provide synchronous broadcasting of audio and visual pre-recorded announcements and to enable near-synchronous transmission of live announcements.

(k) DB Co shall ensure that the PIDS be fully supervised with failure annunciation at the TOCC of all major system components such as PIDS displays, Station controllers, and power supplies.

(l) DB Co shall ensure that all PIDS announcements be recorded in a database on the existing head end PIDS system servers.

(m) DB Co shall ensure that all PIDS display Station time, which shall be synchronised with the existing central time server over the CTS.

(n) DB Co shall ensure that the PIDS be designed that in the event of a power outage, PIDS equipment shall remain operational for a minimum of 4 hours through the use of uninterruptible power supplies, generators, and/or other backup power equipment.

(i) PIDS signs shall have a visual message when the sign is not operational.

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 underground Station 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 (above ground Stations) shall be equipped with sunlight readable LED's (up to 5000 cd/m^2 (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 DB 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 DB 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 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) The Station PIDS shall communicate with a head end server, via a dedicated IEEE 802.3

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

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

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

(ix) 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.

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

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

(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 ETA/ETD screen display shall emphasize the top line of text (using a larger font and/or bolded).

(iv) The following examples describe an ETA/ETD 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).

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

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

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

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

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

(f) The examples above can accommodate the 3-line ETA or a 3-line general announcement of up to 25 - 76.2mm 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) DB Co shall ensure that design is stamped & sealed by a Professional Engineer.

(ii) Racks

DB 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 DB 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.

ARTICLE 5 VOICE / DATA RADIO SYSTEM

5.1 General Requirements

(a) The City shall design the Voice/Data Radio system for Confederation Line to include all BTS, back office, portables and handheld equipment required to provide coverage for the Confederation Line East Extension and Confederation Line West Extension including Moodie Station, Moodie LMSF and the Parkway Tunnel, Connaught Tunnel and Baseline Station Tunnel.

Tunnel Name	Length (meters)
Parkway Tunnel	2500
Connaught Tunnel	400m
Baseline Station Tunnel	400m

(b) The City shall provide DB Co with design details/drawings and specifications identifying equipment/device placement for all active and passive system electronics to DB Co. The City shall provide final specifications and details on cable sizing.

(c) The City shall locate the primary head-end (radio shelter) at the West Portal.

(d) The system shall take the radio signal off-air at the radio shelter and distribute it to the remote amplifier over single mode fibre to each Station where it would be amplified and used to provide coverage enhancement to both the Tunnel and the Station.

(e) A conduit or duct shall be required from the radio shelter to the West Portal to allow for fibre optical cable and coaxial cable routing.

(f) A 48-strand fibre optic cable shall be provided from the radio shelter to each communications room along the Parkway Tunnel to feed each of the remote fibre optic amplifiers (BDA).

(g) The City shall locate the secondary head-end (radio shelter) at Dominion Station.

(h) The system shall take the radio signal off-air at the radio shelter and distribute it to remote amplifiers over single mode fibre to each Station where it would be amplified and used to provide coverage to both the Tunnel and the Station.

(i) A conduit or duct shall be required from Dominion Station to the East Portal to allow for fibre optical cable and coaxial cable routing.

(j) A 48-strand fibre optic cable is required to each telecom room along the Parkway Tunnel to feed each of the remote fibre optic amplifiers (BDA).

(k) The primary system shall allow for the distribution of radio frequency signals down the Tunnel and throughout the Cleary Station and New Orchard Station and in case of a critical Failure the secondary system would automatically be activated to take over the coverage.

(l) DB Co shall include/reserve space along the wayside, in Tunnels, rack space in the equipment rooms, Moodie LMSF and other areas for Voice/Data Radio System equipment per the City's placement details/specifications.

(m) DB Co shall install the conduits and cables required to connect the Voice/Data Radio System equipment in the Underground Stations to equipment in the Tunnels.

(n) DB Co shall complete installation of the Voice/Data Radio system infrastructure and provide the City with full access to the Site to install their communications rack and active system electronics in communication rooms and/or in Tunnels.

(o) DB Co shall complete the installation of the Voice/Data Radio System tunnel infrastructure including power, communications, and the redundant radiating cable no later than 90 days prior to initial Train movements in the Tunnel otherwise subject to further schedule coordination with the City.

(p) DB Co shall complete the final outfitting of the communications rooms where the Voice/Data Radio system is to be located no later than 90 days prior to Train movements in the Tunnel otherwise subject to further schedule coordination with the City.

(q) Once the Voice/Data Radio System infrastructure is in place and tested by DB Co, the City shall install, configure and test the Voice/Data Radio System equipment.

(r) DB Co shall design the infrastructure including power and conduit. The City shall specify the cables and the equipment/device locations.

(s) DB Co shall install the infrastructure including power, conduit and cables (fibre and radiating).

(t) DB Co shall procure and install the fibre, coax, radiating cables and installation hardware.

(u) DB Co shall design, manage the interfaces, supply (including Pre-delivery Test) and install the connections of the voice/data radio System civil infrastructure outside of the ROW including conduits, pits, foundations, buildings, cabinets, etc.

(v) Radio communications system shall be provided. The system shall allow for voice communications between the following:

(i) Trains and Controllers;

(ii) Trains and rail staff;

(iii) Rail staff and Controllers;

(iv) Non-Revenue Vehicles and Controllers;

(v) Maintenance personnel and Controllers;

(vi) Trains and maintenance personnel;

(vii) Controllers and other Emergency service providers along the ROW;

(viii) Trains and Emergency service providers; and,

(ix) Rail supervisors and Emergency service providers.

(w) DB Co shall utilize the existing City of Ottawa Public Safety radio system. DB Co shall be responsible for purchasing licenses and paying the monthly fees for all new mobiles that are used by DB Co through the construction period.

(x) DB Co shall provide rack space (2 racks) at each underground station for Voice/Data Radio System Radio equipment.

(y) The City shall verify Station, Tunnel, and the Moodie LMSF coverage of the Voice/Data Radio System.

(z) The City shall verify Emergency services coverage of the Voice/Data Radio System.

(aa) DB Co shall design, supply, and install (design reviews, drawings, system integration) the redundant feeder coaxial cables and redundant radiating cable (and accessories) and ensure that all electrical, mechanical, physical interfaces are reviewed and approved.

(bb) DB Co shall provide appropriate conduits or pathways to cater for coax cabling from the radiating cable exiting the Tunnel to the remote amplifier within the Stations, Station transition areas, or Tunnels.

(cc) DB Co shall design antennae mounting locations throughout the Underground Stations to cater for the antennas required for the DAS. Antennas shall be located at the Platform level, concourse level, entrances, any Tunnel transition areas and will ensure that cellular coverage is provided in all public areas or on the Vehicle while entering the Platform or stationary at the Platform. Any interfacing hardware for the antennas are to be provided by the City.

(dd) DB Co shall provide suitable locations (will need to be accessible by the City) on Platform and or concourse areas to locate City DAS equipment as required. DB Co shall

provide power to this equipment. The City will provide exact sizing of equipment during design phase of the project. Normally all Voice/Data System equipment is in the communication room.

(ee) DB Co shall provide appropriate conduits or pathways to cater for coax cabling from the remote amplifiers, switches or patching device to the antennas within the Stations.

(ff) DB Co shall provide appropriate space in each Stations' Communication rooms for two 19 inch racks (supplied by the City) of equipment and one fiber entrance panel.

(gg) DB Co shall provide appropriate access to the third party supplier to the various project locations, no different than any other supplier on the project.

(hh) Immediately west of the Pinecrest rail junction, the Confederation Line alignment crosses over Pinecrest Creek on a Bridge Structure, skirts the Hanlon sports field and starts to descend to enter the Connaught east portal. This Tunnel will be 3 to 4 metres below grade at the Connaught Avenue and will emerge east of the proposed Queensview Station along Highway 417. The Tunnel is estimated to be approximately 400 metres in length.

(ii) For redundancy purposes, the City shall supply 2 off-air channelized BDAs, one at the east portal of the tunnel and the second installed at the Queensview station. Each BDA's donor antenna would face a different P25 radio site. Since no structure is available at the east portal the city shall supply a radio shelter within close proximity of the Tunnel.

(jj) DB Co shall provide all electrical work including a new protected AC circuit for this new equipment.

(kk) The amplified signal from the east portal BDA shall be routed down to the tunnel (½" coaxial cables provided by DB Co) and feed a single DB Co installed radiating cable. For redundancy, the amplified signal from the Queensview BDA shall feed a second DB Co installed radiating cable mounted on the opposite wall. The radiating cables shall serve as the signal source for the coverage enhancement. Conduit from the Queensview station to the Connaught tunnel's west portal shall be provided by DB Co. Due length of the cable, DB CO shall install two 7/8" cable radiating cables.

(ll) At Baseline Station, to provide redundancy, the City shall use 2 off-air channelized BDAs. Each BDA's donor antenna would face a different P25 radio site. The preferred location for the donor antennas is on the roof of the **[REDACTED]**. The two donor antennas shall be at least 15m apart from each other. Each shall feed a channelized 800 MHz BDA located in a telecom room in the building or in a telecom room in the Baseline Station Tunnel.

(mm) The amplified signal from each of the BDA shall then be routed down to the Station (two ½" coaxial cables provided by DB Co) and down to the Tunnel where it shall feed the DB Co supplied radiating cable. Again, for the purpose of redundancy, DB Co shall install two independent radiating cables mounted on opposite walls. The radiating cables shall

serve as the signal source for the coverage enhancement. Due to the length of the cable and its loss, DB Co shall install two 7/8" cable radiating cables.

(nn) DB Co shall provide the electrical work including a new protected AC circuit for this new equipment

5.2 Operational Requirements

(a) The City shall develop the performance specifications for the Voice/Data Radio System that provides complete coverage of the Confederation Line Extension, including but not limited to the Guideway, City spaces at the Moodie LMSF and all required materials within the tunnels to ensure full radio reception is achieved from portal end to portal end and all areas within the underground Stations

(b) The City shall integrate the voice/data radio System into the TOCC, BCC, MYCC and BYCC.

(c) The City shall procure, install and test all materials (radios, control head, antenna, base stations/amplifiers, combiner, microphone, batteries, chargers, base transmission system) required for a fully functional integrated system. 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 through the construction period.

(d) The City shall provide all necessary equipment to expand the existing voice recorder at the TOCC.

(e) The City shall install, integrate, test and commission the one new radio dispatch console at the Moodie LMSF for the MYCC.

(f) Battery backups shall be provided for all active components for a minimum of four hours.

ARTICLE 6 FARE CONTROL

6.1 General Requirements

(a) DB Co shall provide power source provisions within the Station electrical service for all fare collection equipment. DB Co shall supply each Ticket Machine and each fare gate with one 15 amp individual circuit for each.

(b) Data communication channels shall be provided within the Station communications rooms so that fare vending equipment may communicate with the existing fare collection head end equipment and accounting personnel located within the TOCC. The fare collection data shall communicate using its own network and fibre optic cabling that extends from the Existing Confederation Line fare collection network backbone cabling. DB Co shall extend the dark fibre to all new Stations and provide space for the City to install their equipment.

(c) DB Co shall procure and install an interposing relay at each Station that when a fire alarm is initiated from the FDAS 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.

(d) The City shall procure, install and test all fare control equipment (Ticket Machine, fare gates and servers). Refer to Schedule 15-2, Part 4 – Stations for location and quantity information.

6.2 Operational Requirements

(a) Ticket Machine, Power and Data requirements:

(i) DB 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 electrical details.

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

(b) Fare Gates, Power and Data requirements:

DB Co shall provide the Power for the fare gates by a single circuit breaker protected line delivered by slab conduits to the base of the fare gate. DB Co shall ensure that no conduits or ducts are exposed.

(i) DB Co shall provide slab conduits from the communications room/cabinet to allow for data cabling to the fare gate locations. DB Co shall ensure that no conduits or ducts are exposed.

ARTICLE 7 CCTV SYSTEM

7.1 General Requirements

(a) DB Co shall provide a CCTV system that serves both operational and security needs of the Confederation Line. The CCTV system shall allow operations, security staff and ESP the ability to monitor elements of the system remotely from the TOCC, BYCC, MYCC, and BCC. DB Co shall ensure that the Confederation Line Extension Project CCTV System integrates with the head end of the existing Confederation Line CCTV system to facilitate seamless interaction.

(b) All NVR's shall be connected to the CTS and able to transmit all required live and recorded video to the TOCC while multiple users are using the system at one time. All NVR's shall be located at each Station or facility and will locally record all video from the same facility.

(c) DB Co shall procure and install NVRs that match the Existing Confederation Line units.

(d) 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.

(e) 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.

(f) DB Co shall undertake a risk and safety assessment of the System and shall install CCTV's and / or any other security devices as an outcome of the assessment.

(g) The City shall update the CCTV into the existing head-end management platform at the TOCC and BCC to ensure that OC Transpo personnel have supervisory control of the new extension's CCTV system equipment.

(h) The City shall update the existing head-end management platform at the TOCC and BCC to ensure that operators have access and the ability to view video from the new extension's CCTV system equipment.

(i) DB Co shall design the CCTV cameras in Facilities to be connected to the system-wide backbone network for transmission of images to the TOCC and BCC.

(j) DB Co shall ensure that security video that is required for long term storage from any Station or facility be stored in a centralized long term storage server at the Belfast MSF; no security video storage is permitted at any other Facility.

(k) DB Co shall design the CCTV system with the capability to identify each camera with a unique IP identification number.

(l) DB Co shall provide commercially available, high quality cameras from reputable and established manufacturers. The cameras shall be fixed cameras and PTZ cameras. The cameras located within the Stations shall be chosen for their ability to meet functional specifications and for their aesthetic appearance. Cameras shall use 6.35mm or 8.5mm 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, minimum 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, minimum 1 MP, 2.5-6mm lens – elevators.

C. High Resolution Fixed WDR cameras, minimum 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 – Moodie LMSF Yard vehicle entrance.

7.2 Operational Requirements

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

(i) In keeping with CPTED principles, including but not limited to complete CCTV coverage of entrances to washrooms, Park & Rides, bicycles parking areas, all (Bus & Train) Platforms, Train doors, corridors, elevators, escalators, and stairways;

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

(iii) Cameras shall monitor all Station and Tunnel entrance and exit points.

(iv) Through the combination of fixed and PTZ cameras, the CCTV system shall provide the TOCC and BCC with complete coverage of all exterior areas of each Station including but not limited to MUPS, Station plazas and general circulation areas, interior and full exterior coverage of all four sides of each TPSS.

(b) DB Co shall provide the Station/Guideway cameras, accessories and Station rack for data/images to be transferred back to the TOCC and BCC via the CTS.

(c) DB Co shall design, manage the interfaces, install, conduct PICO, SAT, SIT and commission the City provided Platform edge cameras for Stations including accessories and Station rack for transferring of data/images back to the TOCC & BCC via the CTS.

7.3 Performance Requirements

(a) DB Co shall design a CCTV system that is proactive in determining intrusion into the alignment and private areas through interface with the SCADA and IAC Systems.

(b) DB Co shall ensure that The CCTV system be designed to interface to the ETELs and access control system so that any events are automatically recorded at higher frame rates and resolution.

(c) DBCO shall design the CCTV system where images can be transmitted from the Station area to the vehicle while the vehicle is located within a Station. DB Co shall design the CCTV system such that recorded video can be downloaded from the on-board Vehicle CCTV system at the Belfast MSF for long term storage for up to 3 years

(d) DB Co shall design the CCTV system based on a distributed video storage architecture; some data will be captured and stored at Stations, some will be captured and stored on Trains. DB Co shall ensure that data stored in local NVRs at each Station and in Trains for a maximum of 31 calendar days with minimum 1080P and 30 fps at H.264 compression.

(e) Expansion of the long term storage servers up to three years and system management servers installed in the data room at 875 Belfast shall be required.

(f) The City shall manage the addition/modification to the Belfast MSF head-end equipment (VMS Server and workstations); to accommodate any expansion.

(g) DB Co shall provide complete CCTV coverage for the System 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).

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

(i) DB 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 IP video system. The CCTV sub-system shall provide records for post event review and analysis. DB Co shall ensure that cameras are rated for the environment installed, including day/night capabilities, heater/blower, appropriate housing, NEMA 4X (IP-66) rated and IEC 62262 IK10 impact resistant enclosure

(j) DB Co shall locate the cameras to ensure the views are clear, unobstructed, and not impaired by structures, signage, foliage, intense lights, or any other obstacles.

(k) DB Co shall ensure that Camera views of the fare collection area be arranged to provide images of the customer's frontal interface with the Ticket Machines and Fare Gates.

(i) DB Co shall ensure that fixed cameras are installed to monitor the following locations:

A. Platform edges including Train doors;

B. Emergency telephones located in TSAs;

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

D. Public and employee washroom entrances;

E. Tunnel access/egress points and entrance/exits;

F. Fare collection equipment;

G. All restricted areas;

H. TPSS interiors and exteriors;

I. Station entrances and exits;

J. Bike racks;

K. Concourse level corridors/passenger circulation area;

L. Station Platforms (bus and Train); and,

M. Tunnel portals.

(ii) DB Co shall ensure that PTZ 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. PPUDO; and,

E. High rail vehicle access points/gates.

(iii) DB Co shall ensure that high resolution cameras with low lux capabilities are installed to monitor tunnel entrances.

(iv) The City shall develop the performance specifications and manage the interfaces for the CCTV equipment.

(v) DB Co shall design, install, test and perform testing and commissioning of the portal CCTV equipment together with the City.

(l) DB Co shall supply and install the CCTV system E&M infrastructure (conduits, poles, brackets, etc.).

(m) The City shall provide all additions/modifications to the TOCC head-end equipment (VMS Server and workstations).

(n) DB Co shall design the CCTV system to interface to the Emergency telephone systems. 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.

(o) DB Co shall design the CCTV system to interface to the IAC System. The CCTV system shall 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.

(p) The City shall integrate the new CCTV system into the existing head-end management platform so that it is capable of including or excluding automatic display of video coverage of any device, type of device, specific event, or general event type as needed.

(q) DB Co shall design the CCTV system such that all alarms can be assessed and if determined that the video/images are required, they will then be saved to the long term storage server. DB Co shall design the CCTV system such that all alarms can be assessed and if determined that the video/images are required, they will then be saved to the long

term storage server. DB Co shall design the CCTV System such that Recordings be digitally watermarked to detect tampering.

(r) The City shall integrate the CCTV System into the existing head-end management platform to ensure that access to recordings is restricted to OC Transpo personnel only.

(s) DB Co shall design the System such that the resolution and clarity of captured images be maintained under a range of lighting conditions from darkness through bright sunlight while ensuring optimal picture quality.

(t) DB 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.

(u) DB Co shall design the CCTV System to allow an administrator to dynamically specify resolution and frame rate variation at a particular camera location for monitoring that location while not affecting the recording parameters.

(v) DB Co shall design the cameras to have de-icing and lens clearance protection. All cameras shall have a unique identity and provide a means of detecting image loss.

(w) DB Co shall design the CCTV System to store all recorded images in an accepted industry standard format.

(x) DB Co shall design the CCTV System 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, generators, batteries, and/or other backup power equipment.

(y) DB Co shall design the CCTV System to ensure cameras installed in public areas are placed in protective vandal resistant environmental enclosures. Refer to Schedule 15-2, Part 4- Stations for location information.

(z) DB Co shall design the CCTV System to ensure that Cameras are located so that they never directly view the sun. The field of view of cameras shall be adequately illuminated either by natural light or by luminaires. Within the field-of-view, particular care shall be taken to avoid extremes of light, shadow and reflection from extreme glare.

(aa) DB Co shall design the CCTV System to provide a video feed to the ICP at each Underground Station.

ARTICLE 8 SCADA SYSTEM

8.1 Scope of Work

(a) The SCADA system shall provide supervisory control of the support systems. The SCADA system(s) provided shall be of the same manufacturer as installed on the Existing Confederation Line. The existing system servers are located at the Belfast MSF and manage all system controls and indications for the System.

(b) The City shall integrate the new SCADA system with the existing GUI and include the ability to filter out unnecessary indications and alarms according to user preference.

(c) DB Co shall ensure that all equivalent equipment included on the Existing Confederation Line SCADA points list is included on the Confederation Line Extension Project points list. DB Co shall ensure that the Existing Confederation Line asset ID convention is followed for the Confederation Line Extension Project.

(d) DB Co shall ensure that all Confederation Line Extension Project systems which interface with SCADA that are expansions of the Existing Confederation Line systems interface using the same architecture as in the Existing Confederation Line.

(e) There are a total of four SCADA system functions required which include:

(i) Traction Power System

A. The Traction Power System SCADA shall be an on-line, real-time, interactive system operated by TOCC personnel at the existing maintenance console to monitor and control power distribution and equipment. The SCADA system shall provide remote control capability for TOCC to sectionalize or isolate any section of contact rail or item of equipment in the TPSS or other Traction Power Facilities. Also, discrete input points shall be provided from Traction Power equipment to SCADA for display of status and to alarm abnormal operating conditions.

B. DB Co shall design, supply, install test, perform systems integration and testing of the Traction Power System SCADA field wiring; all wiring from substation protection and control devices to Marshalling Panel including IED interface with control PLC.

C. The City shall be responsible for integration of the extension's new SCADA system equipment into the existing SCADAs head-end management platform at the TOCC and BCC.

D. DB Co shall supply the local field SCADA cabinet/housing

(ii) Signaling & Train Control

A. The Signaling & Train Control system shall have a separate Train Control SCADA monitoring system operating over the CBTC wireless network. Refer to Article 10 – Signalling and Train Control System, of this Part 3 for details;

(iii) BMS

A. The BMS system shall monitor Station electronics, electrical and mechanical equipment.

B. DB Co shall design, supply and install the conduits, cabling and mounting hardware to provide connectivity and protection of all cabling required to connect field equipment to communications equipment rooms and other equipment rooms.

C. DB Co design, manage the interfaces, and install the E&M equipment for the BMS including interfaces with the FADS.

D. DB Co shall be responsible for all field wiring to marshalling panel; design and install associated conduits and mounting hardware.

E. The City shall update the existing SCADA head-end platform at the TOCC & BCC to accommodate the extension's new BMS Station equipment.

(iv) BAS

A. The BAS system shall monitor and control the Tunnel ventilation systems and FLS systems. This system shall be compatible with the Existing Confederation Line systems and be interfaced with the fire annunciator panel in the TOCC.

B. DB Co shall design the TVS interfaces with the SCADA System to be consistent with the Existing Confederation Line.

C. DB Co shall design, supply, install, conduct PICO and SAT of the control system, damper control panels, and MCC/VFDs.

D. DB Co shall design, procure and install the BAS E&M infrastructure (Conduits, mounting hardware, etc.).

E. The City shall be responsible for head-end SCADA integration; software integration of the tunnel ventilation system control equipment with the head-end SCADA management platform in the TOCC and the BCC at the Belfast MSF via the CTS. Refer to Schedule 15-2, Part 4, Article 6 – Electrical Design Criteria for details.

8.2 General Requirements

(a) The existing 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 be a continuous, dynamic scanning type for gathering information and status indication of all points. Each point shall 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.

(b) DB Co shall design the SCADA system to facilitate the transmission of indications and alarms from the RTUs to the TOCC and the transmission of controls from the TOCC to the RTUs via the CTS.

(c) DB Co shall design the system such that signals transmitted from RTUs to the processors at the TOCC shall be processed to provide monitoring information to 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.

(d) DB Co shall ensure that for each remote location, the SCADA system shall display the following items on the SCADA monitoring workstations in the TOCC:

(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.

(e) Each RTU shall be designed to interface to the CTS.

(f) The City's Existing Confederation Line SCADA servers and related processing equipment is located at the main communications room in the Belfast MSF and connected to a redundant LAN.

(g) DB Co shall design the SCADA System to ensure that schematic, one-line, pictorial, and alphanumeric displays of the SCADA system have the capability to be generated, altered, or deleted online by existing GUI.

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

8.3 Control and Monitoring Requirements

(a) DB Co shall ensure that TOCC, BCC and SCADA system shall operate as a homogenous control system. This system provides indications from field equipment to the TOCC & BCC and controls from the TOCC & BCC to field equipment.

(b) DB Co shall ensure that each remote monitored location shall provide a local HMI for local alarm annunciation and system control.

(c) DB Co shall ensure that each communications cabinet/ signal case and TPSS report status of intrusion detection, fire alarm, to the TOCC & BCC via the SCADA system.

8.4 SCADA Configuration

(a) DB Co shall ensure that SCADA RTUs provide the interface between the field equipment and the CTS, which includes the communications backbone network.

(b) DB Co shall ensure that SCADA RTUs utilize an Ethernet connection via the CTS to communicate with the existing TOCC & BCC head-end equipment.

(c) DB Co shall ensure that Error correction and detection schemes utilize 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.

(d) DB Co shall ensure that The RTU be designed and implemented so that wiring and cabling between the RTU and field devices are uniform in type, routing, and connection locations. The following field interface requirements shall be met:

(i) Signals between the RTU and Train Control houses/cases shall terminate at one centralized location;

(ii) Signals between RTU and TPSS sites shall terminate at one centralized location;

(iii) RTU terminations shall include test points and rapid disconnect; and,

(iv) 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) The City shall ensure that SCADA RTUs be supplied with hardware and software tools and documentation for reconfigurations and expansion.

(b) DB Co shall design the SCADA subsystem such that no action or lack of action by the users or any malfunction of the SCADA subsystem equipment can cause an unsafe condition.

(c) DB Co shall ensure that should the SCADA subsystem become completely inoperative, for any reason, the System shall continue to operate normally and safely.

8.6 Remote Terminal Units

(a) DB 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. 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; and,

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

(b) DB Co shall design the SCADA RTUs to continue operations with the loss of communication to head-end as a result of either communication equipment failures or head-end equipment failures. Upon return to service of failed equipment, the SCADA

system shall automatically resume normal monitoring and management of that equipment.

(c) DB Co shall ensure that SCADA RTUs are designed to continue operation in the electromagnetic environment where they shall be located, such as TPSS, Train control cases/houses, traffic cabinet and communications equipment cabinets.

8.8 Interface Requirements and Data Exchange

(a) The SCADA System RTUs shall support discrete inputs and outputs via relay contact closures (or optically isolated sold-state equivalents such as silicon controlled rectifiers). All discrete inputs to the RTU shall be of the same type. All discrete outputs by the RTU shall be of the same type. The following RTU input and output requirements shall be 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; and,

(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) The City shall 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 shall not exceed 2.0 seconds, unless otherwise approved.

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

(d) DB Co shall ensure that the SCADA HMI hardware shall have TCP/IP with 10/100Mbs connectivity for network communication.

(e) DB Co shall ensure that the SCADA HMI software shall comply with the Open Process Control standards to assure interoperability of the data servers between different RTU Platforms.

8.10 RTU Configuration Requirements

(a) DB CO shall design and procure one RTU to be installed in the data room at the Belfast MSF to support the Confederation Line Extensions' additional SCADA system requirements. The new RTUs shall be 19 inch rack mountable; capable of supporting a minimum of 16 I/O modules within the main RTU rack; capable of adding expansion racks; 256 MB of high speed DDR SDRAM and 128 MB of on board flash memory; capable of supporting 2000+ I/O point capacity; supports field and remote update of system programs.

(b) The initial DB Co provided MSF RTU shall be configured with a minimum I/O of; AI Card (8 I/O), DI Card (160 I/O), DO Card (32 I/O) including 15% spare I/O for future expansion.

(c) The RTU I/O modules shall meet the ANSI C37.90-1978 standard for surge protection.

(d) The Belfast MSF RTU shall have a LCD display/keyboard/touch screen console unit that shall be capable of being mounted on the enclosure door and connected by cable to the processor module.

(e) The City shall install, test and commission the RTU in the computer room at the Belfast MSF.

(f) DB Co shall design, procure, install, test and commission RTUs in each of the new Station CERs and the Moodie LMSF to support the Confederation Line Extensions' additional SCADA system requirements. The new RTUs shall be 19 inch rack mountable; capable of supporting a minimum of 16 I/O modules within the main RTU rack; capable of adding expansion racks; 256 MB of high speed DDR SDRAM and 128 MB of on board flash memory; supports field and remote update of system programs.

(g) The initial DB Co provided Station RTUs shall be configured with a minimum I/O of; AI Card (8 I/O), DI Card (132 I/O), DO Card (32 I/O) including 15% spare I/O for future expansion.

(h) The RTU I/O modules shall meet the ANSI C37.90-1978 standard for surge protection.

(i) The Station RTUs shall have a LCD display/keyboard/touch screen console unit that shall be capable of being mounted on the enclosure door and connected by cable to the processor module.

(j) DB Co shall design, procure, install, test and commission RTUs in each of the new TPSS to support the Confederation Line Extensions' additional SCADA system requirements. The new RTUs shall be 19 inch rack mountable; capable of supporting a minimum of 16 I/O modules within the main RTU rack; capable of adding expansion racks; 256 MB of high speed DDR SDRAM and 128 MB of on board Flash memory; supports field and remote update of system programs.

(k) The initial DB Co provided TPSS RTUs shall be configured with a minimum I/O of; AI Card (8 I/O), DI Card (160 I/O), DO Card (32 I/O) including 15% spare I/O for future expansion.

(l) The RTU I/O modules shall meet the ANSI C37.90-1978 standard for surge protection.

(m) The TPSS RTUs shall have a LCD display/keyboard/touch screen console unit that shall be capable of being mounted on the enclosure door and connected by cable to the processor module.

(n) The Belfast MSF, Station (including Moodie LMSF) and TPSS RTUs shall support all five industry standard IEC 61131-3 PLC programming languages.

(o) The Belfast MSF, Station and TPSS RTUs shall support the following protocols:

(i) Modbus;

(ii) DNP3;

(iii) SNMP;

(iv) BACnet; and,

(v) NTP.

(p) DB Co shall procure and provide the installation, maintenance and Operator manuals that accompanies the supplied RTUs.

ARTICLE 9 INTRUSION ACCESS CONTROL SYSTEM

9.1 General Requirements

(a) DB Co shall design the IAC system to control access and provide for detection of intrusion into non-public or otherwise restricted areas in Stations including coiling grilles, service entrances and along the alignment.

(b) DB Co shall design the IAC system such that Intrusion sensors shall sound an audible alarm locally and trigger an automatic alarm notification to the workstation GUI in TOCC, BCC and MYCC for unauthorized entry or tampering to IAC equipment.

(c) DB Co shall design the IAC system such that 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. Card readers and ACPs shall be designated matching products or equivalent to ensure system compatibility with the existing IAC System.

(d) DB Co shall supply, install, and test all Station IAC equipment. DB Co shall also be responsible for Station IAC equipment integration with the Station E&M RTU and the Station CTS. The City shall be responsible for head-end integration; software integration of the IAC with the head-end management platform.

(e) DB Co shall design the IAC system such that all access-controlled doors in Stations and buildings shall be monitored by the CCTV System.

9.2 Operational Requirements

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

(i) Public to non-public doorways;

(ii) TPSS;

(iii) CIH;

(iv) Station communications rooms;

(v) Elevator machine rooms;

(vi) Escalator machine rooms;

(vii) Electrical equipment rooms;

(viii) Vent plants;

(ix) Mechanical rooms;

(x) Crew/operational Rooms;

(xi) Platform end gates;

(xii) Station perimeter doors and coiling grilles (at some Stations);

(xiii) ICP;

(xiv) Restricted areas; and,

(xv) Moodie LMSF; and,

(xvi) High rail vehicle access points/gates.

9.3 Performance Requirements

(a) Access Cards – access cards shall be provided as follows:

(i) Access cards shall be provided by the City to approved staff for entry into the CIHs, TPSS, and vent plants. The access cards shall be compatible with the existing IAC System.

(b) DB Co shall design the IAC system such 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) DB 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) DB Co shall design the IAC system to ensure that all cardholders shall have access based on Facility, card reader, time, and day. The system shall allow access levels to be defined and to be applied to any or all cardholders. Access authorization shall 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) DB Co shall design the IAC system to ensure that provisions be made for remote signalling of the door unlocking to an IAC panel.

(f) DB Co shall design the IAC system to 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) DB Co shall design the IAC system to incorporate an interface to the fire alarm panel to allow override of door locks in an emergency situation. DB Co shall ensure that any door lock that restricts egress is code compliant and includes approved hardware and signage. Refer to Schedule 15-2, Part 4 – Stations for additional information.

(h) DB Co shall ensure that the IAC 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.

(i) DB 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 4 hours through the use of uninterruptible power supplies, generators, batteries, and/or other backup power equipment.

(j) DB Co shall design the IAC system to ensure a 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) System shall be interlocked with the fire alarm system such that if a zoned fire alarm is activated, all access-controlled doors within that zone are automatically unlocked for free egress.

(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 Scope of Work

(a) DB Co shall provide a complete Signalling and Train Control System (S&TCS) in accordance with these Output Specifications. The S&TCS for the new segments of the Confederation Line shall be an extension of the same CBTC system used on the existing Confederation Line and as described herein.

(b) DB Co shall provide all necessary infrastructure and installation of the S&TCS equipment/cabling to support the design of the S&TCS in accordance with these Output Specifications.

(c) DB Co shall be responsible for all modifications to the Existing Confederation Line signal equipment, including signal equipment at the central location and other distributed system elements as necessary (e.g. software updates), to interface the existing signal system with the signal system as described herein. Modifications shall be made in such a manner that operations are fully supported until the new system is ready to be tested and commissioned.

(d) The City shall provide that all Revenue Vehicles be equipped with S&TCS equipment to meet the requirements set out in the Output Specification.

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

(f) DB Co shall provide all necessary wayside signs required for manual operation of Trains and work zones. DB Co shall install the wayside signs.

(g) DB Co shall provide maintenance planning information for S&TCS to support the asset management planning.

(h) DB Co shall provide training equipment in order to allow training of maintenance staff, including troubleshooting, fault finding and system updates.

(i) DB Co shall provide the training equipment, or update the existing equipment, to be consistent with system operating functions and features.

(j) DB Co shall provide remote diagnostic capability and additional portable test units for S&TCS equipment. The list in the table below defines the minimum equipment to be provided and may be changed during the design process based on obsolescence.

    (i) DB Co shall provide CBTC Test Equipment for the Project as listed below.

Test Equipment	Part Number	Quantity
FLMD Laptop	3CU10081ADAA	2
DCS FLMD Laptop	3CU10081AJAB	2
TAG Programming Kit	183000, plus 612835, 612836	2
Handheld Tag Reader	HR-2 Handheld Reader	2

(k) DB Co shall provide the City with all necessary Project data as required to sequentially update the CBTC simulator.

(l) DB Co shall provide the same level of redundancy built into the S&TCS as the existing Confederation Line.

(m) DB Co shall develop the performance specifications, produce the design, manage the interfaces and supply (including Pre-delivery Test) the CBTC wayside equipment including wayside terminal boxes, switch machines, transponders, wheel detectors (as required), Wayside Radio Units and Signals.

(n) DB Co shall install, conduct PICO, SAT and SIT and commissioning of the CBTC wayside equipment including wayside terminal boxes, switch machines, wheel detectors (as required), transponders, Wayside Radio Units and Signals.

(o) DB Co shall upgrade the head-end management platform in the TOCC and BCC to accommodate the new CBTC equipment installed for the Confederation Line East and West Extensions. DB Co shall be responsible for certifying the head-end management platform based on upgrades required to add the Confederation Line East and West Extensions.

(p) DB Co shall upgrade the VOBC software to support the various phases of the software integration and the final alignment including Confederation Line East and West Extensions.

(q) DB Co shall develop the performance specifications, produce the design, manage the interfaces and supply (including Pre-delivery Test) the CBTC Station equipment including Zone Controllers, Relay Racks, FODF, Control CTFs, point Controllers, Isolations Transformers, GIDS and FDAS interfaces.

(r) DB Co shall install, conduct PICO, SAT and SIT and commissioning of the CBTC Station equipment including Zone Controllers, Relay Racks, FODF, Control CTFs, point Controllers, Isolations Transformers, GIDS and FDAS interfaces.

(s) DB Co shall be responsible for confirming the S&TC wayside equipment properly communicates with the VOBC.

(t) DB Co shall develop the performance specifications and produce the design requirements of the CBTC fibre optic civil infrastructure including conduits, trenches, sub-ducts, etc.

(u) DB Co shall develop the final design, supply, and install the CBTC fibre optic civil infrastructure including conduits, trenches, sub-ducts, etc.

(v) DB Co shall develop the performance specifications for the CBTC civil infrastructure for the main cable runs both outside and inside the stations including conduits, pits, foundations, buildings and cabinets.

(w) DB Co shall design, supply (including Pre-delivery Test), install conduct PICO and SAT of the CBTC civil infrastructure for the main cable runs both outside and inside the Stations including conduits, pits, foundations, buildings and cabinets.

(x) DB Co shall develop the performance specifications and produce the design requirements of the CBTC civil infrastructure within the Ballast, i.e. to and from the switch.

(y) DB Co shall produce the final design, supply, install and test the CBTC civil infrastructure within the ballast, i.e. to and from the switch.

(z) DB Co shall develop the performance specifications and produce the design requirements for the CBTC station to station cable and fibre within the Stations to the local junction boxes near the equipment (copper and fibre network).

(aa) DB Co shall produce the final design, supply, install and test the CBTC Station to Station cable and fibre within the Stations to the local junction boxes near the equipment (copper and fibre network).

(bb) DB Co shall supply, install, and conduct PICO of the CBTC Station to Station cable and fibre within the Stations to the local junction boxes near the equipment (copper and fibre network).

(cc) DB Co shall develop the performance specifications and produce the design requirements for the CBTC cable connecting the local equipment (fibre & copper) local cable network from the junction box to the equipment.

(dd) DB Co shall produce the final design, supply, install, conduct PICO, SAT, and SIT of the CBTC cable connecting the local equipment (fibre & copper) local cable network from the junction box to the equipment.

(ee) DB Co shall develop the performance specifications for the CBTC fibre and copper terminations

(ff) DB Co shall produce the design, supply, install, terminate and test the CBTC fibre and copper terminations.

(gg) DB Co shall coordinate to ensure that enough space is made available within the systems rooms for all DB Co supplied equipment in addition to space required for any equipment delivered by the City.

10.2 General Requirements

(a) All elements of the S&TCS shall be designed to be fail safe and maximize the safety and security of all personnel, Passengers, and equipment.

(b) The S&TCS shall be designed for the operation and control of all equipped Revenue Vehicles.

(c) The S&TCS shall be designed to accommodate the safe operation of the Maintenance Vehicles.

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

(e) The S&TCS expandability and extendibility criteria shall include as a minimum:

(i) additional Tracks;

(ii) additional interlockings;

(iii) additional vehicles;

(iv) additional Station/Stops; and,

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

(f) The S&TCS shall be capable of adapting to the foreseen conditions and constraints such as failures, emergencies, weather conditions, abnormal conditions and interruptions. It shall be DB Co responsibility to identify and mitigate them while ensuring safe and reliable operations at all times.

(g) The S&TCS shall optimize the Train movements and operational speed in accordance with vertical and horizontal Track alignment.

(h) The S&TCS shall be capable of reading and reacting to the inputs from supervisory and control systems as required.

(i) The CBTC system of the existing Confederation Line uses the **[REDACTED]** moving block system capable of operating in manual, restricted manual or ATO Modes, including

STO and UTO, with UTO restricted to yard areas for storage and other yard movements. The moving block system creates a virtual block of protection for each individual Train, dynamically calculated based on the Train's location, speed, and direction. The system shall prevent any Train from entering the virtual block of another Train, while maintaining a variable safe separation distance adjusted according to their actual speeds.

(j) On the mainline, the Trains shall be capable of operating in restricted manual, manual mode under ATP or STO mode. The Trains are driven in STO mode with Operator assistance by the VOBC based on a MA received from the zone controller over the DCS.

(k) With the exception of the MOW Shed, the LMSF yard shall be CBTC territory. Train Operators take control of the Trains for Revenue Service operations at a handoff platform. Transfer between yard and mainline control shall occur at the handoff platform. Train Operators handback control of the Train at the handoff platform. Trains shall be routed directly between the handoff platform and the mainline by the signal system.

(l) Subject to specific hazard analyses, wheel detectors shall be used to detect unauthorized movements of non-communicating Trains on to mainline territory. Trap switch functionality shall be deployed to ensure a route must be set to allow movements onto the Mainline. Once the route has cleared, the switch shall automatically realign to prevent unauthorized movement onto the Mainline.

(m) In the non-revenue areas, up to the handoff platform, including the carwash, Trains shall be capable of operating in UTO mode, under complete control of the signal system.

10.3 Codes, Standards and Manuals

(a) The design and construction of the Works shall comply with the criteria contained in this Article 10, and all standards, regulations, policies, and applicable law, applicable to the Project, including but not limited to each of the following Reference Documents. In the event of a conflict between criteria, commitments or requirements contained within one document when compared with another, the more stringent shall apply:

(i) AREMA Communications and Signal Manual.

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

(iii) EN 50128 Railway Applications – Communication, Signalling, and Processing systems – Software for Railway Control and Protection Systems

(iv) EN 50121 Railway Applications – Electromagnetic Compatibility

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

(vi) EN 50155 Railway Applications – Electronic Equipment Used on Rolling Stock

(vii) EN 50159-2 Railway applications – Communication, Signalling and Processing Systems -- Part 2: Safety Related Communication in Open Transmission Systems

(viii) IEEE Std. 1474.1 IEEE Standard for Communications-Based Train Control (CBTC) Performance and Functional Requirements

(ix) IEEE Std. 1474.2 IEEE Standard for Functioning of and Interfaces Among Propulsion, Friction Brake and Train-borne Master Control on Rail Rapid Transit Vehicles

(x) IEEE Std. 1474.3 IEEE Recommended Practice for Communications-Based Train Control (CBTC) System Design and Functional Allocations

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

10.4 Existing CBTC System Description

(a) CBTC of the Existing Confederation Line:

(i) Uses the **[REDACTED]** moving block system capable of operating in manual, restricted manual or ATO Modes. The moving block system creates a virtual block of protection for each individual Train, dynamically calculated based on the Train's location, speed, and direction. The moving block system shall support an 80-90 second design headway. The system shall prevent any Train from entering the virtual block of another Train, while maintaining a variable safe separation distance adjusted according to their actual speeds.

(ii) Operates in Revenue Service in either a manual mode under ATP (ATPM) or in STO mode. The Trains are driven in STO Mode with Operator assistance by the VOBC based on MA received from the Zone Controller.

(iii) Operates in non-revenue areas of the yard in UTO mode, under the complete control of the CBTC system.

(iv) Consists of equipment located on the wayside, at the TOCC, BCC, BYCC and onboard each Train. The wayside, TOCC, BCC, MYCC, and BYCC equipment connects to each other through redundant fibre optic networks. The onboard equipment communicates to the wayside and TOCC, BCC, MYCC and BYCC equipment through wireless AP connected into the CBTC network.

(v) Utilizes an ATS system management interface between the CBTC system and the operations/maintenance personnel. The ATS does not inherently provide any functionality for safety.

10.5 New CBTC System Description

(a) General

(i) The CBTC system for the Confederation Line East and West Extensions shall consist of equipment located on the wayside, including the Moodie LMSF and MYCC, with additional equipment or upgrades (e.g. software) at the TOCC, BCC, Belfast MSF and onboard each Train. The wayside, TOCC, BCC, Moodie LMSF, and MYCC equipment shall be connected to each other by redundant fibre optic networks. The onboard equipment shall communicate to the wayside through wireless APs connected into the CBTC Network. Systems providing the same functionality, Safety and level of redundancy as that described below are acceptable regardless of the assignment of functions among hardware or the terminology used.

10.6 System Architecture

(a) TOCC, BCC, Moodie LMSF and Belfast MSF Equipment

(i) The TOCC and BCC serve as the command and control centers for the Confederation Line. ATS Workstations located in the TOCC, BCC, and the Belfast and MYCCs shall communicate with redundant ATS and ATC servers located in the Belfast MSF. The ATS workstations shall allow the TOCC, BCC, BYCC and MYCC personnel to setup routes through interlockings in their control areas using entrance/exit selection or direct switch control, and to clear, cancel or fleet signals. Using this system, TOCC and BCC personnel shall also be able to stop and release any Train or group of Trains in Revenue Service. The TOCC and BCC personnel shall be able to put the ATS servers in an automatic mode to automatically set up routes through interlockings, send ATS commands to Trains to control Dwell Times, speeds, and acceleration or braking rates to manage headways, and schedules and/or optimize energy usage. In ATO mode, the ATS system shall also route Trains, with Operator support, out of and into the Moodie LMSF to build up and reduce service around the rush hours.

(ii) The ATC servers shall maintain the most up to date Track Database. The ATC servers shall push the latest version of the Track Database including Track profile, Station locations and civil speed out to the Zone Controllers and to all Trains. Handshaking shall be provided to ensure that all ATC servers, Zone Controllers and vehicles maintain the same up to date version of the Track database. The Zone Controllers shall maintain a registry of all equipped Vehicles in CBTC territory. Authorised TOCC personnel shall be able to use workstations to update, add or remove speed restriction zones and work zones.

(iii) One additional ATS workstation shall be installed in the TOCC to supplement the existing workstations. The ATS workstations at the TOCC shall have at

minimum, two additional overhead video display screens that allow TOCC personnel to view the entire line and all the Trains, interlockings and switch positions as well as equipment warnings, alarms, temporary speed restriction zones and work zones. General user interface controls shall be provided to allow the TOCC personnel to control interlockings and switches, to clear, cancel and fleet signals, to turn switch point heaters on and off, to stop and release Trains and to transfer interlockings and the entire line between automatic and manual operation.

(iv) CBTC maintenance database servers shall be provided, or the existing servers upgraded, at the Belfast MSF to record all faults from additional wayside and on board CBTC and network equipment required by the extensions.

(v) Fault alerts and easy database access shall be provided for maintenance personnel.

(vi) The ATS shall interface to the SCADA. SCADA shall provide the data to the PID systems.

(b) Zone Controllers

(i) DB Co shall provide all CBTC Station equipment including Zone Controllers. DB Co shall be responsible for all infrastructure and installation.

(ii) Zone Controllers shall be distributed throughout the line to control the Train movements in the various zones. Redundant Zone Controllers shall be provided in each zone. The number of zones shall be determined by the latency requirements to provide the required headways, the availability requirements, the product limitations (e.g. capacity), as well as the requirements of the vital interface with the interlocking controllers provided.

(iii) Each Zone Controller shall:

A. Receive Train location, length, speed and identification messages from each Train;

B. Ensure that the Track database version is compatible with the VOBC and ATS database versions;

C. Where applicable read inputs from the smoke detector and intrusion detection systems, GIDS and TVS;

D. Interface to Emergency stop buttons and Emergency stop key switches (yard only);

E. Request and receive the Track database version from each Train in its zone;

F. Deny MA to Trains without a valid Track database version until the database is made current;

G. Send movement authorities to all Trains within its zone including overlap into adjacent zones;

H. Provide Train location to the ATS system;

I. Inform adjacent Zone Controllers of all switch, signal positions and Train location information within its own zone; and,

J. Read inputs from the intrusion detection system installed at Tunnel Portals and the Guideway intrusion systems at Platform ends.

(iv) Read inputs from the intrusion detection system installed at Tunnel portals and Guideway Intrusion from Platform ends. Redundant Zone Controllers shall be provided for each zone.

(c) Local ATS Processor

(i) DB Co shall provide, and test all ATS processors. DB Co shall provide all infrastructure and installation required to support the S&TCS design.

(ii) Redundant local ATS processors shall provide a non-vital interface between the ATS servers and the VMIS to allow ATS control of interlockings. The local ATS processors shall also allow local control of the interlocking, through a local ATS workstation.

(iii) The local ATS function may be combined in various hardware configurations and location provided:

A. Local control of the turn backs at terminal locations and of the interlocking controlling entrance to and exit from the Moodie LMSF is not dependent on the health of the line CBTC network.

(d) Interlocking Control

(i) Vital interlocking logic shall include control of traffic direction between interlockings. Traffic direction status shall be vitally maintained through power failures. Vital interlocking control may be integrated into the Zone Controller package provided that:

A. Local control of the turn backs at terminal locations is not dependent on the health of the line CBTC network;

B. Failure of the CBTC portion of the Zone Controller shall not disable local control of terminal location turn backs or the interlocking controlling entrance to and exit from the Moodie LMSF;

C. The non-vital interface shall support a local control panel for testing and Emergency operation of the interlocking; and,

D. In local automatic operation, Trains shall be routed to the inbound Platform Track first and only if that Track is occupied to the other Platform Track. Provisions shall be made for taking a Platform Track out of service.

(ii) In case of CBTC system failure, signals will go red.

(e) Signal Equipment Room

(i) The S&TCS interior equipment shall be installed within a designated SER location within the Station building such that it is in close proximity to the interlocking as dictated by performance requirements of the signalling system equipment.

(ii) DB Co shall provide and test all equipment located within the SER. DB Co shall provide all infrastructure and installation required to support the S&TCS design.

(iii) All interlockings shall be controlled from a SER.

(iv) The SER shall be secured in accordance with safety and security requirements.

(v) The SER shall be provided 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.

(vi) The SER shall house all microprocessor systems, relays, electronic switch controllers, etc. necessary to control the interlocking from the central ATS servers.

(vii) The SER shall house, as necessary, CBTC equipment such as Zone Controllers, local ATS processors, CBTC networking equipment, etc.

(viii) Local Track switch controls, signal controls and switch indications shall be provided through the local ATS. Controls to select local or central ATS control, and local automatic or local manual control shall be provided.

(ix) The SER shall be resistant to corrosion and weather damage.

(x) The SER shall be insulated to a level that minimizes heating and cooling loads for the HVAC and heating systems.

(xi) DB Co shall provide a single phase AC feed with appropriate step down transformer(s) and distribution panels for signal power and for power outlets, lighting, HVAC etc.

(xii) DB Co shall provide a transfer switch and a connection for a portable emergency generator and pad for placement of that generator

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

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

(xv) A fire detection and suppression system shall be provided which shall be integrated into the central SCADA system.

(xvi) A control head, transceiver and antenna shall be provided for the radio.

(xvii) The SER shall be properly grounded. All racks in the SER shall be connected to the earth ground bus.

(xviii) Where high density termination blocks are used in signalling equipment located within the SER, 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.

(xix) The SER shall be monitored for intrusion detection by either the IAC or SCADA.

(f) S&TCS Backup Power Supply System

(i) DB Co shall provide a UPS 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. UPS filtering shall be sufficient that the ripple requirements of attached processor systems can be met in all conditions.

C. 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.

D. Batteries shall not be lead acid.

(g) Switch Machines

(i) DB Co shall provide all switch machines, switch machine layouts and switch heaters.

(ii) DB Co shall provide all civil infrastructure (conduits duct banks, inserts, etc.) and installation required to support the S&TCS design.

(iii) DB Co shall terminate and test all cabling.

(iv) Power switch machines provided shall:

A. Have heaters to prevent internal condensation;

B. Have a removable hand crank to perform manual switch moves; and,

C. Have a record of reliable operation in heavy traffic transit operation.

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

A. Be equipped with both rail temperature and precipitation sensors allowing for automatic operation.

B. Be equipped with remote control via SCADA by the TOCC, BCC, BYCC and MYCC with local manual control available for maintenance and troubleshooting;

C. Have sufficient thermal rating and capacity with appropriate controls to operate successfully and be effective in the Ottawa climate;

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

E. Failure of switch heaters status to correspond to command status shall cause an alarm indication; and,

F. Include capability for remote control and indications (control on/off, status on/off, status alarm/normal) to be transmitted via SCADA

G. Switch heaters shall operate effectively in the Ottawa climate as described in Schedule 15-2, Part 1, Clause 4.3.

(vi) Electric switch heaters shall be utilized for all main line switches:

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.

D. Electric switch heaters used on the mainline shall be hot air blower type with a minimum of 153,000 BTU/hr.

(vii) Gas heaters shall be utilized for all yard switches:

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.

C. Gas switch heaters used in the Moodie LMSF shall have a minimum output of 400,000 BTU/hr.

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

(ix) Switch heater feeds that are powered from a TPSS shall be metered.

(h) Wayside Signals

(i) DB Co shall provide and test all wayside signal layouts. DB Co shall provide all civil infrastructure (conduits duct banks, foundations, etc.) and installation required to support the S&TCS design. DB Co shall terminate and test all cabling.

(ii) Wayside signals shall be provided only in the Moodie yard and at mainline interlockings.

(iii) Wayside signals shall be mounted such that the vertical center of the signal head is approximately 2.6m above top of rail. Lower signals may be provided in the Moodie LMSF yard but the bottom of the signal head shall be at least 1 meter above top of rail.

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

(iv) Signal heads shall be located outside the dynamic envelope of the LRV.

(v) Wayside signals shall be mounted on the right hand side of the alignment for normal running.

(i) Location Norming Transponders

(i) Passive transponders with location and Track information shall be supplied and installed by DB Co along each Track in CBTC territory. The transponders shall be located at intervals as required to provide the specified Train location error limits, to provide verification of Track at interlockings and to provide the specified Station stopping precision.

(ii) The LRV VOBC shall detect missing or malfunctioning norming transponders and shall report this failure to the CBTC maintenance server.

(j) CBTC Network

(i) DB Co shall provide a CBTC network that supports the requirements of these Output Specifications. DB Co shall provide all civil infrastructure (conduits duct banks, inserts, etc.) and installation required to support the S&TCS design. DB Co shall terminate and test all cabling.

(ii) The TOCC, BCC, MYCC workstations, Belfast MSF servers and all wayside CBTC controllers and interfaces, shall be connected to each other and to wayside APs over independent redundant fibre optic networks.

(iii) Networks design and equipment shall be based upon an open standard such that replacement equipment may be procured from multiple sources.

A. Copper Category 6A or higher cables may be used within control rooms.

B. The fibre optic backbone networks shall designed such that for each node there are 2 paths to any other node.

C. Network switches shall be located in SERs, CILs and in Station communications rooms as needed.

i. All network switches regardless of location shall have at least 4 hours of battery backed up power.

(iv) The network shall be designed to reliably meet the latency requirements determined by the Headway requirements outlined in Schedule 15-2, Part 1, Article 3 – Operational Performance Requirements.

(v) The integrity of vital messages shall not depend on network protocols but upon error checking and time stamp checking methods used by the attached vital systems.

(vi) The CBTC system fibres shall be run in separate cables from all other communications systems. Each of the two CBTC fibre optic networks shall be run in a separate cable and a separate conduit or trough. The routing of fibre cables shall minimize the possibility disabling both networks with a single digging accident or lightning strike.

(k) CBTC Wireless Communication

(i) APs provided by DB Co shall be provided along the right of way. DB Co shall install all civil infrastructure (conduits duct banks, inserts, etc.).

(ii) Communications between APs and Trains shall be based upon an open or proprietary standard such that replacement APs may be procured from multiple sources.

(iii) Advanced encryption and error checking, time stamping, etc. in accordance with EN 50159-2 and other applicable standards shall be used to prevent deliberate and random message falsification and to guarantee message integrity. Additional measures shall be taken to mitigate the possibility of and damage from non-safety critical interference such as denial of service and man in the middle attacks and to reduce potential interference from external wireless networks.

(iv) The CBTC wireless communication system shall not carry data for any other vehicle or wayside system.

(v) Nodes on both backbone networks shall be able to talk to all APs.

(vi) APs shall be spaced along the alignment as needed to provide redundant radio coverage for each Train antenna at all times.

(vii) AP electronics shall be protected in sealed enclosures watertight to IP67 or NEMA equivalent. Alternatively, they shall be IP65, and be mounted high enough to prevent them being under water due to any environmental condition.

(viii) DB Co shall perform propagation studies and intermodulation studies to determine placement of APs and antennas on the wayside.

(ix) Frequency selection and antenna placement for Vehicle voice and non CBTC data radios shall be coordinated to minimize interference with CBTC wireless communication.

(x) Power for all APs shall be provided from a source with a minimum of a 4 hour battery backup. Power distribution to the APs shall be redundant. A short in a single AP shall not affect the operation of any others.

(l) Event Recording

(i) An event recording system shall be provided by the City and updated by DB Co, to record changes in switch positions, and signal aspects, fixed block occupancy, Train location, and ATS commands to the interlockings and Trains.

(ii) All events shall be time stamped.

(iii) Sufficient storage shall be provided by DB Co to record all events for a minimum of 60 days.

(iv) Onboard CBTC systems shall report all changes in MA, all Onboard Computer Train control commands, all changes in speed limits, etc. to the vehicle event recorder.

(m) Onboard CBTC Systems

(i) The City shall install and test the updated onboard CBTC System. Any software or database updates for the onboard CBTC System shall be provided by DB Co.

(n) Train Initiation

(i) Before any equipped Train may enter CBTC mainline territory and receive MA it shall register with the wayside CBTC system.

(ii) During Train initiation the Onboard Computer shall:

A. Provide all data required by the wayside CBTC system to Track the Train and the moving or virtual block it is occupying;

B. Verify the Track database; and,

C. Provide any other information required for ATS scheduling and routing.

(o) Non-Revenue Vehicles

(i) Non-Revenue high rail vehicles provided by the City shall be detected by the SCADA system displayed on ATS and protected by TOCC, BCC, MYCC and BYCC Operators setting a manual reservation for each non-revenue vehicle on the Guideway.

(p) Emergency Stop Devices

(i) Emergency Stop Devices shall be provided by the DB Co in the Moodie yard consisting of ESB and ESS.

(ii) ESBs shall be distributed around the yard. If the ESB is activated, the Tracks associated with the ESB shall be closed. If the ESB is released to the non-active state, the CBTC system shall allow the Tracks to be re-opened.

(iii) The ESS is a keyed switch located at the entrance to the access points to maintenance platforms and other locations based on based on the Hazard Analysis. Activation of the switch shall close the associated Tracks to protect the maintenance crews' activities. The ESS shall be able to be activated without a key, but shall only be returned to the non-active state using the key.

(iv) Locations and quantities of ESB and ESS devices shall be determined based on safety analyses to ensure the safety of maintenance and other personnel that may require yard access.

(q) External wayside and central S&TCS Interfaces:

(i) The ATS interfaces to SCADA and PIDS over an existing network interface.

(ii) The SCADA interface to the ATS shall provide Traction Power and UPS equipment status information. This interface allows the ATS to provide Train location information to the TVS, including onboard smoke detection status.

(iii) The ATS interface to PIDS shall provide Train prediction and other information required for Passenger information displays and automated Passenger announcements at Stations.

(iv) The interface to the smoke detectors and intrusion detection shall be via one pair of normally closed dry contacts per detection device for monitoring by the Zone Controller. Each Underground Station has one set of smoke detectors for each side of the Station. Each Tunnel Portal has one set of intrusion detectors. Each Platform has one Guideway intrusion detector at each end.

10.7 Modes of Operation

(a) Design work for the S&TCS system to be capable of the required modes of operation shall be performed by DB Co and shall mirror operation on the Existing Confederation Line with any specific adaptations required by the additional guideway and Moodie yard.

10.8 Interface with Passenger Information and City of Ottawa Systems

(a) Design work required for interface with Passenger Information and the City of Ottawa systems shall be performed by DB Co.

10.9 Monitoring and Diagnostics

(a) The Vehicle borne CBTC systems including fault monitoring and diagnostic capabilities necessary to meet the requirements of the Existing Confederation Line Vehicles, shall be provided by the City.

10.10 Signal Cable, Signal Case and Junction Box Requirements

(a) Signal Cable

(i) DB Co shall provide all civil infrastructure (conduits duct banks, etc) cabling and installation required to support the S&TCS design. DB Co shall terminate and test all cabling.

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

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

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

(b) Junction boxes

(i) DB Co shall provide install and test all junction boxes associated with the S&TCS design. DB Co shall provide all civil infrastructure (conduits duct banks, foundations, etc.) and installation required to support the S&TCS design. DB Co shall terminate and test all cabling.

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

(iii) Junction boxes shall be earth grounded.

10.11 Performance Requirements

(a) Latency and Response Times

(i) Communications latency and CBTC equipment response times shall be optimized to facilitate the operational performance requirements outlined in Schedule 15-2, Part 1, Article 3 – Operational Performance Requirements.

(b) Maximum Position and Speed Errors

(i) Base ATP location error shall not exceed 5 meters for each vehicle with all wayside transponders working and without any slides or spins or significant creepage due to prolonged acceleration or deceleration.

(ii) The Train shall stop reliably such that all doors are located on the Platform, with the required door setbacks from the Platform ends.

A. The braking profile shall be adjustable to prevent Station over runs during low adhesion conditions.

(iii) The S&TCS shall have the capability to support the future addition of Platform screen doors.

10.12 System Safety

(a) Safe Braking

(i) The OBC shall generate penalty brake speed profiles within the limits of the safe braking model described in IEEE STD 1474.1

(ii) The penalty brake for CBTC shall be an emergency friction brake without any Track brake application. Propulsion shall be disabled in a fail safe manner. Sanding shall be provided but shall be assumed not to work for purpose of safe braking computation.

(iii) The Guaranteed Emergency Brake Rate used by the safe braking model shall be based upon an analysis of plausible combinations of brake failure modes and on brake testing under the full range of adhesion conditions.

(b) Train Operation During Train/Wayside Communication Failure

(i) If the OBC fails to receive a MA update from the Zone Controller it shall continue to enforce the speed profiles from the previous MA as well as speed restrictions. If the communications failure continues for longer than 5 seconds the Onboard Computer shall command and enforce a full service brake to stop.

(c) Response to Intrusion

(i) The CBTC System shall respond to intrusion detection by alarming drivers and enforcing stop and proceed orders, speed restrictions or stop and hold orders as warranted by the Safety analysis.

(d) Fire and Smoke

(i) The Zone Controllers shall stop any Trains from entering the Tunnel or approaching an area, either in response to smoke detectors, or in response to TVS operation. Trains shall not be prohibited from moving in the Tunnel beyond and away from the fire zone.

(e) Speed Restrictions and Work Zones

(i) The speed limit of any temporary or civil speed restriction zone shall be enforced while any part of the Train is within the boundaries.

(ii) When a Train approaches a work zone, ATO operation shall be suspended. The Train shall operate in ATP Only Mode, and the assigned speed limit or stop shall be enforced.

A. Some work zones may require operation at limited speed while others may require a stop before proceeding on permission of the work crew. Both rules shall be enforced by the CBTC system.

(f) Degraded Modes of Operation

(i) The CBTC system design shall account for degraded modes of operation and shall develop a Safety Analysis of degraded mode operation in accordance with the standards outlined in this Article 10.

(ii) Solutions and operational policies for degraded modes of operation such as manual operation through interlockings with switch point detection problems, failed fixed block detection units, developed and implemented for the Existing Confederation Line shall be applied for the Confederation Line Extension.

(g) Safety Design Standards Reference Documents

(i) The CBTC system shall meet the safety requirements of IEEE STD 1474.1 and IEEE 1483-2000 and the formal verification methods referenced in EN 50126,

EN50128 and EN 50129. All required safety documentation of the generic products and the specific application and the operation the CBTC/signal system shall be provided.

10.13 Environmental Requirements

(a) Environmental requirements measures shall be included as part of the overall System design considerations from the start of the design to the final in-service testing. The wayside and onboard systems supplied shall be designed to meet the climate conditions provided in Schedule 15-2, Part 1, Article 4 – Design and Construction.

(b) At a minimum, all wayside equipment shall meet all of the environmental requirements as delineated in the AREMA Environmental Requirements. DB Co shall test equipment and submit certified test results showing the dates, locations and testing agency that performed the verification, at the City's request, unless the equipment has been proven in service in an equivalent environment and test results are available which can support this.

10.14 Testing

(a) General

(i) DB Co shall be responsible for testing the CBTC onboard software changes necessary to support the new Confederation Line Extension segments and required safety regression tests.

(b) Interlocking Testing

(i) Interlocking tests shall include point to point and vital break down tests of control wiring, insulation resistance testing of cables, and full functional testing of switch locking and signal and switch control.

(ii) All non-vital route setup, switch blocking, switch control, signal clearing and cancellation functions shall also be tested from the local control panel and from the ATS work station.

(c) CBTC System Tests

(i) Vital communications between VMIS and zone controllers shall be fully tested for each bit or variable transferred.

(ii) CBTC software shall be subjected to the test cycles required during development by the safety verification standards cited in Clause 10.12 (g) (i) of this Part 3.

(iii) Before any wayside or vehicle CBTC equipment is installed, functional simulations and load testing of the software shall be conducted for the Confederation Line Extension. During load testing, delays shall be simulated to

verify the cycle times can be met under heavy traffic and less than optimal transmission and reception conditions. Actual load tests shall be conducted on site as part of SAT activities.

(iv) CBTC equipped Vehicles shall be used to test communications quality along the Confederation Line West Extension and the Confederation Line East Extension.

(v) Station stopping tests shall be performed under all weather and grade conditions to verify the validity of the speed profile algorithms at the Platforms of the Confederation Line Extension Stations.

(vi) All CBTC safety and supervisory functions shall be tested including: Train separation, coupling, work zones, automatic and manual interlocking control, headway adjustment, adding and removing Trains from the line, ATS workstation displays, local control panels, etc.

(vii) All degraded modes of operation shall be tested.

(viii) The proper functioning of system redundancy including power redundancy shall be tested at all levels.

(ix) The CBTC fault reporting system shall be tested.

ARTICLE 11 EMI / EMC

11.1 Scope of Work

(a) DB Co shall develop the specifications, design and manage the interfaces for the EMI/EMC program.

(b) DB Co shall perform an overall EMI program and develop the requirements to install.

(c) DB Co shall conduct and document a program in which the system achieves compliance with EMC and EMI as set out in this Article 11, while providing safe and reliable operation in all specified functions and modes.

(d) DB Co shall apply the EMI/EMC program requirements to all Systems and sub-contractors within DB Co.'s scope of work including Revenue Vehicle EMI immunity which complies with the Existing Confederation Line Vehicles.

(e) DB Co shall ensure that all equipment provided under this Output Specification and the Performance Specifications provided by the City, taken individually and together, complies with the EMI/EMC requirements set out in this Article 11, in normal, degraded, and emergency operating and maintenance modes.

(f) DB Co shall demonstrate to the City that the equipment installed shall not interfere with any other systems or equipment.

(g) In order to identify existing sensitive receptors and emitters, DB Co shall conduct an EMI Site Survey along the alignment early in the design process as well as prior to the completion of system Commissioning;

(i) DB Co shall engage affected stakeholders to ensure that mutual EMI/EMC concerns are appropriately addressed and mitigated; and

(ii) DB Co shall work with the Authorities (i.e. Industry Canada), or other affected stakeholders to resolve any EMI/EMC problems identified during design, construction, Commissioning and operation and maintenance in accordance with Schedule 15-2, Part 1 – General Requirements and Schedule 17 – Environmental Obligations.

(iii) DB Co shall work with the identified locations below, for Confederation West, in addition to other locations identified during their design survey;

Sensitive Receivers - Confederation West				
Approx. Distance From Bayview Meters	Track Side	Approx. Distance to Centerline	Description	Rationale

(Feet)		Meters (Feet)		
0-1676 (0-5,500)	East	6.1 (20)	Power lines	Low frequency magnetic and electric fields
1219 (4,000)	Perpendicular to Track	N/A	Power line Crossing	Low frequency magnetic and electric fields
1219 (4,000)	West	46 (150)	Transformer Station	Low frequency magnetic and electric fields
2286 (7,500)	East	305 (1000)	**[REDACTED]**	Medium to high frequency plane waves
3810-4724 (12,500-15,500)	East Side, Parallel to Track	31 (100)	Power lines	Low frequency magnetic and electric fields
6919 (22,700)	Perpendicular to Track	N/A	Power Line Crossing	Low frequency magnetic and electric fields
EOL	East	610 (2000)	Queensway Carleton Hospital	Multiple Sources of Possible Electromagnetic Interference: Low, medium, and high frequency magnetic and electric fields, medium to high frequency plane waves, conducted low and high frequency phenomena, and Electrostatic Discharge

(iv) DB Co shall work with the identified locations below, for Confederation East, in addition to other locations identified during their design survey;

Sensitive Receivers - Confederation East				

Approx. Distance From Blair Meters (Ft)	Track Side	Approx. Distance to Centerline Meters (Feet)	Description	Rationale
0 (0)	Perpendicular to Track	N/A	Power line Crossing	Low frequency magnetic and electric fields
0-2560 (0-8,400)	East Side, Parallel to Track	49 (160)	Power lines	Low frequency magnetic and electric fields
3048 (10,000)	Perpendicular to Track	N/A	Power line Crossing	Low frequency magnetic and electric fields
3962-EOL (13,000-EOL)	East Side, Parallel to Track	31 (100)	Power lines	Low frequency magnetic and electric fields
6218 (20,400)	East	62 (200)	Transformer Station	Low frequency magnetic and electric fields
9510 (31,200)	East	305 (1,000)	CML Healthcare Laboratory Service	Multiple Sources of Possible Electromagnetic Interference: Low, medium, and high frequency magnetic and electric fields, medium to high frequency plane waves, conducted low and high frequency phenomena, and Electrostatic Discharge
10607 (34,800)	East	305 (1,000)	Ottawa Police Service	Medium to high frequency plane waves
10729 (35,200)	East	61 (200)	Cell Tower	Medium to high frequency plane waves
<0 (<0)	West	3048 (10,000)	Montfort Hospital	Multiple Sources of Possible

				Electromagnetic Interference: Low, medium, and high frequency magnetic and electric fields, medium to high frequency plane waves, conducted low and high frequency phenomena, and Electrostatic Discharge
<0 (<0)	West	122 (400)	**[REDACTED]**	Medium to high frequency plane waves
1768 (5,800)	West	244 (800)	Power lines	Low frequency magnetic and electric fields
2438 (8,000)	West	366 (1,200)	**[REDACTED]**	Multiple Sources of Possible Electromagnetic Interference: Low, medium, and high frequency magnetic and electric fields, medium to high frequency plane waves, conducted low and high frequency phenomena, and Electrostatic Discharge
2987 (9,800)	West	366 (1,200)	**[REDACTED]**	Multiple Sources of Possible Electromagnetic Interference:

				Low, medium, and high frequency magnetic and electric fields, medium to high frequency plane waves, conducted low and high frequency phenomena, and Electrostatic Discharge

(h) DB Co shall ensure that there is no harmful or disturbing electrical interference of the Systems with external systems, (City traffic system, human beings, radio/television receivers, radio/television transmitters, cellular systems, wireless systems, power gridlines, power substations, cars, buses, police, emergency vehicles, and any other equipment belonging to Passengers, pedestrians and neighborhoods).

(i) DB Co System Infrastructure shall be designed and commissioned to be electromagnetically compatible and not cause any electromagnetic interference to other adjacent railway systems (**[REDACTED]** and **[REDACTED]**).

(j) DB Co shall cooperate with Industry Canada and third party stakeholders in the investigation and resolution of complaints regarding documented or suspected EMI/EMC issues.

(k) DB Co shall provide an O&M manual detailing all identified sensitive receivers, mitigation measures taken, and required maintenance on any EMI/EMC management systems/equipment. The City will consider any EMI issues arising post Completion as a warranty issue or latent defect.

11.2 Reference Documents

(a) The works shall comply with the criteria contained in this Article 11, 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) EN 50121, Railway applications – Electromagnetic compatibility Part 1, Part 2, Part 3-1, Part 3-2, Part 4 and Part 5;

(ii) Industry Canada ICES:

A. ICES-001: Industrial, Scientific and Medical Radio Frequency Generator;

B. ICES-002: Spark Ignition Systems of Vehicles and Other Devices Equipped with Internal Combustion Engines;

C. ICES-003: Information Technology Equipment (including Digital Apparatus - Limits and Methods of Measurement;

D. ICES-004: Alternating Current High Voltage Power Systems;

E. ICES-005: Radio Frequency Lighting Devices;

F. ICES-006: AC Wire Carrier Current Devices (Unintentional Radiators);

(iii) OESC.

11.3 General Requirements

(a) DB Co shall meet current Industry Canada EMI/EMC regulations and licensing regulations at all times during the Maintenance Period.

(b) DB Co shall ensure that all equipment meets emission regulations and that all radio equipment is type certified for use in Canada.

(c) The equipment shall be designed to be compatible with the surrounding electromagnetic environment.

(d) Each system, subsystem or component thereof, installed as part of the work, shall comply or be compatible with applicable Canadian EMC standards (ICES).

(e) The System shall be designed and constructed such that the System does not electrically or magnetically interfere with the safe and proper operation of the Revenue Vehicles, and Maintenance Vehicles, and wayside equipment, including external systems and equipment.

(f) An EMI/EMC Control Plan for the entire System shall be submitted, based on EN50121standard series and related Canadian EMI/EMC standards, according to Schedule 10 – Review Procedure.

(g) The EMI/EMC Control Plan shall define a process for early identification of interference risk areas and development of solutions to mitigate the risk of the electromagnetic interferences and the electromagnetic compatibilities of the System elements in the operating EMC environment. DB Co shall, at minimum, include the following items into the EMI/EMC Control Plan:

(i) Identification of roles and responsibilities for EMI/EMC management and compliance;

(ii) Identification of the applicable standards and equipment characterization tests;

(iii) Ensuring that the EMI/EMC requirements are clearly understood by design and construction team;

(iv) Providing proper definition and support for analysis and allocation of EMI/EMC requirements in applicable system, subsystem and component specifications, and interface control drawings;

(v) Ensuring that the EMI/EMC requirements are met by design and construction teams by reviewing all applicable drawings and specifications prior to their release for proper EMI/EMC control content;

(vi) Compliance with statutory regulations and relevant standards via participating in EMI/EMC design reviews, EMI/EMC control board meetings and test result review;

(vii) Coordination with the regulatory organizations during the design, construction, operation and maintenance shall be maintained to ensure that the EMC requirements are addressed and that necessary licences and approval are acquired and maintained; and,

(viii) Undertaking an EMC risk assessment of the design in order to detail the potential risks for EMC and determine the necessary mitigations to reduce or eliminate those risks.

(h) DB Co shall ensure that each system configuration complies with the EMI/EMC requirements, in all possible operating modes to ensure that all supplied equipment shall operate, without degradation or failure resulting from the installed environment nor cause any other equipment, existing or new, degradation or failure due to emitted interference.

(i) Qualification test reports shall clearly identify the pass/fail status of each test.

(i) Where any test is failed, a clearly defined remedial action report shall be included in the test report identifying the reason for the failure and the proposed remedial action.

(j) No product, system, subsystem or component shall be installed until it has successfully passed EMI/EMC qualification testing.

(k) DB Co may use equipment that can demonstrate prior EMI/EMC performance testing and in-service proven ability.

(i) Use of the service proven equipment shall be assessed on prior records; if this is demonstrable, their inclusion into the design shall be justified using an EMI/EMC risk assessment.

(l) DB Co shall ensure that the equipment is adequately protected against radio frequency emissions from nearby mobile and handheld radios or cellular telephones.

(m) The operation and maintenance manual shall describe the equipment protections as well as any restrictions on equipment operation or maintenance necessary to ensure immunity control (e.g. leaving covers on equipment enclosures).

(n) DB Co shall perform a radio immunity qualification test on equipment to demonstrate its immunity against radio emissions. Radio emissions immunity qualification tests shall demonstrate the following:

(i) Demonstrate that the designed susceptibility thresholds are met under normal and failure conditions, and at the limits of permissible field adjustments. Failure conditions shall include failures identified in the safety analysis above, including relevant un-annunciated failures and maladjustments.

(ii) Demonstrate that the designed susceptibility thresholds are adequate to permit operation with worst-case conducted and inductive emissions expected from Trains in all possible operating configurations.

ARTICLE 12 CORROSION CONTROL

12.1 Reference Documents

(a) The design and construction of corrosion control work shall comply with the criteria contained in this Article 12, and all standards, regulations, policies, Applicable Law, guidelines or practices applicable to the Project, including but not limited to each of the following latest revision of the Reference Documents. In the event of a conflict between criteria, commitments or requirements contained within one document when compared with another, the more stringent shall apply:

(b) American Concrete Institute

(i) ACI Publication SP-77 Sulphate Resistance of Concrete;

(ii) ACI Publication 201.2R Guide to Durable Concrete;

(iii) ACI Publication 222R Protection of Metals in Concrete Against Corrosion; and,

(iv) ACI Publication 506.2 Below Grade Shotcrete Used as Permanent Support.

(c) ASTM International

(i) ASTM A536 Standard Specification for Ductile Iron Castings;

(ii) ASTM A716 Standard Specification for Ductile Iron Culvert Pipe;

(iii) ASTM A746 Standard Specification for Ductile Iron Gravity Sewer Pipe;

(iv) ASTM B418 Standard Specification for Cast and Wrought Galvanic Zinc Anodes;

(v) ASTM B843 Standard Specification for Magnesium Alloy Anodes for Cathodic Protection;

(vi) ASTM C452 Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate;

(vii) ASTM D256 Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics;

(viii) ASTM D516 Standard Test Method for Sulfate Ion in Water;

(ix) ASTM D570 Standard Test Method for Water Absorption of Plastics;

(x) ASTM D638 Standard Test Method for Tensile Properties of Plastics;

(xi) ASTM D1248 Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable;

(xii) ASTM D2216 10 Standard Test Methods for Lab Determination of Water Content of Soil;

(xiii) ASTM D4327 Standard Test Method for Anions in Water by Suppressed Ion Chromatography;

(xiv) ASTM D4658 Standard Test Method for Sulfide Ion in Water;

(xv) ASTM G16 Standard Guide for Applying Statistics to Analysis of Corrosion Data;

(xvi) ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing; and,

(xvii) ASTM G57 Standard Test Method for Field Measurement of Soil Resistivity Using the Wenner Four-Electrode Method.

(d) AWWA

(i) AWWA C104/A21.4 Cement-Mortar Lining for Ductile-Iron Pipe and Fittings;

(ii) AWWA C111/A21.11 Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings;

(iii) AWWA C116 Protective Fusion-Bonded Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings;

(iv) AWWA C151/A21.5 Ductile-Iron Pipe, Centrifugally Cast;

(v) AWWA C200 Steel Water Pipe 6 Inch (150mm) and Larger;

(vi) AWWA C203 Coal-Tar Protective Coatings and Linings for Steel Water Pipelines-Enamel and Tape-Hot Applied;

(vii) AWWA C207 Standard for Steel Pipe Flanges for Waterworks Service-Sizes 4 In. Through 144 In. (100mm Through 3,600mm) for Potable Water and Other Liquids;

(viii) AWWA C209 Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines;

(ix) AWWA C210 Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines;

(x) AWWA C213 Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines;

(xi) AWWA C214 Tape Coating Systems for the Exterior of Steel Water Pipelines;

(xii) AWWA C215 Extruded Polyolefin Coatings for the Exterior of Steel Water Pipelines;

(xiii) AWWA C216 Heat-Shrinkable Cross-Linked Polyolefin Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines; and,

(xiv) AWWA C302 Reinforced Concrete Pressure Pipe, Non-cylinder Type.

(e) Canadian Electrical Code

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

(ii) CSA C22.2 Canadian Electrical Code Part II General Requirements; and,

(iii) CSA C22.3 No. 4-1974(R1995) Control of Electromechanical Corrosion of Underground Metallic Structures.

(f) Electronic Industry Association (EIA)

(i) EIA RS-169 Thermoplastic Insulated and Jacketed Hook-Up Wire; and,

(ii) EIA 214 Method for Calculation of Current Ratings on Hook-Up Wire.

(g) European Standard

(i) IEC 62128-1 Part 1: Protective Provisions Relating to Electrical Safety and Earthing.

(h) International Union of Railways (UIC)

(i) UIC605OR Protection from Corrosion.

(i) Institute of Electrical and Electronics, Inc. (IEEE)

(i) IEEE C2 National Electrical Safety Code (NESC);

(ii) IEEE 80 IEEE Guide for Safety in AC Substation Grounding;

(iii) IEEE 81 IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements;

(iv) IEEE 142 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems;

(v) IEEE 316 Standard Requirements for Direct Current Instrument Shunts; and,

(vi) IEEE 837 Qualifying Permanent Connections Used in Substation Grounding.

(j) ICEA

(i) ICEA S-61-402 Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy; and,

(ii) ICEA S-66-524 Cross Linked Thermosetting Polyethylene Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

(k) NACE International

(i) Report 10B189 Direct Current Operated Rail Transit Stray Current Mitigation (24255-SG);

(ii) NACE RP 0104 Recommended Practice The Use of Coupons for Cathodic Protection Monitoring Applications;

(iii) NACE SP 0109 Standard Practice Field Application of Bonded Tape Coatings for External Repair Rehabilitation and Weld Joints on Buried Metallic Pipelines;

(iv) NACE SP 0169 Standard Practice Control of External Corrosion on Underground or Submerged Metallic Piping Systems;

(v) NACE SP 0177 Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems;

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

(vii) NACE SP 0207 Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Surveys on Buried or Submerged Metallic Pipelines;

(viii) NACE SP 0285 Standard Practice Corrosion Control of Underground Storage Tank Systems by Cathodic Protection;

(ix) NACE SP0290 Design Considerations for Corrosion Control of Reinforcing Steel in Atmospherically Exposed Concrete Structures;

(x) NACE TM 0101 Standard Test Method Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems; and,

(xi) NACE TM 0497 Standard Test Method Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems.

(l) NEMA:

(i) NEMA AB 1 Molded Case Circuit Breakers and Molded Case Switches;

(ii) NEMA ICS 6 Industrial Controls and Systems: Enclosures;

(iii) NEMA MR 20 Cathodic Protection Units; and,

(iv) NEMA ST 1 Specialty Transformers (except General Purpose Type).

(m) National Sanitation Foundation

(i) NSF/ANSI 61 - Drinking Water Standards/Certification.

(n) OEC

(i) Ontario Reg. 164/99 Electrical Safety Code.

(o) Transit Cooperative Research Program

(i) TCRP Report 155 Track Design Handbook for Light Rail Transit Chapter 8 Corrosion Control.

(p) UL

(i) UL 83 UL Standard for Safety Thermoplastic-Insulated Wires and Cables; and,

(ii) UL 486A Wire Connectors and Soldering Lugs for Use with Copper Conductors.

(q) NFPA

(i) NFPA 70 National Electric Code; and,

(ii) NFPA 130 Standard for Fixed Guideway Transit and passenger Rail Systems.

12.2 Scope of Work

(a) Introduction

(i) This Article 12 describes the Design Criteria for corrosion control. Corrosion control is required to prevent premature corrosion failures on System facilities, on metallic and concrete pipes, and on other underground structures. Such measures shall also minimize stray current levels and their effects on underground and

above-grade structures. Types of corrosion control include mitigation for stray currents and protection against atmospheric and underground corrosion. Corrosion control systems should be economical to install, operate, and maintain.

(b) Objective

(i) Corrosion-control Design Criteria encompass all engineering disciplines applied to the Project.

(ii) The criteria are separated into three areas: stray current corrosion, soil corrosion, and atmospheric corrosion. The Design Criteria for each of these categories, and their implementation, shall meet the following objectives:

A. Realize the Design Life of System facilities by avoiding premature failure caused by corrosion;

B. Minimize annual operating and maintenance costs associated with material deterioration;

C. Provide continuity of operations by eliminating corrosion-related failures of systems and subsystems;

D. Minimize to a tolerable limit the detrimental effects to facilities belonging to others that may be caused by stray earth currents from transit operation; and,

E. Provide a means for monitoring stray current and corrosion control systems including electrical continuity, cathodic protection, and coating integrity.

(iii) DB Co shall ensure all structures be protected against environmental conditions by the use of coatings, insulation, cathodic protection, electrical continuity, or a combination of the preceding, as appropriate.

12.3 General Requirements

(a) DB Co shall design the ground of all Structures and equipment meets the requirements for protection of the public as described in IEC 62128-1 and IEEE C2 NESC 2012.

(b) DB Co shall retain 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 to serve as the responsible professional and approve and coordinate all elements of the corrosion mitigation measures for the Project.

(i) DB Co.'s responsible professional shall be approved by the City and shall provide all reference materials regarding similar projects, certifications, and experience with references for the City's approval.

(ii) DB Co.'s corrosion control measures shall be coordinated by DB Co with the other relevant disciplines including Track, Traction Power, OCS, signaling and Train control, communications, EMI/EMC, facilities, safety, civil, structural, geotechnical, electrical, and mechanical.

(iii) DB Co. shall produce a Project corrosion control and stray current mitigation coordination management plan report to address the corrosion control mitigation technologies to be employed, the coordination with the discipline designers, and the coordination with the adjacent and outside utilities. DB Co shall complete the Corrosion Control and Stray Current Mitigation Coordination Management Plan no later than 120 days after Commercial Close.

(c) 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 implements within 30 calendar days after Commercial Close and completed within the Project design duration for each identified Utility or Structure.

(iii) DB Co shall be responsible to obtain adequate soil/rock samples and ground water samples in areas of anticipated extensive below grade construction. 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) DB Co shall be responsible to obtain in-situ Wenner 4 electrode soil resistivities along the ROW at 150m spacings and at electrode spacings of 1.5, 3.0, 4.5, and 6.0m and at electrode spacings of five times the diagonal distance of the anticipated ground mat diagonal distance. These data shall be used to calculate the Barnes layer resistivity for each layer and both the average and Barnes layer data shall be statistically analyzed to determine the overall corrosivity of the ROW. These data shall also be used in the computer Track-to-earth resistance simulation to calculate the allowable stray current levels and required Track-to-earth resistance to minimize stray current to 0.075 volts earth potential gradient per 300 meter distance perpendicular to the Tracks.

(v) DB 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.

(vi) DB Co shall obtain in-situ soil resistivity measurements, in accordance with IEEE81, using the Wenner 4 pin method at all TPSS locations for the design of ground mats. The location of the in-situ tests shall be within the footprint of the substation location and in accordance with IEEE80.

(d) Stray Current Corrosion Control

(i) DB Co shall develop stray current corrosion control designs and reports early in the project and coordinate with the utility designers and adjacent utilities to ensure that the designs can be implemented during construction of the facilities and utilities and cause no impact to the project schedule. DB Co shall initiate the Stray current corrosion control design within 30 calendar days after Commercial Close and completed within the project duration for each identified Utility or Structure.

(ii) Stray current corrosion control minimum requirements apply to measures installed with the Traction Power System and Trackwork to assure that stray earth traction currents do not exceed maximum acceptable levels. These levels are based on system characteristics and the characteristics of underground Structures and shall be obtained from the soil resistivity study and the load flow program.

(iii) These minimum requirements also apply to measures installed with fixed facilities, and to facilities belonging to others. They are based on anticipated stray earth traction current levels and the characteristics of fixed facilities and other buried Structures.

(iv) DB Co shall perform a baseline stray current survey for post-construction and pre-energization to establish the reference levels of stray current existing prior to energization of the System. DB Co shall ensure the baseline stray current survey include transit facilities, adjacent utilities, and Third Party Utilities and structures. DB Co shall provide the report of this testing to the City.

(v) A revenue stray current survey shall be performed by DB Co no later than 90 days after the start of Revenue Service to determine the levels of stray current generated by the new system extensions on transit facilities, adjacent utilities and Third Party Utilities and structures. The report of this testing shall be provided to the City.

(vi) The DB Co shall provide continuous Track to ground current monitoring to detect any stray current faults.

(vii) DB Co shall provide an annual survey that includes stray current monitoring for transit structures and adjacent utility structures at least 90 days prior the end of the construction warranty period and provide the reports to the City

(viii) DB Co shall provide Track-to-earth resistance testing for all Track during construction including Mainline Track and Yard Track of Track-to-earth resistance unless measures are incorporated to allow for indirect testing of Track-to-earth resistance during revenue serviced provide the reports to the City.

(e) 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) DB Co shall apply the requirements 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) DB Co shall ensure that the electrical insulation 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).

(f) Coatings

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

A. Minimum thickness as recommended for the specific system, but not less than 380 microns in accordance with NACE International Standard SP0169 and the manufacturers' recommendations;

B. A chemical or mechanical bond to the metal or concrete surface; Pressure-sensitive systems shall not be accepted; non-bonding systems may be used in special instances, after review;

C. Minimum 15-year performance record for the intended service;

D. Mill application wherever possible, with field application of a compatible system; and,

E. Mechanical characteristics capable of withstanding installation abuse during handling and earth pressure after installation for the Design Life of the system.

(g) Electrical Insulation of Piping

(i) DB Co shall design all devices used for electrical insulators for corrosion control to include non-metallic inserts, insulating flanges, couplings, unions, and/or concentric support spacers.

(ii) DB Co shall design all devices to meet the following requirements:

A. A minimum resistance of 10 Megaohms prior to installation;

B. Sufficient electrical resistance after insertion into the operating piping system such that no more than 2 percent of a test current applied across the device flows through the insulator, including flow through conductive fluids if present;

C. Mechanical and temperature ratings equivalent to the Structure in which they are installed;

D. Internal coating (except complete non-metallic units) with a polyamide epoxy for a distance on each side of the insulator equal to two times the diameter of the pipe in which they are used. Where conductive fluids with a resistivity of less than 2,000 ohm-centimeters are present, internal coating requirements shall be based on separate evaluation and comply with NSF/ANSI 61 for potable water systems;

E. Devices (except non-metallic units) buried in soils shall be encased in a protective coating bonded coating or a petrolatum 4 part coating system;

F. Devices (except non-metallic units) installed in chambers or otherwise exposed to partial immersion or high humidity shall have a protective coating applied over the components or a petrolatum 4 part coating system;

G. Inaccessible insulating devices, such as buried or elevated insulators, shall be equipped with accessible permanent test facilities; and,

H. In the event that construction of the System disturbs or affects an existing grounding system, DB Co shall be responsible for the reinstatement or modification of the system equal to the pre-existing conditions.

(iii) DB Co shall ensure a minimum clearance of 300mm is provided between new and existing metallic structures. When conditions do not allow a 300mm clearance, the design shall include special provisions to prevent electrical contact with existing Structure(s).

(h) Electrical Continuity of Piping

(i) DB Co shall ensure electrical continuity is provided for the non-welded metallic pipe joints and shall meet the following requirements:

A. Use of direct burial, insulated, stranded, copper wire with the minimum length necessary to span the joint being bonded;

B. Wire size shall be based on the electrical characteristics of the structure and resulting electrical network to minimize attenuation and allow for cathodic protection; and,

C. Any coating damage incurred from the installation of pipe joint bonds shall be repaired.

(ii) DB Co shall design a minimum of two wires per joint for redundancy.

(i) Cathodic Protection

(i) DB Co shall accomplish cathodic protection by sacrificial galvanic anodes to minimize corrosion interaction with other underground Utilities. DB Co shall use impressed current systems only when the use of sacrificial systems is not technically and/or economically feasible. DB Co shall not use cathodic protection schemes that require connection to the transit System negative return system, in lieu of using a separate isolated anode ground bed.

(ii) DB Co shall coordinate all cathodic protection systems with the utility operators including water mains, gas mains, petroleum pipelines, power transmission/distribution pipe type cables, lead sheath cables, underground storage tanks, and any other structure that can be impacted by stray current and/or corrosion control.

(iii) DB Co shall base the Cathodic protection system design on theoretical calculations that include the following parameters:

A. Estimated percentage of bare surface area (minimum 1 percent);

B. Cathodic protection current density;

C. Estimated current output per anode;

D. Estimated total number of anodes, size, and spacing;

E. Minimum anode life of 30 years; and,

F. Estimated anode ground bed resistance.

G. Impressed current rectifier systems shall be capable of operating in constant voltage, constant current or potential control mode. Rectifiers shall be rated at a minimum of 50 percent above calculated operating levels to overcome a higher-than-anticipated anode ground bed resistance, lower-than-anticipated coating resistance, or presence of interference mitigation bonds. Other conditions which may result in increased voltage and current requirements shall be considered.

H. Test facilities consisting of a minimum of two structure connections, one coupon reference electrode connection, conduits and termination boxes shall be designed to permit initial and periodic testing of cathodic protection levels, interference currents, and system components (anodes, insulating devices, and continuity bonds). The designer shall specify the locations and types of test facilities for each cathodic protection system.

(j) Structures and Facilities

(i) The following paragraphs establish the protective measures to be incorporated for specific underground Utilities and buried Structures.

A. Ferrous Pressure Piping

i. All new buried cast iron, ductile iron, and steel pressure piping shall be cathodically protected. System design shall satisfy the following minimum requirements and in accordance with NACE International SP0169;

ii. Application of a bonded protective coating to the external surface of the pipe;

iii. Electrical insulation of pipe from interconnecting pipe, other Structures and segregation into discrete electrically isolated sections depending upon the total length of piping;

iv. Electrical continuity through the installation of copper wires across the mechanical pipe joints other than intended insulators;

v. Permanent test/access facilities to allow for verification of electrical continuity, electrical effectiveness of insulators and coating, and evaluation of cathodic protection levels, installed at the insulated connections. Additional test/access facilities shall be installed at intermediate locations, at intervals determined on an individual Structure basis; and,

vi. Number and location of anodes and size of rectifier (if required) shall be determined on an individual Structure basis.

B. Copper Piping

i. Buried copper pipe shall be cathodically protected and electrically isolated from non-buried piping, such as that contained in a Station Structure, through use of an accessible insulating union installed where the piping enters through a wall or floor. Pipe penetrations through walls and floors shall be electrically isolated from building structural elements. The insulator shall be located inside the Structure and not buried.

C. Gravity Flow Piping

i. Corrugated steel piping shall be internally and externally coated with a sacrificial metallic coating and a protective organic coating.

ii. Cast or ductile iron piping shall be designed and fabricated to include the following provisions:

1 An internal mortar lining with a bituminous coating on ductile iron pipe only (not required for cast iron soil pipe);

2 A bonded protective coating on the external surfaces in contact with soils;

3 An unbounded dielectric encasement shall not be allowed; and,

4 A bituminous mastic coating on the external surfaces of pipe 150mm on each side of a concrete/soil interface.

iii. Reinforced concrete non-pressure piping shall include the following provisions:

1 Water/cement ratios meeting the minimum provisions of ACI Publication 201.2R ACI Publication 222R; and,

2 Maximum 250 ppm chloride concentration in the total concrete mix.

D. Electrical Conduits

i. Buried metallic conduits shall include the following provisions:

1 Galvanized steel with PVC or other coating acceptable for direct burial, including couplings and fittings. The PVC coating is not required when conduits are installed in concrete; and,

2 Electrical continuity through use of standard threaded joints or bond wires installed across non-threaded joints.

E. Hydraulic Elevator Cylinders

i. Steel hydraulic elevator cylinders shall be designed, fabricated and installed to meet the following requirements:

1 External protective coating resistant to deterioration by petroleum products;

2 Outer concentric FRP casing. Casing thickness, diameter and resistivity shall be designed to prevent moisture intrusion (including the bottom) and to maximize electrical insulation between the cylinder and earth;

3 Sand fill between the cylinder and FRP casing with a minimum resistivity of 100,000 ohm-centimeters, a pH of between 6 and 8 and a maximum chloride content of 250 ppm;

4 Cathodic protection through the use of impressed current with the anodes installed in the sand fill;

5 Permanent test facilities installed on the cylinder, anodes and earth reference to permit evaluation, activation, and periodic retesting of the protection system;

6 Removable moisture-proof sealing lid installed on the top of the casing prior to installation of the cylinder. The top of the casing shall be permanently sealed against moisture intrusion after installation of the cylinder; and,

7 Alternative protective measures in lieu of cathodic protection shall be Union Gard 160 or equal.

(ii) Buried Concrete/Reinforced Concrete Structures

A. The design of cast-in-place concrete Structures shall be based on the following provisions and the Design Life requirements included 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.

B. Precast standardized facilities, such as vaults and maintenance holes, shall be reviewed on an individual basis to determine alternative requirements when they cannot be practically modified to meet some or all of the requirements herein.

C. Precast segmented concrete ring construction shall meet the requirements of this Article 12 or be reviewed on an individual basis to determine alternative requirements when they cannot be practically modified to meet some or all of the provisions specified.

D. Support Pilings

i. The following is 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:

1 A Design Life as per the requirements included in Schedule 15-2, Part 1, Article 4 – Design and Construction;

2 Water/cement ratio and cement types in accordance with Applicable Codes;

3 Chloride restrictions for concrete with non-prestressed members shall be in accordance with Applicable Codes;

4 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,

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

iv. 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) This section provides requirements for designs to minimize the corrosive effect of stray earth traction currents from transit operations on transit Structures and Adjacent Structures.

(ii) Stray current control shall reduce or limit the level of stray currents at the source, under normal operating conditions, rather than trying to mitigate the corresponding effects (possibly detrimental) which may otherwise occur on transit facilities and other underground Structures. The basic requirements for stray current control are as follows:

A. Maximize the isolation of the electrical systems and prevent inadvertent electrical connections between the positive and negative Traction Power distribution circuits and ground; and,

B. Design the Traction Power System and Trackwork to minimize stray earth currents during normal revenue operations.

(iii) Traction Power System

A. Traction Power supply System shall be designed as a dedicated system, providing power to the System. The Traction Power supply System shall be designed electrically isolated.

B. TPSS shall be spaced at intervals such that maximum Track-to-earth potentials do not exceed 50 volts during normal operations and 75 volts during contingency operation as defined in Article 14 – Overhead Contact System, of this Part 3.

C. Substations shall be provided with access to the dc negative bus and ground mat for stray current monitoring in the same enclosure. Access shall be provided either inside, through use of dedicated space if available, or outside through the use of a weather tight enclosure with an open conduit between the enclosure and the dc negative bus.

D. Substations shall be provided with a Utility drainage panel(s) for connection of Utility drain cables if deemed necessary. The drainage panels shall be connected through a raceway system to a drainage pullbox exterior to the substation to facilitate Utility interconnection.

E. Provisions shall be included to monitor Track-to-earth potentials on a continuous basis at TPSS.

F. TPSS shall include a negative return shunt with test lead access to the current monitoring terminals in the negative bus and ground mat enclosure identified in C above.

(iv) Positive Distribution System

A. Positive distribution system shall be normally operated as an electrically continuous bus, with no breaks, except during Emergency or fault conditions. Intentional electrical segregation of mainline positive distribution systems is the only type of segregation permitted.

B. OCS, consisting primarily of support poles, insulators, the contact wire and the messenger wire, shall be designed to meet the following minimum requirements and include the following minimum provisions:

i. Discrete grounding of individual at-grade support poles, in lieu of interconnecting poles to each other or to a common ground electrode system. Establish electrical continuity of reinforcing steel in OCS support poles by fillet welding of the reinforcing steel and electrically connect support poles to the foundation reinforcing steel through the use of an embedded plate to protect the copper bond cables from vandalism; and,

ii. Common grounding of support poles on aerial structures through electrical connection to either bonded (welded) reinforcing steel in the deck or to each other and a common ground electrode system, when present.

(v) Negative Return System

A. Running Rails. The mainline, including Special Trackwork, and grade crossings shall be designed to have a minimum, uniformly distributed, in-service resistance to earth per 300 m of Track (two rails) (based on 115# rail resistance) as determined by the following:

i. A computerized simulation shall be used to determine the level of stray current to be permitted and the required Track to earth resistances; and,

ii. Soil layer resistivity (ASTM G-57) along the entire alignment shall be used in the above simulation to determine anticipated earth potential gradients.

B. The requirements shall be met through the use of appropriately designed insulating Track fastening devices, such as insulated tie plates, insulated rail clips, direct fixation fasteners, rail boots, or other approved methods.

C. Ballasted Track construction shall meet the following minimum provisions:

i. Use of a hard rock, non-porous, well drained ballast material;

ii. A minimum 25mm clearance between the ballast material and the metallic surfaces of the rail and metallic Track components in electrical contact with the rail;

iii. Mainline Track shall be electrically insulated;

iv. Mainline Track shall be electrically insulated from foreign railroad connections (sidings) by use of insulating rail joints. Location of the insulating joints shall be chosen to reduce the possibility of a vehicle bridging the insulator(s) for a time period larger than required moving onto or off mainline;

v. Select grade crossing and Track locations shall utilize permanent reference electrode arrays with test stations for monitoring of stray current activity and evaluating the isolation of Track. The requirements for the use of these earth potential gradient test arrays shall be based upon a case by case review of the Track or grade crossing location, type of Track construction, adjacent critical utility Structures and others as deemed appropriate.

D. Track-to-earth resistance shall be monitored periodically during construction to detect variations or decrease in resistance. Investigations shall be initiated as soon as a low resistance reading is obtained and the cause of the low reading repaired.

E. Minimum Track-to-earth resistance requirements based on the type of Track shall be based on the computer simulation and not less than the following values:

i. Concrete tie-and-ballast Track, yard and mainline, 500 ohms-300-Track meters;

ii. Direct fixation Track, 500 ohms-300-Track meters;

iii. Embedded Track using girder rail with rail boot system including special Track construction, 250 ohms-300-Track meters;

iv. Embedded Track using tee rail with rail boot and snap-on flangeway filler, 200 ohms-300-Track meters; and,

v. Embedded Track using tee rail with rail boot and screeded concrete flangeway, 200 ohms-300-Track meters.

F. Ancillary Systems

i. Switch machines, signalling devices, Train to wayside Communication Systems, and other devices or systems attached to the rails shall be electrically isolated from the rails. The requirements shall be met through the use of dielectric materials electrically separating the devices/Systems from the rails.

G. Electrical Continuity

i. The running rails shall be constructed as an electrically continuous Traction Power return circuit through use of rail joint bonds, continuously welded rail, or a combination of these, except for the use of insulated rail joints at specific locations. To allow isolation of each special Trackwork area, the maximum spacing between insulated joints shall be 3000m. The linear resistance of each individual negative rail shall not exceed the resistivity of the steel alloy used for the running rails (18 micro-ohm centimeters), the cross sectional area of the running rail, and the length of the running to calculate the actual resistance.

(vi) Underground Trackway 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:

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

ii. Welding of all longitudinal members to a transverse (collector) member at intervals not exceeding 150 m and at electrical (physical) breaks in the longitudinal reinforcing steel, such as at expansion joints; and,

iii. 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.

B. 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.

C. Precast segmented concrete ring tunnel construction shall meet the requirements in Section 3.1 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:

i. Embedded steel reinforcing members should be constructed without special provisions for establishing electrical continuity.

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

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

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

D. Steel liner tunnel construction must 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.

(vii) Aerial Trackway Structures

A. Column and Bearing Assemblies, Tie and Ballast

i. This section applies to aerial structures 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.

ii. 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 x 1012 ohm-cm.

iii. 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.

B. Column and Bearing Assemblies, Direct Fixation.

i. This section applies to aerial Structures 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.

ii. 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.

iii. 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.

iv. 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 150 m between collector bars.

v. 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 450 m. The number, location, and earth resistance of the ground electrode system shall be determined on an individual structure basis.

vi. Provide test facilities at each end of the Structure and at intermediate locations to maintain a maximum spacing of 500 ft between test points. The facilities shall house test wires from the collector bars and ground electrode system, if present.

vii. 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.

C. Bents and Girders, Tie and Ballast

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

ii. 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.

iii. 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.

iv. 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.

v. 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.

vi. 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.

vii. 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.

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

ix. 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 x 1012 ohm-cm.

D. Bents and Girders, Direct Fixation.

i. This section applies to aerial Structures that use bent type supports with reinforcing steel extending into the deck/girders. Girders can

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

iii. 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 installed on each side of a break with a minimum of two cables.

iv. 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.

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

vi. 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.

vii. 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.

viii. 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 will house bonding cables from adjacent collector bars on each side of the hinge/joint. Facilities at columns/bents will house two wires from vertical column/bent steel and from the collector bar at the top of the bent.

ix. 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.

E. Concrete Deck/Exposed Steel, Tie and Ballast

i. This section applies to 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.

ii. 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 x 1012 ohm-cm.

iii. 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.

iv. 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.

F. Concrete Deck/Exposed Steel, Direct Fixation.

i. This section applies to 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.

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

iii. 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.

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

v. If the total structure length exceeds 3,000m 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 450m. The number, location and earth resistance of the ground electrode system shall be determined on an individual structure basis.

vi. 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 will house test wires from the collector bars and ground electrode system, if present.

vii. 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.

viii. 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 must be established by appropriate welding and bonding procedures.

ix. 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.

(l) OCS Pole Foundation Grounding

(i) All metallic components, inclusive of the pole baseplate, that shall be partially embedded or come in contact with concrete surfaces shall be coated with a sacrificial/barrier coating. The coating shall be applied to the entire component. The coating shall extend a minimum of 152.4mm into the concrete and a minimum of 12.7mm above the surface of the concrete.

(ii) At-Grade OCS Support Poles

A. Electrical continuity of reinforcing steel within support pole foundations shall be established to provide an adequate means for dissipating any leakage current from the contact wire and, where applicable, the messenger wire. The following minimum provisions shall be included with design:

i. The outermost layer of vertical reinforcing steel within the concrete foundation shall be tack welded at the intermediate vertical lap joints and to reinforcing bar collector rings (two) installed at the top and bottom of the reinforcing bar cage;

ii. A copper cable shall be connected between the base of the catenary support pole and the foundation reinforcing steel. The cable shall be thermite welded or brazed to the support pole and routed in such a manner that it shall not be susceptible to damage during construction or after installation is complete. The connection to the pole shall be coated with a zinc-rich weather resistant coating material; and,

iii. The copper cable shall be sized based upon anticipated fault current and fault clearing time.

(iii) OCS Poles on Aerial Structures

A. OCS poles located on aerial structures shall include either of the following minimum set of provisions, depending on the type of aerial structure.

B. Where the aerial structure includes welded deck reinforcing steel connected to a ground electrode system, electrically interconnect the OCS support poles on the structure and connect these poles to the ground electrode system.

i. Cabling used to interconnect the poles and the ground electrode system shall be sized based upon anticipated fault current and fault clearing time.

ii. The cabling shall be routed in conduit and terminated in junction boxes or test cabinets that also house wires from the deck reinforcing steel and the ground electrode system.

iii. Cabling shall be designed to allow for connection of interconnected OCS poles along the aerial structure to the ground electrode systems installed with a particular aerial structure.

C. Where the aerial structure has welded deck reinforcing steel but does not include a ground electrode system, electrically connect the OCS support poles to the welded deck reinforcing steel.

i. Provide a copper cable from each OCS support pole to the deck reinforcing steel. The copper cable shall be sized based upon anticipated fault current and fault clearing time.

ii. Thermite weld or braze the cable to the OCS support pole and to the nearest transverse collector bar installed in the aerial structure deck.

iii. Where it is not practical to connect an OCS pole directly to a transverse collector bar, because of excessive distance or other factors, connect the pole to a local transverse reinforcing bar using a copper cable and weld the transverse reinforcing bar to at least three upper layer longitudinal reinforcing bars in the deck.

(m) Utility Structures

(i) Piping and conduit shall be non-metallic, unless metallic facilities are required for specific engineering purposes.

(n) Metallic Facilities (Systemwide)

(i) Pressure or non-pressure piping exposed in crawl spaces or embedded in concrete inverts shall not require special corrosion prevention provisions.

(ii) Pressure piping that penetrates foundation, or Station walls shall be electrically insulated from the external piping to which it connects and from watertight wall sleeves. Electrical insulation of interior piping from external piping shall be made on the inside of the foundation or wall.

(o) Facilities Owned by Others

(i) Replacement/Relocated Facilities

A. Corrosion control facilities provided for protection of buried Utilities and installed by DB Co as part of the System shall become the responsibility of the individual Utility owner/operator following acceptance of the corrosion protection system.

B. DB Co shall protect the buried Utilities including City water mains so that the maximum anodic potential shift caused by dynamic stray currents on any water main or buried Utility along the alignment shall not exceed 50 mV anodic shift from the average baseline value of the voltage time data logger graphs. Monitoring locations of the dynamic potential shifts and stray currents shall be at the discretion of the Utility operators. DB Co shall obtain copies of the sample baseline monitoring charts and information on some of the possible future monitoring locations from the individual Utilities. Such testing shall be performed by a corrosion/cathodic protection specialist. Where the anodic shift exceeds 50 mV, cathodic protection shall be installed by DB Co at all affected areas to

mitigate any adverse impact of corrosive stray currents that are induced by the System.

C. Relocated or replaced Utilities installed by DB Co as part of a separate contractual agreement between DB Co and the Utility, shall be installed in accordance with the Utility owner agreed upon specifications and shall include the following minimum provisions. These provisions are applicable to ferrous and reinforced concrete pressure piping. Other materials and Structures shall require individual review.

i. Electrical continuity through the installation of insulated copper wires across the mechanical joints for which electrical continuity cannot be assured;

ii. Electrical access to the Utility Structure via test facilities installed; and,

iii. The need for additional measures, such as electrical isolation, application of a protective coating system, installation of cathodic protection, or any combination of the preceding, shall be based on the characteristics of the specific Structure and to not adversely affect the existing performance within the environment.

(ii) Existing Utility Structures

A. The need for stray current monitoring facilities shall be jointly determined by DB Co and the individual Utility operators. If utilities have no stray current guidelines, DB Co shall provide direction based on the following:

i. Test facilities at select locations for the purpose of evaluating stray earth current effects during start-up and revenue operations. Guidelines for location of test facilities shall be as follows:

1. At the utility crossings with the system and on Structures parallel to the Tracks; and,

2. At locations on specific utility Structures that are near the System TPSS.

(iii) Existing Bridge Structures

A. Stray current corrosion control for existing Bridge Structures shall be addressed by limiting earth current levels at the source (running rails). Meeting the requirements established shall provide the primary stray current control for these facilities.

(p) Corrosion control coatings

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

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

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

(iv) Metallic-Sacrificial Coatings

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

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

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

iii. Aluminum-zinc;

iv. Cadmium and electroplated zinc (sheltered areas only); and,

v. Inorganic zinc (as a primer).

(v) 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, are as follows:

i. Aliphatic polyurethanes;

ii. Vinyl copolymers;

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

iv. Acrylics, where not exposed to direct sunlight;

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

vi. Epoxy as a primer where exposed to the atmosphere or as the complete System where sheltered from sunlight.

(vi) Conversion Coatings

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

(vii) Ceramic-Metallic Coatings (Cermets)

A. This hybrid-type coating system shall be acceptable for use on metal panels and fastening hardware.

(viii) Sealants

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

(ix) Barrier Coating System

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

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

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

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

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

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

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

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

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

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

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

(q) Grounding Coordination

(i) Coordination shall be undertaken to ensure that grounding design and corrosion control measures do not conflict so as to render either the grounding system or the corrosion control system ineffective.

(r) DB Co shall implement a stray current test program prior to Commissioning. The DB Co test program shall be a pre-operation baseline and serve as the basis for decisions regarding mitigation of System caused stray current impacts.

ARTICLE 13 TRACTION POWER SYSTEM

13.1 Scope of Work

(a) The Traction Power supply System shall consist of a network of TPSS and all equipment between the interface point with **[REDACTED]** and/ or **[REDACTED]** and the interface point with the catenary and the negative return systems and the interface points of the Existing Confederation Line TPS. The TPS shall be designed and constructed to accommodate future expansion. This section provides the performance objectives for the TPS. The TPS shall be designed to be an integrated system for supplying power to the Vehicles, switch heaters, and related equipment in order to meet the Project operational performance requirements provided in Schedule 15-2, Part 1, Article 3 – Operational Performance Requirements. These criteria govern the design, performance, and installation requirements of the TPS. The system shall provide safe, efficient and continuous operation in all operational and environmental conditions. The TPS and associated components shall perform to the environmental characteristics defined in Schedule 15-2, Part 1, Article 4 – Design and Construction. In areas where the Traction Power equipment presents high risk of visual intrusion DB Co shall provide design enhancements to minimise or mitigate visual impact. In all other areas, the equipment shall be of a style and appearance similar to that used by comparable transit systems.

(b) The equipment includes, but is not limited to the following: AC cables and raceway systems, AC switchgear, transformer-rectifier unit, DC switchgear, positive and negative raceway systems, positive and negative cables, negative drainage panel and cables, rail to ground monitoring equipment, prefabricated substation housing (or dedicated space in or adjacent to a Station facility) and foundation, grounding system, protective device systems, communications interface systems, auxiliary power supply system, climate control, UPS systems, intrusion access control system, interior and exterior CCTV cameras, MV lightning arresters, high voltage protection, alarm control, monitoring health and safety equipment, and SCADA equipment.

13.2 Codes, Standards and Manuals

(a) The design and construction of the Works shall comply with the criteria contained in this Article 13, 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. In the event of a conflict between criteria, commitments or requirements contained within one document when compared with another, the more stringent shall apply:

(i) ANSI;

A. ANSI C34.2-1968, Practices and Requirements for Semiconductor Power Rectifiers

B. ANSI C37.14-2015 - IEEE Standard for DC (3200 V and below) Power Circuit Breakers Used in Enclosures

C. ANSI C37.20.2-2015, IEEE Standard for Metal-Clad Switchgear

D. ANSI C37.20.6-2015 - IEEE Standard for 4.76 kV to 38 kV Rated Ground and Test Devices Used in Enclosures

E. ANSI C57.12.01-2015, Standard Requirements for Dry Power Transformers

F. IEEE C57.18.10 Requirements for Semiconductor Power Rectifier Transformers

G. IEEE C57.12.91 Requirements for Dry-Type Distribution and Power Transformer

(ii) NEMA;

(iii) CSA;

(iv) City of Ottawa Codes and By-Laws;

(v) IEEE;

A. IEEE 80-2013, IEEE Guide for Safety in AC Substation Grounding

B. IEEE 519-2014, IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems

C. IEEE 1653.2-2009, IEEE Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output

D. IEEE C37.14-2015, IEEE Standard for Low Voltage DC Power Circuit Breakers Used in Enclosures

E. IEEE C37.20-2015, IEEE Standard for Metal Clad Switchgear

F. IEEE 81-2012 Guide for measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of A Grounding

(vi) IEC;

A. IEC 61992-1:2006, Railway applications - Fixed installations - DC switchgear - Part 1: General

B. IEC 61992-2:2006: Railway applications - Fixed installations - DC switchgear - Part 2: DC circuit-breakers

C. IEC 62271-1, High-voltage switchgear and control gear—Part 1: Common specifications

D. IEC 62271-100, High-voltage switchgear and control gear—Part 100 High voltage alternating current circuit breakers

E. IEC 62271-1020, High-voltage switchgear and control gear—Part 102 Alternating current disconnect switches and earthing switches

F. IEC 62271-200, High-voltage switchgear and control gear—Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV

(vii) UL and ULC;

(viii) IBC;

(ix) ICEA;

(x) EIA;

(xi) ASTM;

(xii) NETA;

(xiii) NECA;

(xiv) OEC;

(xv) OESC;

(xvi) AREMA;

(xvii) APTA; and,

(xviii) NFPA:

A. NFPA 72: National Fire Alarm and Signaling Code.

13.3 Performance Requirements

(a) DB Co shall provide a Traction Power System that is a fully integrated system of TPSS which shall support normal and contingency operations with no degradation of performance. Normal and contingency operation of the TPS shall be defined as:

(i) Normal: The Traction Power supply System is in full operation with all feeder breakers in closed positions. All scheduled service is running in accordance with the headway and consist with all civil speeds applied; and

(ii) Contingency: The Traction Power supply System shall maintain full performance service with any one TPSS completely out of operation. In order to maximize the allowable Train voltage during contingency operations, the DC breakers shall remain closed or the motor operated DC bypass switches and paralleling switches shall be closed at the affected TPSS thereby utilizing the TPSS as a DC tie station. At end of line substations motor operated DC OCS paralleling switch shall be closed when the end of the line TPSS is out of operation.

(b) DB Co shall design, procure, install, and test the Traction Power System to perform satisfactorily under the environmental conditions identified in Schedule 15-2, Part 1, Article 4 – Design and Construction.

(c) DB Co shall design, procure, install and test a The Traction Power System that is a high resistance grounded system, meaning the running rails are insulated from ground and there is no intentional connection to ground (earth potential).

(d) The traction return shall be through both running rails of each Track and cross-bonds shall be installed where necessary. Negative cables shall be appropriately sized between the running rails and the TPSS. As per the Existing Confederation Line, a bolted connection shall be used to connect the negative return cables to the running rails.

(e) DB Co shall base the design and analysis of the TPSS locations and ratings and voltage shall be confirmed by load flow studies that DB Co performs. The studies shall be real time computer generated simulations of the electrical system utilizing validated traction system software and performance based upon the operational performance requirements. The load flow study shall utilize the following criteria:

(i) Final Track alignment:

A. Track horizontal alignments, vertical profiles, Station locations, and operating speeds shall be based on the latest Track drawings.

(ii) Operating Plan:

A. Normal Operations:

i. 2 minute headways: Lincoln Fields Station to Trim Station.

ii. 4 minute headways: Baseline Station to Lincoln Fields Station.

iii. 4 Minute headways Moodie Station to Lincoln Fields Station.

B. Contingency Operations:

i. 2 minute headways: Lincoln Fields Station to Blair Station.

ii. 2-2-4 minute headways: Blair Station to Trim Station.

iii. 4 minute headways: Baseline Station to Lincoln Fields Station.

iv. 4 minute headways: Moodie Station to Lincoln Fields Station.

(iii) Utility Source Short Circuit Availability: 250 MVA.

(iv) TPRU:

A. 3 MW Extra heavy traction service per IEEE 1653.2.

B. DC voltage regulation is 5.0% up to 200% load, 5.25% between 200% to 300% load, and 5.5% above 300% load.

(v) Substations:

A. 14 new 3 MW TPSS's:

i. On the Confederation Line East Extension: Montreal Station, Jeanne d'Arc Station, Orleans Blvd Station, Place d'Orléans Station and Trim Station.

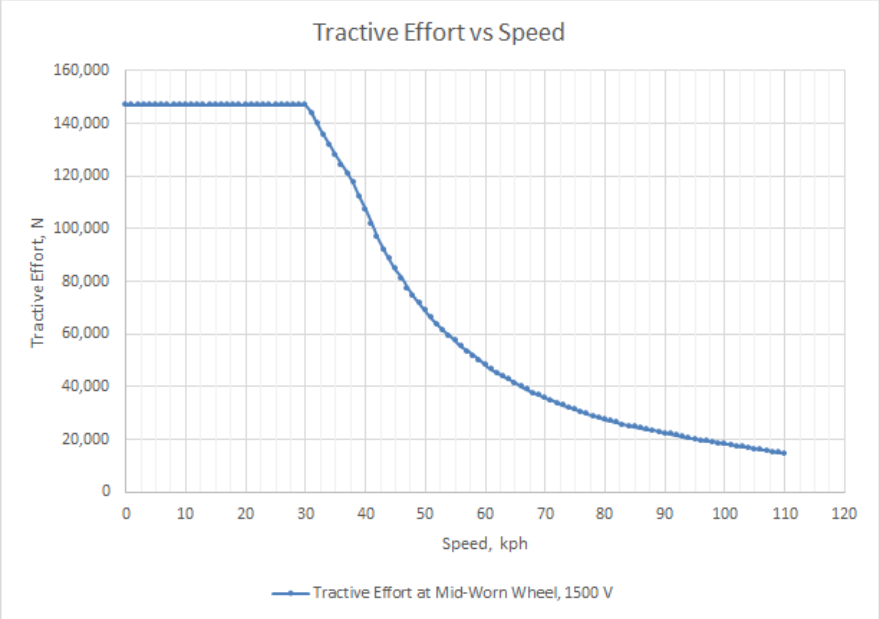
ii. On the Confederation Line West Extension: Dominion Station, Cleary Station, Lincoln Fields Station, Baseline Station, Queensview Station, Bayshore Station, Moodie Station, Moodie LMSF and one I MW TPRU at Moodie LMSF Shop.

(vi) Light Rail Vehicle:

A. **[REDACTED]** two car Train with AW2 loading. Vehicle operates at full performance above 1275V. Per the Vehicle manufacturer, between 1275V and 1050V, the current is reduced from 100% to 0%. At 1050V the Vehicle has no tractive effort.

Parameter	Value
Nominal Voltage	1500 V dc
Cars per Train	2 cars per Train
Car length	48.89m per car

Axels per car	10
AW2 full weight	103,548 kg per car
AW0 full weight	80,028 kg per car
Rotational mass	5,332 kg per car
Auxiliary power	62.5 kW per car
Frontal area	8.3 m^2
Wheel flange coefficient	0.045
Air drag coefficient, lead car	0.0024
Air drag coefficient, trailing car(s)	0.00034
Average curve resistance (lbs per ton per degree of curvature)	0.8
Acceleration Limit at AW2 (excluding rolling resistance effort)	1.35 m/s^2
Deceleration for Station stops	0.89 m/s^2
Regenerative braking	Not Used



(vii) Running Rails:

A. Two 115 lb RE rails per Track at 60 deg C, 10% worn.

(viii) Leakage Resistance:

A. Direct fixation, rail-to-earth resistance 500 ohms*kft for single-Track, two rails.

(ix) Cross Bonding:

A. 2000 V, 3-1/c 500 kcmil, copper conductor, 75 deg C, 30 ft length.

(x) Positive Feeders:

A. 2000 V, 3-1/c 500 kcmil, copper conductor, 75 deg C, 300 ft length.

(xi) Negative Feeders:

A. 2000 V, 3-1/c 500 kcmil, copper conductor, 75 deg C, 200 ft length.

(xii) OCS:

A. 350 kcmil copper contact wire, 30% worn, and 500 kcmil copper messenger wire at 60 deg C

(xiii) Acceptance Criteria:

Parameter	Value
Maximum allowable equipment voltage	1800 V dc
Nominal system voltage	1500 V dc
Train tractive effort knee voltage (Beginning of performance reduction)	1275 V dc
Minimum allowable train voltage during normal operations	1275 V dc
Minimum allowable train voltage during contingency operations	Between 1275 V and 1050 V for less than 0.5% of complete train trip
Absolute minimum allowable train voltage	1050 V dc
Maximum allowable running-rail to ground voltage under contingency operation	75 V dc
Maximum allowable running-rail to ground voltage under normal operation	50 V dc

Rectifier Size	Rating
1000 kW, 1500 V dc	667 A continuous (100%) 3000 A peak (450%)
3000 kW, 1500 V dc	2000 A continuous (100%) 9000 A peak (450%)

A. Rectifier operation shall not exceed the continuous rating. DB Co shall provide a TPS that is a fully integrated system of TPSS that shall support normal and contingency operations with no degradation of performance, and no time limits are given for contingency operation.

(f) The TPS shall be fully integrated into the Existing Confederation Line TPS including but not limited to incorporation into the SCADA head end, interface of SCADA functions including DC bypass switch status and transfer trips. TPSS protection and control system must be integrated with SCADA as per the Existing Confederation Line design.

(g) DB Co shall furnish, install, and commission DC switchgear in two existing end of line Phase 1 TPSS's to accommodate the expansion of the TPS in Phase 2. The DC switchgear shall include, but is not limited to, two DC feeder breakers including cubicles, bus detail, DC disconnect switches and tie switches, protective relays, duct banks, wires, cables, and appurtenances.

(h) The Traction Power system for the Moodie LMSF shall be electrically separate and isolated under normal operations from the remainder of the Traction Power System. This shall apply to both the positive and negative sides of the Traction Power Systems. The Moodie LMSF TPSS shall have a backup feed from a mainline TPSS, and the backup shall also be able to power the DC shop supply.

(i) The electrical limits of the Traction Power System (excluding OCS) shall be the System side of the **[REDACTED]/[REDACTED]** disconnect switch on the Utility side and up to and including the OCS disconnect switches on the OCS distribution side. The installation limits shall include the **[REDACTED]/[REDACTED]** switch foundation and Infrastructure in compliance with utility standards.

(j) All TPSS equipment shall be CSA or UL/ULC approved.

(k) The Traction Power System shall meet the requirements set out in IEEE 519 for harmonic disturbance and any requirement outlined by **[REDACTED]/[REDACTED]**.

(l) DB Co shall develop a protective device coordination plan and relay settings for the Traction Power System.

(m) The supply voltage selected by DB Co shall be supported by a complete computer simulation and engineering analysis.

(n) Significant effort has been made during Preliminary Engineering in working with **[REDACTED]/[REDACTED]** and in capacity and planning delivery of power feeders to Supply Points (X – Y coordinates) across the alignment. DB Co shall make every effort to utilize these power Supply Points during design. Any changes in **[REDACTED]/[REDACTED]** Supply Points locations as a result of design shall be borne by DB Co.

13.4 Traction Power Substations

(a) The TPSS shall be located as close to Passenger Stations and the Guideway as possible.

(b) Negative rail voltage rise shall be limited to 50V under normal operation and 75V under outage conditions. Rail to ground sensing devices shall be implemented to monitor the negative voltage to ground and "clamp" the rails to ground upon exceeding preset limits.

(c) Minimum Train voltage shall be coordinated with the Vehicle manufacturer.

(d) All TPSS equipment with the exception of the medium voltage switchgear, shall be standardized, and allow for interchanging of equipment and spare parts. Medium voltage switchgear equipment and spare parts shall be standardized and interchangeable within their voltage class. Integration of TPSS equipment shall be the sole responsibility of a single manufacturer/supplier.

(e) Each TPSS shall be furnished internally with emergency trip stations adjacent to each entrance. The emergency trip station shall, upon activation, de-energize the entire TPSS and its associated line sections and the DC sections at adjacent TPSS back feeding into the TPSS.

(f) Mass trip function shall be provided through TPSS SCADA which shall remove power from the overhead catenary system for the entire alignment. The human machine interface shall be operated from the TOCC and BCC.

(g) Building Structures and Foundations

(i) The TPSS shall be completely factory assembled, pre-wired, pre-tested, and installed in a compact, climate controlled, self-supporting, transportable enclosures or provided in Passenger Station rooms designed for the application. The TPSS shall be ready for connection to the Utility interface and outgoing DC feeders prior to shipment. The TPSS shall include all elements necessary to provide Traction Power including the following: the enclosure shall be flush mounted on the concrete foundation (and insulated) to prevent water leaking. All exterior screws/bolts must be vandal resistant and tamper proof. The TPSS

grounding cable must be completely protected and buried to prevent any tampering or vandalism.

A. TPSS shall be designed to minimize their impact on the areas where they are installed. Architectural treatment, to provide an acceptable appearance, may be required for TPSS located in sensitive areas such as those located on or adjacent to Federal Lands.

B. The TPSS enclosure shall at a minimum consist of a structural steel frame, double sided walls and thermal /acoustic insulation; the TPSS shall have watertight insulation and be tested; the test report shall be provided to the City for review.

C. Removal of all large equipment (rectifier transformer, circuit breakers) shall be accommodated without structural modifications; all equipment removal doors shall have a minimum of 4m clearance to any outside obstruction.

D. Interior and exterior lighting shall be provided. Emergency backup power shall be provided for at least 2 interior and 2 exterior TPSS lighting fixtures.

E. Intrusion access control shall be provided to selectively limit access to the TPSS.

F. Fire detection system shall include separate fire alarm control panels and intrusion alarm panels. Activation of the fire alarm system shall trip and lockout the affected TPSS and transmit an alarm to the TOCC, BCC, MYCC and BYCC. Intrusion detection shall provide a remote alarm to the TOCC.

G. The TPSS enclosure shall include interior and exterior CCTV system cameras. Exterior CCTV cameras shall provide the TOCC, BCC, MYCC and BYCC views of all four sides of the TPSS.

(ii) The TPSS enclosure Water Leakage Test: Pre-shipment of the enclosure, perform a water leakage test in the factory by applying a uniform spray of water from hoses for 15 minutes to surfaces to verify the enclosure is completely watertight.

(iii) TPSS located in Station facilities shall contain identical manufacturer switchgear to pre-fabricated TPSS. Performance, testing and environmental requirements for TPSS located in Station facilities or other areas shall match those indicated for pre-manufactured TPSS, indicated in Clause 13.4(g)(i) of this Part 3.

(iv) Foundations shall be designed and constructed based upon local, national and international standards and codes and the structural loading (live and dead loads)

of the TPSS during installation, normal operation, maintenance and faults. The foundation shall be coordinated with the TPSS and distribution elements.

(v) TPSS sites shall have road access for both pedestrians and maintenance vehicles, a minimum of two vehicular parking spaces, and adequate space around each substation to permit the use of heavy maintenance vehicles to remove and deliver the largest pieces of Traction Power equipment. Adequate space shall be provided around the TPSS to allow removal of equipment onto an apron which has 6m clear between the TPSS wall and the nearest Track centre.

(vi) A hard surfaced walkway between the TPSS and the closest Station shall be provided to enable technicians to access the TPSS without having to obtain a Track authority. The walkways shall be separated from the active Train envelope by fencing or other protective barrier.

(h) DB Co shall conduct soil resistivity test at the TPSSs foundation locations. DB Co shall review the soil resistivity test results to confirm the soil meets the standard requirements. DB Co shall ensure that if the soil does not meet the standard requirements, the soil shall be replaced with the proper soil requirement according to IEEE 80. DB Co shall produce and supply the soil test results to the City once complete.

13.5 Traction Power Transformer

(a) Design Tests for Rectifier Power Transformers

(i) Each Traction Power transformer design shall have design tests performed as per IEEE C57.12.01-1989, C57.12.91-2001 and C57.18.10-1998, and design tests indicated in this Article 13.

(ii) Temperature Rise Test: this test is defined as a test to determine the temperature rise above the ambient of one or more transformer windings as measured at the terminals. For conditions under which temperature limits apply, refer to IEEE C57.12.01 for dry type transformers, IEEEC57.12.00 for liquid filled transformers and IEEE 1653.1.

13.6 Traction Power Transformer-Rectifier Units

(a) DB Co shall ensure that each Traction Power transformer and associated traction rectifier is designed as an integral unit. Each Traction Power transformer/rectifier unit shall be tested in accordance with ANSI Test Codes C57.12 and C34.2 and IEEE 1653.2. A complete design test sequence shall be performed on one transformer/rectifier unit of each design, each voltage class, and each rating. The design tests shall include a rated current test, loss measurement and short circuit test to verify the integrity of the mechanical system. For the rated current, loss measurement and short circuit test, test results on a transformer-rectifier unit of duplicate design and rating, and of recent date, can be submitted for review. Rectifier tests, unless otherwise herein specified, shall be

made in accordance with IEEE1653.2. Complete load-cycle test shall be conducted at the factory. Tests shall be conducted at reduced voltage sufficient to attain the load current ratings specified in IEEE1653.2 7.3.3 for Extra Heavy Traction Service. A surge test shall be made to test the effectiveness of the surge protection equipment. In this test an impulse voltage of 75Kv shall be applied to a simulated system from a source with a surge impedance comparable to that of the actual circuit. Routine production tests for rectifier transformers shall be performed by the manufacturer in accordance with IEEE Std. C57.18.10-1998 and IEEE P1653.1. The rectifier's manufacturer shall perform routine production tests on all rectifiers in accordance with IEEE 1653.2-2009.

(i) DB Co shall design the transformer-rectifier units to conform to the following requirements:

A. Rectifier transformer Insulation Class: 220°C, UL or ULC Listed.

B. BIL for static discharge shall be as follows:

i. Insulator Class 15.0 Kv 95 BIL (Kv); and,

ii. Insulator Class 34,5 Kv 150 BIL(Kv).

C. Rectifier transformer maximum temperature rise by resistance of all individual windings at the end of the two hour extra-heavy traction service load cycle: 115°C.

D. Both high voltage and low voltage windings shall be copper conductor.

E. Diode bridge type 12 pulse double way rectifier.

F. Convection cooled with no forced cooling to meet the Extra Heavy Traction Service requirement per IEEE Std. 1653.2.

G. Rated full (100%) load of 3MW.

H. Rated primary input voltage shall be either 13.2 kV or 27.6kV.

I. Rated full (100%) load output voltage: 1500 Vdc.

(ii) DB Co shall ensure that the TPSS locations have been coordinated with and made available to **[REDACTED]/[REDACTED]** in determining the power feed requirements based on a 3MW TPRU. DB Co shall evaluate and confirm through a load flow study that 3MW TPRU are suitable for this system expansion. DB Co shall coordinate with **[REDACTED]/[REDACTED]**. DB Co shall ensure that a displacement power factor of the TPRU shall be 95% or greater has been achieved.

(iii) DB Co shall ensure that the TPRU is protected from damage due to surges and transients transmitted through the utility network with MV surge protection.

(iv) DB Co shall ensure that the overall efficiency of the TPRU is greater than 97.5%.

(v) DB Co shall design the TPRU to comply with ANSI C57.12.01.

(vi) The noise generated by the TPRU shall not exceed 55dBA at full load inside the substation through the use of rectifier load balance, coupling, or interphase transformer, or other alternative method to reduce audible noise.

(vii) DB Co shall design the rectifier transformer supplied from 13.2kV and 27.6kV **[REDACTED]/[REDACTED]** feeders to be dry type, vacuum pressure impregnation or cast coil construction, convection cooled with no forced cooling necessary to meet the IEEE 1653.2 extra-heavy traction operations requirement and two-stage temperature monitoring. DB Co. shall evaluate the need for protective snubber circuits on the TPRU's in substations serviced by 27.6kV feeders. Snubber circuits shall be monitored by TPSS SCADA for health.

(viii) DB Co shall ensure that the High-voltage windings of each rectifier power transformer be wound for their rated voltage and be equipped with a total of five full capacity taps, at 2-1/2% and 5% below nominal and at 2-1/2% and 5% above nominal. DB Co shall ensure that the taps are connected to the high voltage coils so that unbalanced magnetic forces and short circuits will be reduced to a minimum. The tolerance on voltage difference between any pair of adjacent taps shall not exceed ± 1/4%.

(ix) DB Co shall design the TPRU for extra-heavy traction service operation with no damage or degradation of performance. The Extra-heavy traction service is defined in IEEE 1653.2-2009: IEEE Standard for Uncontrolled Traction Power Rectifiers.

(x) DB Co shall ensure that the imbalance in the rectifier caused by loss of one diode per phase not reduce the overload capability of the TPRU.

(xi) DB Co shall ensure that the rectifier is furnished with a negative disconnect switch, two-stage temperature monitoring, two-stage diode monitoring, two-stage enclosure monitoring as a minimum.

(xii) DB Co shall ensure that the each rectifier is furnished with a NGD which shall monitor the potential between the negative bus and the TPSS ground grid. For both above ground and below ground TPSS the NGD shall be connected between the TPSS ground grid and the TPSS negative bus.

(xiii) DB Co shall ensure that the TPRU shall is furnished with digital metering for:

A. DC rectifier current;

B. DC Voltage; and,

C. Winding and rectifier over-temperatures.

(xiv) DB Co shall ensure that the rectifier enclosure energized/grounded protection be provided which shall detect when the enclosure has a positive to frame fault or when grounded. Upon detection of a positive to frame fault the substation shall be automatically shut down. DB Co shall ensure that there is local audio – visual warning which shall be communicated along the SCADA to the TOCC, BCC, MYCC and BYCC.

(xv) DB Co shall produce and provide the traction transformer and traction rectifier test results reports according to standard requirements (IEEE C57.12.01 & C57.12.91 & C57.18.10).

(xvi) DB Co shall provide the performance qualification test result report for each Traction Power transformer-rectifier integrated unit according to IEEE 1653.2. DB Co shall provide testing parameters for the integrated unit under the performance qualification test section in the Project Agreement.

(b) Routine tests for rectifier power transformers:

(i) DB Co shall ensure that the each rectifier power transformer l have routine tests performed as per IEEE Std. C57.12.01-1989, IEEE Std. C57.12.91-2001 and IEEE Std. C57.18.10-1998, plus the following additional tests shall be performed as routine tests. DB Co shall ensure that the impulse test precede all low frequency tests as part of the test sequence.

A. DB Co shall ensure that the impulse tests consisting of the following, are applied in the following order: one reduced full wave, two chopped waves and one full wave. DB Co shall ensure that the details of impulse wave shapes shall be as per IEEE Std. C57.98-1993 “Guide for Transformer Impulse Tests”;

B. Partial discharge test;

C. Load tests:

i. Rated voltage test;

ii. Rated current test; and,

iii. Rated load test.

D. Loss Measurement tests:

i. Efficiency; and,

ii. Forward Current loss.

E. Waveshape tests:

i. Oscillographic tests; and,

ii. Harmonic tests.

F. Excitation loss test; and,

G. Load Loss Test.

(c) DB Co shall ensure that the TPSS AC Switchgear meet the following requirements:

(i) TPSS supplied from 13.2kV and 27.6kV **[REDACTED]/[REDACTED]** feeders shall be equipped with Drawout, metal clad (as defined by ANSI C37.20.2) switchgear which prevents the accidental contact of live parts by maintenance personnel;

(ii) Circuit interrupting devices which do not have load- break capabilities and doors equipped with interlocks to prevent unsafe operations;

(iii) Adequate space for removal and maintenance of both AC and DC circuit breakers;

(iv) Multifunction protective devices for phase imbalance, overcurrent, undervoltage, diagnostics, alarming, monitoring, data storage and power metering;

(v) Equipment to test the AC and DC breakers in the TPSS after it has been removed from its cubicle;

(vi) DB Co shall ensure that the AC switchgear be equipped with Digital metering capable of monitoring and transmitting the following analog functions to SCADA:

A. AC voltage;

B. AC current;

C. Power;

D. Power factor; and,

E. AC Energy metering.

(vii) DB Co shall ensure that the AC switchgear also contain the auxiliary power transformer supplying "house" power for the TPSS building, with appropriate protection and disconnect devices on the primary and secondary. DB Co shall ensure that the auxiliary transformer supply power to the AC distribution panel.

(d) DB Co shall ensure that the DC Switchgear meet the following requirements:

(i) DC switchgear shall be metal enclosed single pole, draw-out type feeder breakers equipped with load measuring auto-reclosing systems, rated to interrupt maximum available fault current;

(ii) The major elements of the TPSS DC switchgear shall consist of a main cathode circuit breaker, high speed DC feeder circuit breakers, and PLC based controller with protection functions;

(iii) PLC based protection and data storage devices shall be provided for the DC circuit breakers. These devices shall perform all the functions of overcurrent protection, breaker control, breaker monitoring, data storage, transfer trip, alarm summary storage, event summary storage, ammeter, voltmeter, SCADA interface, HMI interface for establishing and adjusting breaker protective parameters and visual display of metering;

A. Main cathode circuit breaker shall meet the following requirements:

i. Protect against reverse current;

ii. Include a DC enclosure device to detect enclosure faults;

iii. Provide an interlock to the AC breaker; and,

iv. Include a lockout device.

B. Feeder circuit breakers shall meet the following requirements:

i. PLC based circuit breaker protection with instantaneous, long time and rate of rise overcurrent protection;

ii. A transfer trip scheme to ensure all feeder circuit breakers supplying power to a faulted section shall trip and de-energize the faulted section; , (including the existing feeder circuit breakers in the Existing Confederation Line substations); and,

iii. Equipment shall be metal enclosed as defined by the C37 series of ANSI specifications and shall prevent the accidental contact of live parts by maintenance personnel.

(iv) Digital metering shall be provided for:

A. DC bus voltage; and,

B. On each feeder circuit breaker through the PLC based protective device and controller displaying DC feeder voltage, and feeder current.

(v) Each TPSS shall be furnished with a negative grounding device which shall monitor the potential between the negative bus and the substation ground grid. The NGD shall provide an open circuit when the potential is at an acceptable level. The NGD shall close if the pre-set potential is exceeded. Once the potential has decreased below the pre-set level the NGD shall automatically open. Status points shall be provided from the NGD to the SCADA system.

(vi) DC enclosure energized/grounded protection shall be provided which shall detect when the switchgear has a positive to frame fault or when grounded. Upon detection of a positive to frame fault the substation shall be automatically shut down. There shall be a local audio – visual warning which shall be communicated along the SCADA to the TOCC, BCC, MYCC and BYCC.

(vii) Equipment shall be metal clad as defined by the C37 series of ANSI specifications and shall prevent the accidental contact of live parts by maintenance personnel.

(viii) The main cathode circuit breaker and the negative disconnect switch shall be interlocked such that the cathode circuit breaker cannot be closed when the negative disconnect switch is open and the negative disconnect switch cannot be opened when the cathode circuit breaker is closed.

(e) DB Co shall ensure that the Utility Power meet the following requirements:

(i) **[REDACTED]/[REDACTED]** have identified Supply Points across the alignment to supply power, both traction and facility in accordance with Article 6 of Schedule 15-2, Part 4 – Stations, and in the Hydro supply strategy document titled "**[REDACTED]**" provided in the Background Information. **[REDACTED]/[REDACTED]** shall terminate MV power supply feed at the pad mounted switchgear.

(ii) Utility power needs, codes and requirements shall be coordinated with **[REDACTED]/[REDACTED]**.

(iii) DB Co shall provide a cubicle in the customer owned switchgear lineup for **[REDACTED]** to install revenue metering. For Trim Station, DB Co shall furnish a pole adjacent to the overhead **[REDACTED]** supply point where **[REDACTED]** will supply and install pole mount primary metering. Additional customer owned revenue class metering equipment shall be on the load side of medium voltage TPSS circuit breakers that supply station and or mechanical loads.

(iv) All Infrastructure and cabling elements (duct banks, foundations, grounding, maintenance holes) to facilitate the **[REDACTED]/[REDACTED]** Supply Point switchgear, serving the TPSS and/or facilities shall be by DB Co and shall be constructed to meet **[REDACTED]/[REDACTED]** standards and require **[REDACTED]/[REDACTED]** approval.

(v) Utility power from **[REDACTED]/[REDACTED]** Supply Point switchgear to the TPSS shall be configured such that no two electrically adjacent TPSS are supplied from a feeder sourced from the same bus at a **[REDACTED]/[REDACTED]** substation.

(f) DB Co shall ensure that the Control Power meet the following requirements:

(i) Control power in the TPSS shall be used for TPSS controls, relaying, SCADA and other functions. The system shall consist of a step down transformer, battery bank, battery charger, DC distribution panels and all necessary equipment to provide a complete control power system.

A. The battery shall be capable of supplying TPSS demand to support control power for 8 hours and to support duration as identified in a failure mode analysis.

B. The battery shall be sized based upon a load calculation incorporating TPSS switching operations and all static TPSS loads during normal and contingency operation.

C. The battery charger shall include a ground detection system and alarm function reporting to the SCADA system.

(g) DB Co shall ensure that the following control requirements are met:

(i) The TPSS shall be designed for unattended operation with remote supervision and control from all control centres through the SCADA system.

(ii) Local control shall be provided for all elements of the TPSS through a HMI and computer based TPSS control unit (PLC). Remote control shall be disabled when in local control. Local control shall be enabled by means of a “local/remote” switch. This switch shall enable and disable local control of the entire TPSS

excepting circuit breaker trip functions. All TPSS indication and alarms shall be provided to the HMI.

(iii) HMI located in each TPSS shall be the local TPSS status screen annunciator. The HMI/PLC shall provide all information to SCADA at the TOCC, BCC, MYCC and BYCC. This includes alarms, equipment status and real-time metering values. The default screen shall be a representation of the TPSS single line indicating the current status.

(h) DB Co shall ensure that the following SCADA requirements are met:

(i) TPSS shall be provided with a TPSS SCADA monitored and controlled reporting directly to TOCC, BCC, MYCC and BYCC.

(ii) DB Co shall provide a TPS system where all TPSS metering is monitored and logged by the SCADA system.

(iii) The TPSS shall be provided with a TPSS SCADA RTU that shall interface with the SCADA systems specified in Article 8 – SCADA System, of this Part 3 for the purposes of transmitting the information and control to TOCC, BCC, MYCC and BYCC.

(iv) The following status and control points, at a minimum, shall be incorporated into the TPSS SCADA system functionality:

A. AC switchgear – Status and control:

i. Protective devices – Status; and,

ii. Lockout device – Status;

B. Loss of utility power – Status;

C. Rectifier transformer:

i. Winding over temperature – Status;

D. Rectifier:

i. Over temperature – Status;

ii. Negative disconnect switch position – Status;

iii. Negative overvoltage – Status;

iv. Diode failure – Status;

v. Surge suppressor failure – Status;

vi. Reverse current trip – Status;

vii. Enclosure energized alarm – Status; and,

viii. Enclosure grounded alarm – Status;

E. DC Switchgear:

i. Cathode (main) breaker – Status and control;

ii. Feeder breakers – Status and control;

iii. Transfer trip trouble/failure – Status;

iv. Feeder breaker reclosure failure – Status;

v. Feeder breaker protective relay trouble/failure – Status;

vi. Lockout relay trip – Status;

vii. Enclosure energized alarm – Status;

viii. Enclosure grounded alarm – Status; and,

ix. OCS section energized – Status;

F. Negative Grounding Device:

i. Closed – Status;

ii. High Current – Status; and,

iii. Failure – Status;

G. TPSS Local Control Enabled – Status;

H. Loss of Station auxiliary power – Status;

I. Intrusion Detection – Status; and,

J. Fire alarm:

i. Trouble – Status;

ii. Power Supply – Status; and,

iii. Alarm – Status;

K. Loss of control power – Status;

L. Battery charger trouble/failure – Status;

M. Climate Control – Status;

N. TPSS air temperature – Status;

O. Emergency trip activated – Status; and,

P. Mass trip control – Status.

(v) 25% additional status and control point spare capacity shall be provided at each TPSS.

(vi) Communication between the local SCADA system, the TOCC, BCC, MYCC and BYCC shall be redundant via the CTS.

(i) DB Co shall ensure that the following climate control requirement is met:

(i) All TPSS shall include a climate control system which shall maintain indoor temperature and humidity to allow for PLC and SCADA equipment operational performance to be maintained throughout all expected external temperature variations. The climate control system shall be designed to continuously maintain the temperature within the TPSS and provide status to the TPSS SCADA system.

(j) DB Co shall ensure that the following communications System requirements are met:

(i) Connection panel to the CTS for redundant data and telecommunication shall be provided.

(ii) Telephone connection to TOCC and BCC shall be provided for local control and emergency functions.

(k) DB Co shall ensure that the following intrusion detection requirement is met:

(i) Each substation shall be equipped with an intrusion detection system which shall allow keyed and keyless access and upon unauthorized access provide a local audible and visual alarm as well as remote notification. The IAC System shall be compatible with the IAC System provided for in Article 9 – Intrusion Access Control System, of this Part 3.

(l) DB Co shall ensure that the following fire/smoke detection System requirement is met

(i) Each TPSS shall be equipped with a fire alarm system which shall detect and alarm upon detection of a smoke or fire event and report to TOCC, BCC, MYCC and BYCC through SCADA. Activation of the fire alarm system shall trip and lockout the TPSS. The fire/smoke detection System shall be designed in accordance with NEPA 72 Standard.

(m) DB Co shall ensure that the following TPSS grounding requirements are met:

(i) A TPSS grounding system shall be provided for life safety and fault detection purposes. The grounding system shall be designed in accordance with IEEE Standard 80 and 81 or IEC equivalent specification for ground fault detection and touch and step potential for safety. Prior to installation of the grounding system, the grounding system calculation shall be submitted to the City in accordance with Schedule 10 – Review Procedure. All required data such as available short circuit current, available Z and X/R ratio shall be obtained prior to installation and implemented in the grounding system report. The grounding test report shall be submitted to the City in accordance with Schedule 10 – Review Procedure.

(ii) Any metallic structures exterior to the TPSS shall be connected to the ground grid.

(iii) Traction Power DC ground grid shall not be interconnected with any Passenger Station grounding grid. TPSS's that share a structure with Passenger Stations shall have a common ground grid.

(iv) Surge protection shall be provided for all cables entering and exiting the TPSS as follows:

A. All non-current carrying parts of 1500 DC TPSS equipment (traction rectifier and DC switchgear) shall be isolated from ground and connected to the ground grid through a ground fault detection system. The ground fault detection system shall, upon detection of a grounded condition, disconnect the substation from sources of power and annunciate an alarm locally and at the TOCC, BCC, MYCC and BYCC; and,

B. Security fencing, lamp stanchions shall be connected to the ground grid. This includes any conductive hardware where public can inadvertently come in contact with high voltages.

13.7 DC Feeder System

(a) DB Co shall ensure that the DC feeder system be provided and consists of all raceways, cabling and switching equipment necessary to connect the TPSS to the OCS and rail returns.

(b) The DC feeder system shall include positive cable and connections from the TPSS DC switchgear to the OCS and negative cable and connections between the TPSS negative bus and return rails. Where specified, impedance bonds shall be installed between the running rails. Positive cable connections shall include motor operated DC disconnect switches to provide a means to isolate the TPSS from the OCS. Motor operated load break switches shall be installed at TPSS locations to provide a means to bypass OCS insulated overlaps and equalize across Track OCS systems during contingency conditions when TPSS DC switchgear is out of service.

(c) DB Co shall ensure that the following cable ampacity ratings be based upon the worst case maximum RMS currents indicated in the load flow studies with any necessary de-rating due to duct bank/raceway routing and appropriate temperature rise. DB Co shall ensure that the positive DC feeder system be designed to provide adequate ampacity and to maintain the electrification voltage within acceptable limits.

(d) DB Co shall design the DC negative feeder system to include any necessary equipment to interface with the running rail traction return so as not to interfere with the Train control system.

(e) DB Co shall design the negative feeder system to maintain a low rail to ground voltage and provide sufficient ampacity.

(f) DB Co shall design the negative feeder system to be continuous through the four running rails including interlockings at all locations.

(g) DB Co shall ensure that the Yard Tracks are supplied from a dedicated yard TPSS.

(h) DB Co shall ensure that the Yard Tracks have the ability to connect to the mainline Tracks through normally open DC disconnect switches during yard TPSS outages.

13.8 Negative Return Path

(a) DB Co shall ensure that the negative return current is carried through the running rails, which shall be insulated from the ground. DB Co shall ensure that locations requiring insulated joints, impedance bonds be used to maintain continuity. DB Co shall ensure that insulated joints be installed at the entrance to the yard and to the shop buildings to prevent any connection between the grounded rails in the shop and the ungrounded system in the yard and between the yard and mainline rails.

(b) DB Co shall develop and submit to the City for review and approval a Stray Current Monitoring Plan.

(c) Once the Stray Current Monitoring Plan has been approved by the City, DB Co shall implement a Stray Current Monitoring System.

(d) Drainage Feeder System

(i) DB Co shall ensure that the provisions be made for the monitoring and control of stray current through the use of drainage panels. DB Co shall design the drainage panels to provide a means of permitting metallic utilities to connect to the substation negative bus. DB Co shall ensure that provisions shall are made to provide a raceway system to a demarcation pull box for utility company drainage cables to be connected to the drainage system.

(e) DB Co shall ensure that the following AC feeder system requirement is met:

(i) The medium voltage AC feeder system shall be provided and consist of all raceways, cabling maintenance holes, foundations, ground rods and switching equipment necessary to connect the TPSS to the **[REDACTED]/[REDACTED]** utility supply switchgear in accordance with utility requirements.

(f) DB Co shall ensure that the following duct banks and raceways requirements are met:

(i) Duct banks shall be provided from the TPSS exiting point to the intersect point of the distribution system and constructed of non-conductive material encased in concrete.

(ii) All underground raceways shall have a utility marking tape (with magnetic tracer) installed 0.33 meters above the raceways.

(iii) Positive and negative feeders shall not be installed in the same raceway, pullbox or maintenance hole.

(iv) Ten percent (10%) spare duct shall be included in each duct run.

(g) DB Co shall ensure that the following communication raceway system requirement is met:

(i) Duct banks shall be provided from the TPSS exiting point to the intersect point of the communication CTS system and constructed of non-conductive material encased in concrete.

(h) DB Co shall ensure that the following sectionalization requirement is met:

(i) The Traction Power distribution system (OCS) shall be circuited into manageable electric sections. These sections shall be redundantly fed from two adjacent TPSS to maintain reliability, continuity of service, fault discrimination and distribution of loading.

(i) DB Co shall ensure that the following Cabling Identification System requirement is met:

(i) All cable and wire terminations shall be labeled with tags indicating termination points of both ends and function.

13.9 Switch Heaters

(a) DB Co shall design the TPS to supply power to the location of electric switch heaters, refer to Article 10 - Signalling and Train Control System, of this Part 3.

13.10 LRT Vehicle power requirement

(a) TPS shall supply power to the Revenue Vehicles, Maintenance Vehicles, non-communicating Trains and non-equipped vehicles throughout the Confederation Line.

13.11 Testing

(a) DB Co shall be responsible for all factory acceptance testing, field testing, and all testing and commissioning of the Traction Power System. DB Co shall be responsible for all installation tests (power, grounding, cabling, etc.) for all work installed.

(b) All test reports shall be submitted to the City for review and approval to meet required performance qualifications of the City.

ARTICLE 14 OVERHEAD CONTACT SYSTEM

14.1 General Requirements

(a) This section provides the criteria for the OCS, also referred to as the catenary system, including technical, operational, maintenance, local climatic and economic considerations.

(b) The OCS consists of the catenary wires and their physical supporting structures. The OCS distributes DC electric power from TPSS to the Vehicles operating on the Mainline Tracks, yards and within the Moodie LMSF through the pantograph mounted on top of the vehicle.

(c) On the mainline, a simple catenary system shall be employed, consisting of a single contact wire supported by a messenger wire via hangers (droppers). This configuration shall be auto-tensioned, consisting of balance weight assemblies mounted out of running, one span away from the overlap transition span and supported with standard anchorage assemblies. Spring tension assemblies are also permitted at crossovers and interlockings. The auto-tensioned operating range shall accommodate the designed tension length.

(d) On the Connecting Track a simple catenary system shall be employed and on the LMSF a single contact wire system shall be employed. These configurations may be auto-tensioned utilizing a balance weight assembly or semi-compensated using a spring tension assembly. The tension compensated operating range shall accommodate the designed tension length.

(e) For tunnel/ underground areas, an overhead conductor rail support system shall be used. This OCS configuration shall consist of contact wire inserted at the bottom of from an extruded aluminum profile rail section, which in turn shall be mounted to the underside of the Tunnel structure. Double insulation shall be provided between the OCS and Tunnel structure.

(f) DB Co shall blend the appearance and style of the overhead catenary system into the adjacent communities and at visually sensitive areas including, but not limited to the following elements:

(i) Pole size, shape and color;

(ii) Location of the pole; and,

(iii) Special attention shall be paid to the design of the catenary system and supporting system in visually sensitive areas of the alignment corridor as follows:

A. Visually sensitive areas include:

i. Within all Station Platform areas extending 15m to either side of Platform end;

ii. Within the existing BRT trench from Tunny's Pasture Station to Carleton Avenue; and,

iii. All SI located on Federal Lands.

B. In visually sensitive areas of the alignment corridor, closed or tapered sections shall be used. Multi-sided poles shall have a minimum of 16 sides.

(iv) Pole base covers shall be provided in areas easily accessible to the public, and other historic or special designated locations identified by the City. The base cover shall match the color of the pole.

(g) Design shall include components that:

(i) Are standard and off-the-shelf, available from multiple suppliers;

(ii) Match, or similar to that provided for the Existing Confederation Line;

(iii) Have a proven maintenance performance; and,

(iv) Maintain functionality even during extreme weather conditions and temperature changes as defined in this Article 14.

(h) In addition, the design shall take into consideration existing overhead obstructions such as Bridges, overpasses, buildings and aerial Utilities that may impact the final layout.

(i) As an extension of the existing system, wherever possible, the OCS design shall match or blend, function, and operate seamlessly with the existing OCS system.

(j) DB Co shall design, supply, and install all components of the OCS, including poles, foundations, cantilevers, conductors, and associated hardware and assemblies.

(k) In addition, DB Co shall provide all electrical feeding, grounding, and bonding arrangements required for proper system performance.

14.2 Codes, Standards and Manuals

(a) The design, materials selected and construction of the Works shall comply with the criteria contained in this Article 14, 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. In the event of a conflict between criteria,

commitments or requirements contained within one document when compared with another, the more stringent shall apply:

(i) ANSI;

(ii) NEMA;

(iii) CSA;

A. CAN/CSA-C22.3 No. 1, Overhead Systems

B. CAN/CSA-C22.3 No.8, Railway Electrification Guidelines

C. CSA S6, Canadian Highway Bridge Design Code

(iv) City of Ottawa Codes and By-Laws;

(v) IEEE;

(vi) IEC;

A. IEC 60913, Railway applications – Fixed installations – Electric traction overhead contact lines

B. IEC 62128-1, Protective provisions relating to electrical safety and earthing

(vii) UL and ULC;

(viii) ASTM; and,

(ix) AREMA;

A. AREMA Chapter 33, Electrical Energy Utilization.

14.3 Operational Requirements

(a) The OCS shall be comprised of the following major items:

(i) Catenary Wires: Messenger and Contact/Trolley;

(ii) Feeder Cables: Feeders from Substation to Catenary;

(iii) Supports: Cantilever, Headspan or Cross-Span, Pull-Off, Overhead Conductor Rail;

(iv) In-Span Materials: Hangers, Jumpers, Splices, etc.;

(v) Midpoint Anchors: Tie Wire and Downguy Assemblies;

(vi) Poles: Poles both Center and Wayside;

(vii) Foundations: Drilled Shaft and Ground Connections;

(viii) Lightning Arresters: Surge Protection;

(ix) Structure Guying: Termination, Anchors;

(x) Tensioning Systems: Concentric Wheel or Pulley Type with balance weight assemblies and Spring Type tensioning systems;

(xi) Insulated Overlaps: Sectionalization;

(xii) Section Insulators: Isolation; and,

(xiii) Disconnect Switches: Isolation.

(b) OCS Configuration and Tension Systems

(i) DB Co shall design the OCS system to meet:

A. Line speed;

B. Clearance;

C. Mandatory national standards;

D. Climatic and environmental constraints;

E. Vehicle power consumption and ampacity determined by the operational performance requirements; and,

F. Traction Power load flow simulation.

(ii) Where there is a requirement for the transition between auto-tensioned and fixed termination catenary, it shall be accomplished by a catenary parallel wire overlap. The fixed termination overlap catenary shall be supported by an intermediate cantilever structure on the catenary at mid-span.

14.4 Design Parameters

(a) The design parameters are outlined in Table 3-14.1.

Table 3-14.1

Ambient Temperature Range	In accordance with environmental conditions referenced in Schedule 15-2, Part 1, Article 4 – Design and Construction
Loading / Climatic Conditions	In accordance with environmental and loading conditions referenced in CAN/CSA 22.3 No.1 & 8
Maximum Design Train Speed	100km/hr, mainline 30km/hr, Connecting Tracks 15km/hr, Moodie LMSF
Elevation Above Sea Level	60m
Durability	Reinforcing steel in substructure concrete within the splash zone of adjacent Roadways treated with de-icing salts shall be stainless steel. Splash zone shall be as defined in MTO Structural Manual.

14.5 Electrical Clearances

(a) Clearances shall be maintained between live conductors, including pantographs and any overhead structures, in accordance with Table 3-14.2.

Table 3-14.2

Clearances	Static (1)	Passing (2)
Normal Minimum	155mm	130mm
Absolute Minimum	130mm	80mm

Where:
(1) Static clearance is the clearance between the catenary system and any overhead structure when not subject to pantograph pressure.
(2) Passing clearance is the clearance between the catenary system or pantograph and an overhead structure under actual vehicle operating conditions during the time it takes the Train to pass.

(b) Clearance from the pantograph to any fixed item, excluding the steady arm or registration arm of a cantilever, shall not be less than 130mm. Pantograph clearance to steady arm shall not be less than 38mm.

(c) For Vehicle related clearance, full allowances shall be included for dynamic displacement of the Vehicle under operating conditions, including tolerances for construction and maintenance of the Track.

(d) Personnel clearances according to IEC 62128 for public and restricted areas as a minimum shall be incorporated into the DB Co design. Obstacles shall be appropriately designed and located to protect direct contact with live parts

14.6 Height, Depth and Gradient Requirements

(a) The nominal contact wire height perpendicular to the TOR at super elevated Track centerline shall be in accordance with the requirements outlined in CAN/CSA C22.3 No. 1 & No. 8 as detailed in Table 3-14.3.

Table 3-14.3

Route Description	Track Type	Type of OCS	Contact Wire Height (mm)
Tunnel/ Underground	Direct Fixation	Overhead Conductor Rail	3940 minimum
Open Route Alignments	Ballast	Auto –Tension Simple Catenary	4900 normal
Yard/ Moodie LMSF Tracks	Ballast	Auto-Tension Single Contact Wire	6500 maximum 5700 minimum
Road Crossing	Embedded	Auto-Tension Simple Catenary	5500 minimum
Overhead Bridges	Ballast	Auto-Tension Simple Catenary Overhead Conductor Rail	4100 desirable minimum 3900 absolute minimum

(i) The contact wire height at supports shall take into consideration the effect of wire sag, due either to temperature rise or to ice loading, and construction tolerance, including Track construction and maintenance tolerances.

(b) The system depth is defined as the height or vertical distance between the messenger and contact wires at the point of support. The nominal system depth is outlined in Table 3-14.4.

Table 3-14.4

Locations	System Depth, Nominal
Open Route Alignments	1220mm
Underneath Overhead Bridges	152mm

(i) These heights may vary at specific locations for the profile transitioning from Tunnel structures or underneath overhead structures.

(c) The contact wire gradient is defined as the rate of change in elevation of the contact wire with respect to top of rail. Where possible, the contact wire grade shall match the grade of the Track for a contact wire gradient of zero.

(i) Table 3-14.5 presents the maximum gradient as per CAN/CSA C22.3 No. 8:

Table 3-14.5

Train Speed	Maximum Contact Wire Gradient
Yard / LMSF (15 km/hr)	2.0% (1:50), Storage and Maintenance Tracks
50 km/hr	1.3% (1:77)
75 km/hr	0.8% (1:125)
100 km/hr	0.6% (1:167)

(ii) Except for Yard / LMSF conditions, the change of grade from one span to the next (between consecutive spans) shall not exceed one half the values shown above.

(iii) The Moodie LMSF Lead Tracks shall be governed by the 50km/hr requirement.

14.7 Vertical Clearances

(a) The vertical clearance requirements to Structures are provided in Schedule 15-2, Part 2, Article 4 – Structural Design Criteria and Requirements. The values given in Schedule 15-2, Part 2, Article 4 – Structural Design Criteria and Requirements represent the acceptable minimum for existing Structures, provided that the Track is tangent and a direct fixation type and the catenary can be suspended between poles spacing 18m maximum or supported from the existing Bridges and Structures. Additional clearance is required to account for Track superelevation.

(b) DB Co shall ensure for those TPSS that are only accessible by rail that the OCS wire in front of the TPSS shall be no less than 5.5m in order to accommodate TPSS equipment removal operations. Additionally, DB Co shall ensure that no OCS poles shall be installed directly in front of the TPSS.

(c) DB Co shall ensure all structures are clear of the clearance envelopes for the Vehicle and pantograph under all operating conditions. Clearance envelopes shall incorporate all relevant construction and maintenance tolerances.

14.8 Loading and Overload Factors

(a) Loadings and overload factors shall be based on the most current CAN/CSA 22.3 No.1 & 8 requirements.

(b) Canadian Highway Bridge Design Code CSA S6 with ice accretion (31mm) for bridge sections shall be employed for radial ice on the wires and associated equipment and treated as an additional loading condition. The 31mm Non-Operating ice loading condition is for the purposes of structural capacity of the OCS on bridge segments. The CSA CHBDC S6 31mm ice loading condition shall apply to all Bridges along the alignment where OCS is present. If any portion of an OCS span between supports runs along a Bridge section, that entire span shall be subject to this loading condition. The CSA CHBDC S6 31mm ice loading condition also shall apply to any OCS span where one of the supports is attached to an Overhead structure.

(c) The following climatic conditions shall also be taken into consideration for the design of the system:

(i) Operating conditions (Vehicles in service and running):

A. 90km/hr wind speed at 8°C.

B. 65km/hr wind speed with 12.5mm radial ice thickness on messenger wire, 6.25mm thickness on contact wire at -20°C.

C. No ice or wind at -27°C.

D. No ice or wind at 55°C.

(ii) Non-Operating Conditions (Vehicles not in service):

A. 90km/hr wind speed with 12.5mm radial ice thickness at -20°C.

B. No ice or wind at -32°C.

14.9 Strength Requirements

(a) DB Co shall design the OCS in accordance with the strength requirements specified in CAN/CSA 22.3 No.1 & 8, latest edition.

14.10 OCS Wires Tensions and Tension Lengths

(a) The messenger wire shall be 500 kcmil stranded hard-drawn copper

(b) The contact wire shall be 350 kcmil solid-grooved hard-drawn copper

(c) The design shall take into account a maximum permissible wear of 30% cross-sectional area loss of contact wire

(d) The following shall be the base wire tensions for the stated tensioned system with a base temperature of eight (8) degrees Celsius:

(i) Mainline/ Surface Alignment (Auto-Tension):

A. Messenger: 2700 kg.

B. Contact Wire: 1350 kg.

(ii) Tunnel/ Underground:

A. Overhead Conductor Rail.

(iii) Moodie LMSF Tracks (Auto-Tension, Spring Type):

A. Contact Wire: 1100 kg.

(e) DB Co shall locate tension segments in the alignment according to sectionalizing requirements and to minimize the tension loss due to cantilever restraining forces. Tension lengths shall be limited by the allowable along-track movement and limits of the tensioning devices.

14.11 Mid-Point Anchor Assembly

(a) The mid-point anchor assembly is used to anchor or hold the catenary and allow the catenary to expand and contract from that point. It is typically installed at or in the vicinity of the mid-point of the OCS tension length. The assembly is comprised of turnbuckles, in-line insulators, wire terminations, high strength steel cable, parallel clamps, steel links and pole bands.

14.12 Sectionalizing Requirements

(a) The OCS shall be electrically sectionalized by means of insulated overlaps or section insulators near each substation. The OCS design shall adopt a combination of both insulated wire overlaps and section insulators (sleds). The OCS shall require sectioning at crossovers, the Moodie LMSF, and other Special Trackwork. Section insulators shall be used at crossovers, Pocket Tracks, turnout, and siding locations. Overlaps shall not be placed on sharp curves.

(b) Additional sectioning may be required at specific sensitive areas of the alignment where EMI considerations are required to be mitigated.

(c) Sectioning at Interlocking

(i) The sectioning of the standard two Track "Universal" crossover arrangement, facing or trailing, shall be the standard arrangement of three (3) switched mainline insulated overlaps or section insulators, and two (2) section insulators in the crossover wires. The positioning of all sectioning assemblies shall be capable of allowing the ultimate (5+4 car consist) Train set to pass the Track switch and signal.

(ii) Diamond crossovers shall have switched insulated overlaps or section insulators on both Mainline Tracks, and section insulators in the crossovers wires. Sectioning of this crossover type shall consist of a minimum of four disconnect switches, and a combined total of six section insulators and/or insulated overlaps.

(iii) The electrical sectioning and isolation of OCS shall be arranged in a manner that prevents any "dead spots", or un-energized portions of catenary, from occurring under normal Vehicle operating conditions.

(d) Sectioning in the Moodie LMSF

(i) The Tracks in the Moodie LMSF area shall be divided into working groups of four Tracks or less. Exceptions may be granted for more Tracks of shorter lengths. Each group shall have a manually operated switch and section insulators to accomplish the section isolation. The catenary for the entrance to and exit from the Moodie LMSF shall not be fed from the same DC breaker.

(e) Sectioning at the Maintenance and Storage Buildings

(i) Each Track inside the Moodie LMSF buildings shall have the capability of individual sectioning. A door mechanism shall be installed with insulation, which allows continuous pantograph passage when the door is in the "open" position. A switch shall be installed for de-energizing the contact wire. Manual OCS dis-connect switches in Moodie LMSF Yard shall be monitored via the SCADA system. Insulated joints shall be installed at the apron of all Moodie LMSF Tracks.

(ii) Isolation Requirements

A. On the Mainline, the OCS shall be designed using motor-operated disconnect switches, including for isolating sections of wire at interlockings, and at Lead Tracks for isolating the Moodie LMSF from the mainline. Motorized disconnect switches shall have operating and monitoring capabilities via SCADA. Manual disconnects shall be used throughout the Moodie LMSF for isolating sections of Track, and in the shop for isolating each section of wire.

14.13 Switching and Feeding Assemblies

(a) Manual or motorized switches shall be used as specified in Section 14.12 (e) (ii) A above. The switch assembly usually comprises of a blade style switch, mounted in a weatherproof box; full feeding jumpers positioned on either side of the switch, and insulated cables from the switch to the individual sets of catenary wires. For motor operated switches, an electrical interlock circuit shall be provided to prevent operation with voltage on either side of the contact. The interlock shall prevent local and remote electrical operation of the switch motor. Emergency manual operation shall not be prohibited.

14.14 Safety Assurance

(a) As a minimum, the following items shall be provided by DB Co in the design, specification, construction, and functionality of the OCS:

(i) Double insulation from any type of grounded pole, structure, building, etc. shall be provided to eliminate the possibility of bridging or spanning from neutral or grounded parts to live wires.

(ii) Warning signs shall be attached to OCS or the supporting structures to warn personnel of the proximity of high voltage wires. Signs shall be attached to the OCS to denote the end of the electrified wires over the Tracks. The signs comprise of “High Voltage”, “Danger”, “Danger Live Wire” and “Electric Train Stop” in red and black with white background.

14.15 Pole Deflection

(a) Pole deflection under all Vehicle operating conditions shall not exceed 50mm at contact wire height. Pole deflection at the top of the pole under CSA C22.3 heavy loading condition shall not exceed 3% of pole length. Overload factors shall not be applied in the calculation of pole deflection. All pole deflection values shall take into account the effects of foundation translation and rotation for the applied loading condition.

14.16 OCS Pole Grounding and Bonding

(a) Each pole or structure shall be grounded by a 4/0 AWG copper stranded wire by exothermic weld connections to two reinforcing bars in the foundation and to a ground rod adjacent to the foundation if necessary. The use of an appropriately sized copper-weld ground wire shall be permitted at locations with public access or in areas susceptible to vandalism and wire theft. All OCS support structures shall be grounded to a total ground resistance not exceeding 25 ohms.

(b) Ground connections to disconnect switches shall have a maximum ground resistance of 5 ohms. Ground rods shall be utilized to obtain the required ground resistance.

(c) Touch potential overvoltage at each pole or structure shall be limited to 50 V under normal operation and 70 V under outage conditions.

(d) Where the tested resistance exceeds the specified value, additional ground rods shall be driven and interconnected with a suitable conductor and the test repeated.

(e) All test results shall be provided to the City for review and approval.

14.17 Bridge, Overhead and Roof Structure Attachments

(a) Attachment to overhead Bridges and overhead structures shall be prohibited unless other methods are not available. In instances with clearance limitations or where Bridge spans are greater than the allowable OCS span, attachments may be required. Underneath roof structures, a soft suspension assembly shall be used to minimize pantograph bounce and loss of contact between the pantograph and contact wire.

(i) DB Co shall provide protection against arcing or ground from the OCS lines in other areas such as Stations, at grade Structures, etc.

(ii) In addition to OCS lines, where and if DB Co installs other medium voltage lines such as **[REDACTED]**, DB Co shall protect metallic parts and Structures, including protecting **[REDACTED]** metallic infrastructure against arcing or ground from other medium voltage lines.

(iii) Near existing **[REDACTED]** infrastructure, DB Co shall protect metallic parts and Structures against arcing or ground from **[REDACTED]** infrastructure medium voltage lines.

(iv) When **[REDACTED]** is installing or maintaining medium voltage lines, **[REDACTED]** normal safety protocols apply to **[REDACTED]**.

(b) Overhead Bridge and Tunnel Portal Protection

(i) At locations where the catenary passes underneath overhead structures that are equipped with sidewalks or walkways without guard and there is less than 3m of clearance to the nearest wire, fencing shall be provided as specified in Schedule 15-2, Part 6, Article 2 – Design Criteria.

(ii) At locations where the OCS underpasses structures are susceptible to corrosive elements, such as salt spray on bridge, an insulated protection board(s) is to be provided directly above the catenary wires, shielding them from potential corrosion risk. Alternate protection measures shall be permitted only after review and approval of the City.

(c) Overgrade Bridges

(i) Where the catenary and Track are supported by overgrade Bridges, all metal materials attached to the Bridge shall also be attached to the electrical grounding system. Where poles are to be mounted, the pole ground shall be attached to the electrical grounding system.

14.18 Overhead Conductor Rail Support

(a) In tunnel, underground areas, or other areas that warrant special consideration due to low clearances and spatial confinement, overhead conductor rail supports may be used. Support spacing shall typically range between 10m to 12m maximum, and shall be bolted together section by section.

(b) The DB Co conductor rail design shall include provisions for a smooth transition between the flexible OCS and the overhead conductor rail system. The section lengths shall be properly size taking into account tangent and curved Track and shall include the use of mid-points with overlap sections where applicable. Supports shall be either sliding or pivoting type.

(c) A grounding cable shall be provided the entire length of the Tunnel or underground area to which the conductor rail is attached. The cable shall be suspended near and bonded to the overhead conductor rail supports and bonded to the collector bar to provide a continuous grounding system.

14.19 OCS Span Length and Staggers

(a) The span lengths (spacing between contact wire registration points) and stagger shall be designed to provide for pantograph security (i.e. no pantograph de-wirement). Pantograph security shall be established by maintaining a minimum contact wire edge distance from the tip of the pantograph of 75mm under worst-case Vehicle operating conditions. Maximum span lengths shall be determined so as to achieve this minimum pantograph security allowance at any point within the span.

(b) For mainline OCS, the contact and messenger wires shall be staggered on both tangent and curved Tracks, relative to Track centerline. The amount of stagger is based on the various class of Track allowances, vehicle body and pantograph tilt, sway, and other dynamic movements; and construction tolerance.

(c) For LMSF and yard areas, the OCS wires shall be staggered on curved Tracks, similar to mainline OCS. However, tangent Tracks do not require stagger in these areas.

14.20 OCS Assemblies, Equipment, and Hardware

(a) All OCS materials and equipment shall be standard products of manufacturers regularly engaged in the production of such materials, shall be designed for use on electric railways, and shall be the manufacturer's latest proven design.

(b) DB Co shall provide appropriately sized turnbuckles in all wire assemblies for maintenance purpose to adjust the registered messenger or contact wire position. Where applicable, the turnbuckle shall be located on the slack wire, such as headspan or cross-spans.

(c) Splices shall not be permitted in the system without prior approval of the City.

(d) DB Co shall provide section insulators suitable for use by new and worn pantograph carbons and shall be designed to remain stable dynamically and structurally under all Vehicle and operating conditions.

(e) DB Co shall provide automatic tensioning systems that operate freely within the specified temperature range and shall not interfere with clearance envelopes if a breakage in the OCS wires occurs.

(f) DB CO shall provide jumper clamps with two bolts.

14.21 Cathodic Protection

(a) Each structure shall be designed with a passive protection system. For specific requirements, refer to Article 12 – Corrosion Control, of this Part 3.

14.22 OCS Structure Numbering and Chainage

(a) DB Co shall coordinate the OCS pole numbering and system chainage with the Existing Confederation Line to produce a logical sequence between new and existing systems. Pole identification shall use the same numbering scheme implemented in the Existing Confederation Line.

(b) The numbering system and chainage shall continue in Tunnels at reasonable spacing to support location identification by maintenance staff, EROs, and ESPs.

14.23 Construction Tolerances

(a) DB Co shall specify allowable construction tolerances for safety and current collection quality related parameters according to standard industry practice, IEC 60913, and AREMA Ch 33 Part 4.

(b) The following are minimum System-wide allowable construction tolerances:

(i) Contact wire height: -13mm to +25mm, open route; 0mm to +13mm, Tunnel

(ii) Messenger and contact wire stagger: +/- 25mm (Relative to centerline of pantograph)

(iii) System Depth: +/- 50mm, open route; +/- 25mm, Tunnel (if applicable)

14.24 Lightning Protection

(a) A connection from the OCS to a lightning arrestor/surge arrester and to ground shall be provided at a minimum of each feeder pole. DB Co shall additionally place arresters at a regular spacing that has been determined by assessment of geographical location, environmental conditions, public safety, operational and maintenance risks and ground conditions. The lightning arrestors shall have a minimum energy discharge capability of 2.6 kJ at 1000 kV. The grounding connection from the lightning arrestor will be connected directly to a ground rod(s) or mat, with a total ground resistance of not more than 5 ohms. Lightning/ surge arrestor connection may be combined with the pole/ structure ground connection.

(b) The grounding connection from the arrester shall be connected directly to a ground rod(s) or mat, with a total ground resistance of not more than 5 ohms. Arrester connection may be combined with the pole ground connection.

(c) For poles on aerial structures having an arrester, an independent ground wire and ground rod shall be utilized.

(d) The arresters shall be appropriately chosen based on the expected peak system voltage including regenerative braking. The complete discharge voltage shall be sufficiently low enough to prevent damage to connected system elements. Surge arresters shall have a minimum thermal energy rating of 2.6 kJ per rated kV.

14.25 Performance Requirements

(a) The Vehicles shall be equipped with ice removal device(s) for operations during snow and ice conditions.

(b) All OCS equipment and installation shall undergo all complete factory and on-site inspections and testing. On-site inspection and testing shall, at a minimum, include the following:

(i) Acceptance Measurements: Stagger, Contact Wire Heights at support and mid-span, Pole Horizontal Offset, Mid-Span Offset, Span Lengths, Messenger Wire Heights or System Depths, Wire Stringing Tensions and corresponding installation temperature, Pole Stationing/ Structure Identification, and Contact Wire Gradient;

(ii) Visual Inspection: Visual inspection of the OCS equipment and installation shall consist of the following:

A. At contact wire level, checks shall be made for fit and tightness of components, ensure split pins, locknuts and other fastening components are secure, contact wire checks for kinks, roll, or other damage, messenger wire checks for damaged strands, correct steady arm fittings and heel

settings, checks that OCS jumpers are correct type, have adequate travel capability, are properly fitted, and well formed to avoid fatigue failure, and installation checks for locations of possible interference with passage of pantographs, including spots where pantographs could tangle with wires or suspension assemblies.

B. At ground level, check that hangers are plumb and within tolerance of design position, and check cantilevers are in correct along-Track position under given temperature.

(iii) Clearance Envelope Tests: Pantograph Clearance Envelope and Vehicle Clearance Envelope; and

(iv) Electrical Tests: The following electrical tests shall be performed on the OCS once installation is complete and all components and related electrical equipment are in final locations:

A. OCS Section Proving

B. Circuit Continuity (or Loop Resistance) Test,

C. Hi-Pot Insulation Test,

D. OCS Pole Grounding,

E. Ground Resistance Measurement at Lightning Arrestors.

(v) DB Co shall perform all static, or subsystem tests, involving individual or isolated components of the Overhead Contact System. DB Co shall perform the integration testing and commissioning of the system.

ARTICLE 15 CELLULAR SYSTEMS

15.1 General Requirements

(a) DB Co shall coordinate with the City for the installation of public cellular and WiFi service at the Stations.

(i) At At-Grade Stations, Underground Stations and within the Tunnel, DB Co shall coordinate the installation of cellular service. DB Co shall provide the infrastructure that will support installation of antennas, cabling, amplifiers and associated equipment that will be designed and installed by the City.

15.2 Cellular System

(a) DB 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. DB Co shall install and test a minimum 7/8" radiating cable in the Tunnel sections. DB Co shall provide the radiating cable, including mounting hardware.

(b) DB Co shall provide power to the remote units required along the Tunnel or in any Station areas. A number of remote units shall be installed by the City throughout the Tunnel and/or Stations at various locations to be determined during design. Typical installation requires an RU at approximately every 500m, one RU at each Station entry or exit, and/or in the communications room and one RU at each Tunnel portal. Installation brackets hardware shall be the responsibility of the City.

(c) DB Co shall provide a minimum 75mm conduit in the Tunnel(s) for installation of cellular required fibre.

(d) DB Co shall provide all necessary conduits, junction boxes, pull boxes to cater for cellular fibre that will connect the various remote units within any Underground Stations.

(e) DB Co shall provide appropriate conduits or pathways to cater for coax cabling from the radiating cable exiting the Tunnel to the Remote Units within the Stations or Station transition areas, or Tunnel.

(f) DB Co shall provide power to RUs, and other telecom equipment as required, located in the Tunnel, and / or at Stations.

(g) DB Co shall provide appropriate number of conduits (for fibre and coax) from the Tunnel to a location close to the Tunnel but external to the Tunnel, where a BTS site will be located. DB Co shall provide a manhole as the interface point where the conduits will terminate.

(h) The Telecom provider shall coordinate with the electrical service provider and provide a connection to the BTS site electrical interface panel for the BTS site (the electrical panel shall be designed by the City. The City may require consolidation of Voice/Data Radio System and cellular BTS sites depending on the requirements of each provider – the City wants to minimize the footprint of a BTS hotel The BTS site shall include fencing, foundation, access road, shelters, conduits, electrical panel, hydro incoming connection, drainage etc. This shall all be part of the City scope.

(i) DB Co shall design antennae mounting locations throughout the Stations to cater for the antennas required for the cellular system. Antennas shall be located at the Platform level, concourse level, entrances, any Tunnel transition areas and will ensure that cellular coverage is provided in all public areas or on the Vehicle while entering the Platform or stationary at the Platform. Any interfacing hardware for the antennas shall be provided by the City.

ARTICLE 16 GUIDEWAY INTRUSION DETECTION SYSTEM

16.1 General Description

(a) Confederation Line Trains are attended by Operators on a segregated Guideway that is protected by ROW fencing.

(b) The system shall be equipped with a GIDS to detect when intruders attempt to enter the Guideway off the end of a Station Platform, at the LMSF access Track or at Tunnel portals.

(c) The GIDS shall operate using laser based technology with programmable logic to distinguish between Trains, human beings, and other objects.

(d) When there is a human intrusion detected by the GIDS, alarms shall be raised in the TOCC, BCC, MYCC, BYCC and automated responses shall be triggered by both the CBTC and SCADA systems. TOCC, BCC, MYCC, and BYCC staff shall then initiate procedural responses. For other observed or reported intrusions on the Guideway, investigation and follow-up response shall be strictly by procedure.

(e) The GIDS shall detect when intruders proceed beyond the end of a Station Platform onto the Guideway.

(f) The system shall also be installed at all Tunnel portals, including the Parkway Tunnel, Connaught Tunnel, Baseline Station and HWY 417 E-N/S Pinecrest Rd Ramp Tunnel to detect when persons enter the Guideway at a Tunnel portal location.

(g) The system shall use laser scanners which produce 180 invisible beams with a scan arc of 180 degrees. The scanners shall be equipped with environmental hoods to facilitate all weather operation. The laser scanners shall measure the time it takes for a laser beam to project to an object and reflect back to the scanner. Using this time, the distance from the scanner to the object surface is calculated.

(h) Laser data shall be transmitted to a PLC which combines the data from the individual lasers to determine the outline of an object. Using pre-defined permissible shapes and sizes the system shall be able to distinguish between various types of objects providing for intelligent object detection. Detected objects such as a Train or a bird shall not generate an alarm while other objects, such as a person, are programmed to meet the criteria of an intrusion. When an object fits the criteria of an intrusion, the PLC shall transmit alarm signals to both the SCADA and the CBTC systems.

16.2 Intrusion Detection Automated Responses

(a) Upon detection of an intrusion, the following automated responses shall be triggered:

(i) Upon detection of an intrusion, the CBTC behaviour shall be identical to that of the Existing Confederation Line.

(ii) Alarms shall be raised on the ATS workstations in the TOCC and BCC providing notification and warning of the GIDS detected intrusion.

(iii) An alarm shall be raised on the SCADA workstations annunciating a GIDS detected intrusion and CCTV video coverage of the intrusion location shall be presented on the monitors. The video presented can be in the form of live images or lagged images (for example 15 seconds prior to the intrusion).

(b) In addition to these automated responses to an intrusion, the SCADA system shall monitor the ongoing health of the GIDS equipment and annunciate alarms when a malfunction or failure has occurred. Alarms shall also be raised when the system has been tampered with.

16.3 Guideway Intrusion Detection Equipment

(a) DB Co shall design, procure, install, test and commission the GIDS equipment that includes the laser scanners along with IP 67 rated protective outdoor enclosures and protective shields; all associated mounting hardware and all of the required system cables to connect the laser scanners to the respective junction boxes.

(b) DB Co shall install a PIU or junction box for each laser scanner to be installed in a NEMA 4X stainless steel enclosure including a tamper alarm door switch within close proximity to the laser scanner. The PIU provides the interface location between the laser scanner and the electrical cabling system. A 24VDC power supply shall be installed for each laser scanner. The PIU shall include a dry contact closure for intrusion detection/tamper alarms per unit. The PIU shall include a Local LED alarm display. The PIU shall include a serial and RJ45 for connections of data cables.

(c) DB Co shall also install an alarm cabinet, known as a PAU to be located at each Station. The PAU is where the laser scanner output signals are received and processed. The main components of the PAU shall include the power supply, circuit breakers, PLC, Ethernet switch, alarm relays, and terminal blocks. The PAU shall be installed in a NEMA 4X stainless steel enclosure. The PAU enclosure shall include a tamper alarm door switch, a 24 VDC power supply, an Ethernets and a PLC for alarm handling.

(d) DB Co shall procure and install a detection software package required for each laser scanner.

(e) DB Co shall design and install the GIDS equipment such that individual laser scanners do not conflict with the location of other equipment such as OCS poles and radio antennas.

(f) DB Co shall ensure that all installation, operation and maintenance manuals are procured and delivered along with the GIDS equipment.

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ARTICLE 17 HIGH SPEED DATA RADIO SYSTEM

17.1 General Description

(a) The HSDR is a wireless data network Train-to-Station based system between the Train-based data network and the base station units installed at Stations along the Guideway. The wireless network shall support standard Ethernet interfaces and IP protocols and operate within the 5GHz unlicensed band.

(b) DB Co shall design and build the Confederation Line Extension wayside HSDR system such that it integrates with and forms a single complete system with the Existing Confederation Line system.

17.2 General Requirements

(a) The HSDR shall support the following operations:

(i) High speed/high volume data transfer of Station Platform edge/Train door CCTV images from wayside to Train cab display;

(ii) Transfer of Passenger count information from Train to wayside and on to the Passenger counting server;

(iii) Transfer of Vehicle diagnostics information from Train to wayside and on to the Vehicle central maintenance server; and,

(iv) Transfer of Passenger information display messages from wayside to Train at the Moodie LMSF and at the Stations.

(b) Data transfer Platform edge/Train door CCTV images to Train cab display

(i) The high speed/high volume radio shall transfer encoded video streams from the Platform edge cameras to\from the wayside to the Operators Train cab display.

(ii) The system shall start transmitting the images of four Platform edge cameras to the two displays on each side of the Train Operator display only when the Train is stopped at the Station.

(iii) The two sets of four Platform edge cameras shall be provided by DB Co as four independent IP UDP video streams in each Station. The CCTV images shall be streamed as live images using RTSP or approved equal from the wayside modem to the Vehicle modem.

(iv) The transmission of images shall continue for 10 seconds after the Train has started to move. Those images shall be shown for the same period of time on the existing cab CCTV display.

(v) Once the time period is over (10 seconds) the screens in the Operator cab shall go blank.

(vi) The system shall display the correct set of CCTV cameras from the Station Platform the Train is stopped at, on the Vehicle. The location and direction of the Train shall be known by the system in order to display the proper camera images.

(vii) There shall be two sets of four CCTV cameras per Station. One set per Platform per direction.

(viii) The Platform edge/Train door CCTV cameras shall be accessible for viewing at any time from the TOCC, BCC, MYCC and BYCC. The images of those cameras shall be recorded via the same system as the rest of the CCTV cameras of the remaining part of the Station. However the images of those cameras shall be streamed simultaneously to the Vehicle, the storage location and the TOCC, BCC, MYCC and BYCC live on demand.

(ix) The HSDR shall be able to transfer a minimum of one live video data stream from the Train CCTV system to the wayside CTS network when the Train is in a Station. The video stream shall support the ONVIF standard and be streamed using RTSP streaming protocol. The minimum resolution and frame rate from the onboard video source being streamed over the HSDR shall be CIF resolution and 12FPS.

(c) Transfer of Passenger count information

(i) The system shall provide a high speed connection to transfer at each Station and at the Moodie LMSF the Passenger counting information. The transfer of the Passenger information shall be done two ways:

A. Once per day at the LMSF, and at every Station when the Train is stopped. Those transfers shall be done automatically without any command from the TOCC, BCC, MYCC and BYCC.

(ii) The data transmitted at the Station shall be “raw” with no post process to be viewed by the TOCC & BCC personnel only.

(d) Transfer of Vehicle diagnostic information from Train to wayside

(i) The transfer of Train health data from the Train to the wayside CTS network which passes data to the Vehicle central maintenance server shall be done at every Station. Information such as, but not limited to:

A. Low voltage power supply;

B. Door control system;

C. HVAC system;

D. CBTC system;

E. Brake system;

F. Communications and Passenger information sub systems;

G. Propulsion system;

H. Auxiliary inverters; and,

I. Event recorder system.

(ii) Shall be transferred to the SCADA system and shall be communicated to the Moodie LMSF at the same time. The data shall be transferred from the Train to the wayside wirelessly. Once on the wayside it shall be connected to the Station network to transmit the information to the relevant location.

(iii) The transmission of the data at every Station is aimed at identifying faults only. The status of the Train's health shall be used to prioritize the removal of un-healthy Trains to the Moodie LMSF during service reduction.

(e) Transfer of PID messages from wayside to the Train

(i) The HSDR system shall be able to transfer data from the PIS located in the Belfast MSF and controlled in TOCC & BCC to the PIDS located on the Train. The data transmitted from the PIS may be directed to a specific train, a group of Trains, or all Trains.

(ii) The PIDS determines which messages need to be displayed in the Trains, and when, to provide accurate and reliable information to Passengers.

(iii) The pre-recorded messages, both visual and audio shall reside in the PIDS system within the Vehicle. Those messages shall be in both English and French and shall have their individual ID that can be triggered by the PIS through the HSDR at any given time when the Vehicle is stopped at the Station or the Moodie LMSF.

(iv) The HSDR shall support the transfer of PIS system configuration data, pre-recorded audio files and visual messages to onboard PIDS wirelessly in the Stations or in the Moodie LMSF

(v) The HSDR shall provide data connection to allow new messages to be sent from the PIS system to the vehicle PIDS system to be displayed in a single Vehicle or fleet wide when the Vehicles are stopped at the Station.

(vi) The transfer of any data messages between the PIS and the Train borne PID equipment over the HSDR should not affect the transmission of Platform edge camera video from a Station to the Train.

(f) HSDR fault reporting

(i) The HSDR shall provide fault alarms and warning to the SCADA system using the SNMP standard protocol.

(ii) Alarm messages shall include but not be limited to;

A. Failure of HSDR in a station other operating parameters that are supported by the HSDR.

(g) HSDR Subsystem

(i) The HSDR shall operate within the unlicensed 5GHz bands and meet Industry Canada and FCC regulations compliant. It shall transmit in the 5GHz unlicensed bands in order to provide radio frequency separation from any CBTC transmissions in the 2.4GHz ISM band,

(ii) There shall be AP or base station at each end of each Platform and it is expected that there shall be APs or subscriber units at the end of each Vehicle to ensure maximum coverage and redundancy for RAMS purposes.

(iii) Each AP shall be wired to the local network switch, either on the wayside or within the Vehicle to enable connectivity with other Ethernet devices as appropriate. The City shall procure and free-issue to DB Co, 60 Wi-Fi Access Points (four per Station). The City shall procure and free-issue to DB Co, 60 Transceiver SFPs for access points (four per Station).

(iv) All base station units or subscriber units, irrespective of location, shall be approved by Industry Canada for operation within the Ottawa environment.

(v) When coupled, the intermediate access points on the two Vehicles shall be disabled.

(h) Wayside Network Connectivity

(i) The wayside (station AP's) shall be wired through an Ethernet switch at each Station. The Ethernet switches shall be connected to the main Confederation Line CTS through a dedicated wireless access. All high speed wireless data traffic traversing the CTS network shall be provided with a dedicated VLAN or similar protocol to segregate network traffic originating from the HSDR access points and route data traffic to the wayside servers.

(i) Protocols

(i) Given the data that shall be passed across them, all base station units shall be able to support more than one multi-protocol session and all shall be able to support the protocols used for the services described above. The HSDR shall support remote management tools, SNMP V3 and NTP protocols.

(j) Antennae

(i) The antenna shall be selected to support the selected radio frequency spectrum, signal strength and gain requirements to meet the system requirements. The antennas shall be selected and mounting locations shall be based on the required radio frequency coverage and minimum signal strength of the selected high speed radios. All base station units shall be connected to their antennae by low loss co-axial cable such as LDF-450 or LMR-400. All antennae ports shall be protected and suitable for the environment in Ottawa. The use of MIL style covers over 'N' style connectors is encouraged to provide weather protection.

(ii) The City shall procure and free-issue to DB Co, 240 Station directional antenna (16 per Station).

(k) Environment

(i) All APs shall be rugged and suitable for service within the Ottawa environment, including temperature, condensing humidity, snow and ice accretion and seismic requirements, in which they are deployed. Refer to Schedule 15-2, Part 1, Clause 4.3 for details.

(l) Latency

(i) The latency time of the end of Platform video for display to the driver screen shall be 100 ms or less measured from the data leaving the wayside AP to the data network port of the Vehicle video decoder.

(m) CCTV Video Interface

(i) The Platform edge cameras video shall be provided to the high speed radio as four independent analog video feeds per Platform in the communication rooms in each Station. The CCTV analog feed shall be 1.0 Vp-p, NTSC/PAL composite, 75 ohms, BNC connector. Alternately an IP video feed for each camera can be provided. The IP video shall be H.264 or MJPEG compliant 30 FPS 4cif resolution and comply with ONVIF specification for streaming. The connection shall be through a RJ 1000baseT Ethernet connection supporting UDP streaming. IP addressing and network interface to be arranged with the CTS network manager.