

THE CITY OF EDMONTON

PROJECT AGREEMENT

VALLEY LINE LRT – STAGE 1

Schedule 5 – D&C Performance Requirements

Part 6: Systems

VALLEY LINE PROJECT
SCHEDULE 5
D&C PERFORMANCE REQUIREMENTS

PART 6: SYSTEMS

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PART 6: SYSTEMS

SECTION 6-1 – RAIL SYSTEMS

6-1.1 INTRODUCTION

- A. Provide the following Rail Systems, and all associated infrastructure required for the Operation and control of the System, each as more specifically described in this Section 6-1 [*Rail Systems*]:
1. a Train Control System to provide Positive Train Separation, where Sighting Distances are restricted, in the Quarters Tunnel and wherever Conflicting Moves may be a consequence of normal operations;
 2. a Train Routing and Priority System to provide automatic Train routing and Transit Signal Priority to optimize Run Times;
 3. an Office Supervisory Control system to provide centralized Train monitoring and control;
 4. all Wayside Equipment and associated Wayside Equipment Enclosures;
 5. a Systems Duct Bank to provide mechanical protection and access for electrical, communication and signalling cable;
 6. a Fibre Optic Backbone to provide high capacity communications infrastructure;
 7. a main Data Centre and back-up Data Centre(s), as required, to encompass data collection, processing, storage and networking functions;
 8. electrical systems and all associated infrastructure required to energize the System and all associated distributed loads, except Traction Power loads;
 9. mechanical systems and all associated infrastructure required to provide the HVAC, plumbing and other mechanical requirements for the spaces in Stops and Stations and other Building Structures;
 10. a Surveillance System to provide security and operational Closed Circuit Television surveillance;
 11. one or more radio systems and infrastructure to provide wireless voice communications for operational, emergency and security purposes;
 12. telephone systems to provide landline voice communications for operational purposes, and for the convenience and safety of passengers;
 13. a Building SCADA system and Tunnel Ventilation SCADA system to centrally monitor and respond to conditions within the Transportation and Building Structures;
 14. a security and alarm system to protect critical System facilities;
 15. a Network Management System to centrally monitor all networked devices;
 16. infrastructure required to support the Ticket Vending Machines and other fare collection/validation infrastructure which are to be supplied and installed by the City;
 17. infrastructure required to support the installation of the advertising signs and screens which are to be supplied and installed by the City;
 18. Automatic Grade Crossing Warning System(s) to ensure the safety of persons and property at specific Grade Crossings, as identified pursuant to the Grade Crossing Hazard Analysis;

19. Public Address and Variable Message Sign systems to provide fire command post announcements, automated Train arrival announcements and centrally controlled passenger announcements;
20. all wire, cable and other infrastructure required to provide connectivity of equipment;
21. infrastructure required to support the installation of WiFi systems to be supplied and installed by the City; and
22. a Master Clock system to synchronize all time based event logging and reporting systems.

6-1.2 APPLICABLE CODES STANDARDS AND REGULATIONS

A. Without limiting Section 1-1.7 [*Reference Documents*] of this Schedule and except as otherwise specified herein, the Rail Systems and all associated infrastructure shall comply with the following codes, standards and regulations, to the extent applicable:

1. Alberta Building Code, provided that any electrical facilities, infrastructure and systems that are not subject to the Alberta Building Code shall comply with Section 6-4 [*Transportation Electrical Service Plan*] of this Schedule;
2. Alberta Fire Code;
3. ASHRAE Handbooks (HVAC Applications, Fundamentals, HVAC Systems and Equipment);
4. ASPE Handbooks (Volumes 1-4);
5. ANSI/BICSI 002;
6. ANSI/ICEA S-87-640-2006 Standard for Optical Fiber Outside Plant Communications Cable;
7. AREMA C&S Manual;
8. ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality;
9. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings;
10. ASHRAE 55 – Thermal Environmental Conditions for Human Occupancy;
11. Boeing Specification Support Standard BBS-7239 toxicity ratings;
12. Canadian Electrical Code Part I;
13. Canadian Electrical Code Part II;
14. Canadian Electrical Code Part III;
15. CGSB 24.3 – Identification of Piping Systems;
16. CAN/CSA Z462 Workplace Electrical Safety Standard;
17. CENELEC Standards;
18. CSA B149.1 – Natural Gas and Propane Installation Code;
19. IEEE 802.3at Power over Ethernet Standard;
20. International Railway Industry Standard;

21. National Plumbing Code;
22. NFPA-10 Standard for Portable Fire Extinguishers;
23. NFPA 13 Standard for the Installation of Sprinkler Systems;
24. NFPA 14 Standard for the Installation of Standpipe, Private Hydrants, and Hose Systems;
25. NFPA-76 Standard for the Fire Protection of Telecommunications Facilities;
26. NFPA-130 Standard for Fixed Guideway Transit and Passenger Rail Systems;
27. Telcordia Technologies, Inc - GR-20-CORE;
28. Telcordia Technologies, Inc - GR-326-CORE;
29. Telcordia Technologies, Inc - GR-449-CORE;
30. Telcordia Technologies, Inc - GR-771-CORE;
31. Telcordia Technologies, Inc - GR-2866-CORE;
32. Telcordia Technologies, Inc - GR-3120-CORE; and
33. Transport Canada Grade Crossings Standards, July 2014;
34. United States Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900 (PE-90).

6-1.3 TRAIN CONTROL SYSTEM (TCS)

- A. The TCS shall maintain Positive Train Separation by means of an arrangement of Block Signals, Wheel Counters, Track Circuits, Vital Controllers, Power Operated Switch Machines, Switch Position Indications, relays or other Vital equipment.
- B. Determine the Sighting Distance, calculated as the sum of the Service Brake Distance and the Train distance travelled in any section of Mainline Track, based on reasonable Driver Reaction Times at Maximum Operating Speed under unrestricted night-time viewing conditions.
- C. The System shall be principally designed for right hand running, Line-of-Sight Operation. Notwithstanding the previous sentence, provide a TCS to maintain Positive Train Separation:
 1. at all sections of the Mainline Track for which the Sighting Distance is less than the distance between the Driver and any potential Track Occupancy;
 2. in the Quarters Tunnels; and
 3. wherever Conflicting Moves may be a consequence of normal operations.
- D. If the TCS uses:
 1. A Block Signal, each Block Signal shall:
 - a. be of Vital design;
 - b. display a horizontal lunar bar aspect, as its default state, to convey an LRT-Stop indication;
 - c. display a vertical lunar bar aspect to convey an LRT-Proceed indication. A vertical lunar bar aspect shall not be displayed unless the Block it governs is free of any Track Occupancy;

- d. be equipped with luminaires that comply with the environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class B (*Wayside Outdoors*) equipment;
 - e. have sighting and conspicuity such that the Block Signal, or a Vital repeater signal, can be seen at the Sighting Distance in advance of the Block Signal, by a person having normal 6/6m vision, under normal daylight conditions; and
 - f. be equipped with day/night ambient lighting compensation;
2. a Wheel Counter to detect the presence of a Train within a Block, each Wheel Counter shall comply with AREMA C&S Manual Part 3.1.16, *Recommended Functional/Operating Guidelines for Wayside Based Train Detection Systems Not Based on Track Circuits Used to Activate Highway-Rail Grade Crossing Warning Systems*, or equivalent International Railway Industry Standard or CENELEC standard(s), applicable to the country of origin for the Wheel Counters;
3. a Track Circuit to detect the presence of a Train within a Block, each Track Circuit shall:
- a. be of Vital design;
 - b. be designed to operate with characteristic ballast resistance as low as two (2) Ω per 300m;
 - c. be designed to operate safely under the maximum allowable rail to rail shunt resistance applied by the LRV, pursuant to Section 7-1.18.6 [*Shunt Performance*] of this Schedule; and
 - d. notwithstanding the requirement of Section 6-1.3D.3.c [*Train Control System (TCS)*] of this Schedule, comply with AREMA C&S Manual Part 8.2.1, *Recommended Design Criteria and Functional Guidelines for Audio Frequency Track Circuits*, or equivalent International Railway Industry Standard or CENELEC standard(s), applicable to the country of origin for audio frequency Track Circuit equipment;
4. a Vital Controller, each VC shall:
- a. be of Vital design;
 - b. be a service proven model and version with a minimum of 100,000 hours of relevant revenue service;
 - c. be designed and manufactured in accordance with a product safety plan that describes all of the safety aspects of the product, including procedures for its development, installation, implementation, operation, maintenance, repair, inspection, testing and modification, and includes analyses supporting any safety claims;
 - d. react in a safe manner to all failure modes, such that it assumes a predetermined restricted state for each failure mode, and will not continue to operate if it fails any system integrity test;
 - e. have electrically isolated Vital outputs and inputs, with Vital outputs, inputs and interfaces conforming to AREMA C&S Manual Part 1.5.15, *Recommended Practice for Electrical Interfaces Between Signal, Train Control and Grade Crossing Equipment*, or equivalent International Railway Industry Standard or CENELEC standard(s), applicable to the country of origin for the VC;
 - f. have built-in diagnostic capabilities to periodically confirm operation of on-board processors, memory, I/O and other elements critical to the Vital integrity of the VC;
 - g. be provided with tools for testing, simulation, monitoring, and display of application software;

- h. be provided with a configuration management control plan designed to ensure that the VC configuration, including the hardware components and software version, is documented and maintained through its life cycle;
 - i. be equipped such that erasable portions of memory have physical or electrical protection to prevent unauthorized and accidental changes;
 - j. be equipped with sealed, locked, or otherwise tamper-resistant, modules for all portions of memory containing Vital software or firmware routines;
 - k. communicate with adjacent VCs to exchange Vital Block information wherever Trains may run in opposing directions within the same Block;
 - l. interface in a Vital or non-Vital manner with the OSC system and the TRPS;
 - m. generate alarms to the OSC to advise of critical events such as ground faults, operational violations such as switch run-throughs, and equipment board/module failures;
 - n. include a data and activity event logging subsystem, with a logging storage capacity of at least ten (10) days. The logging storage shall be capable of being interrogated remotely in accordance with Section 8 [*Remote Data Queries*] of Schedule 7 [*O&M Performance Requirements*]. All logs shall be time stamped, with time synchronized by the Master Clock system; and
 - o. be compliant with the environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class C (*Wayside Equipment Enclosures*) equipment;
5. a Power Operated Switch Machine, each POSM shall:
- a. be of Vital design;
 - b. be compliant with AREMA C&S Manual Part 12.2.1, *Recommended Design Criteria and Functional Guidelines for Lockable Electric Motor Switch Operating Mechanism*, or the equivalent International Railway Industry Standard or CENELEC standard(s) applicable to the country of origin for mainline switch machines;
 - c. comply with the environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class B (*Wayside Outdoors*) equipment;
 - d. be a service proven model and version with a minimum of 100,000 hours of in-street light rail revenue service in a climate designated as Koppen classification Dfb, with at least three months per year of ice and snow cover;
 - e. have electric detection of point or tongue positions;
 - f. allow reversal of machine in mid-stroke or at any point between end positions;
 - g. be provided with a plastic laminated or plastic encased internal-wiring diagram;
 - h. be trailable, meaning that the construction allows for a planned run-through of the switch from the trailing end by a Train operating at Restricted Speed, without damage to the switch mechanism;

- i. not provide correspondence indication after having been trailed, until the switch is called for and moves to the originally requested position;
 - j. have the internal movement of the locking and throw bars achieved hydraulically, or by an electric motor that is mechanically engaged to the bars;
 - k. provide for manual cranking operation of the switches by a single person, using a crank handle in case of failure of power operation capability. Insertion of the hand crank shall automatically inhibit motor power and if applicable, switch correspondence;
 - l. be designed to prevent collection of water within housings;
 - m. be provided with removable covers or other protection for the ends of lock rods and operating rods, where they extend beyond the switch mechanisms;
 - n. be equipped with an SPI; and
 - o. be provided with Detector Locking;
6. a Switch Position Indicator, each SPI shall:
- a. be of Vital design;
 - b. be mounted on a low mast near the switch points, as close to the point of switch as possible;
 - c. inform the Driver of an approaching Train of the position in which the switch is currently locked, by means of a visual indication;
 - d. have sighting and conspicuity such that the SPI, or a Vital repeater signal, can be seen at the Sighting Distance in advance of the SPI, by a person having normal 6/6m vision, under normal daylight conditions; and
 - e. comply with the environmental requirements of AREMA C&S Manual Part 11.5.1, Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment, for Class B (Wayside Outdoors) equipment;
7. a relay which is integral to safety of the TCS, each relay shall comply with the requirements of AREMA C&S Manual Part 6.2, *Recommended Plug-in Vital Relays*; or
8. a hand throw switch within a Block, each hand throw switch shall:
- a. be equipped with a switch circuit controller in compliance with AREMA C&S Manual Part 12.1.1, *Recommended Design Criteria for Switch Circuit Controller*, or equivalent International Railway Industry Standard or CENELEC standard(s) for switch circuit controllers; and
 - b. be configured as to cause the Block to become occupied when the hand throw switch point is more than 6mm from the normal and closed position.

6-1.4 TRAIN ROUTING AND PRIORITY SYSTEM

A. The TRPS is an arrangement of special purpose Vital or non-Vital computing devices, logic controllers, LRV on-board GPS receivers, wireless transceivers, transponders, display panels, control units, wayside transponders, loops, antennas, data radios, interrogators or other special purpose modules which together comprise a system for initiating:

- 1. TSP sequences for execution by the Traffic Controllers; and

2. Train routing commands for conditional execution by the TCS.

B. The TRPS shall:

1. initiate Transit Signal Priority in accordance with Section 6-3.5 [*Transit Signal Priority*] of this Schedule;
2. initiate field automatic Train routing;
3. enable Driver initiated Train routing;
4. enable OSC initiated Train routing;
5. provide Train position field reporting with sufficient data accuracy to support Operational Availability, schedule adherence and payment deduction reporting;
6. provide TCS field equipment status reporting; and
7. provide Train onboard TCS equipment status reporting.

C. All elements of the TRPS which are equipped with a CPU and on-board memory shall include data and activity event logging capability, with a logging storage capacity of least ten (10) days which is capable of being interrogated remotely in accordance with Section 8 [*Remote Data Queries*] of Schedule 7 [*O&M Performance Requirements*]. All logs shall be time stamped, with time synchronized by the Master Clock system.

D. The TRPS may communicate to one or more VC(s) via a Vital or non-Vital communication link, or via Vital or non-Vital discrete I/O.

E. TRPS trackside equipment shall comply with the temperature and vibration environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class B (*Wayside Outdoors*) equipment.

F. TRPS equipment housed within signal cabinets, signal rooms or other Wayside Equipment Enclosures shall comply with the temperature and vibration environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class C (*Wayside Equipment Enclosures*) equipment.

6-1.5 OFFICE SUPERVISORY CONTROL SYSTEM

A. The OSC system shall provide centralized Train monitoring and control from within the Operations Control Centre.

B. Provide an OSC system to acquire and report:

1. Travel Time for each Train, identified by unique Trip identifier;
2. time that a Train was stationary at each Grade Crossing as a result of an LRT-Stop aspect, as described in Section 6-3.5 [*Transit Signal Priority*] of this Schedule, aggregated for each Train, identified by unique Trip identifier;
3. time that a Train was stationary at a Block Signal as a result of an LRT-Stop aspect;
4. any manually entered delay codes associated with a Train;

5. any manually entered Platform and Track closure information;
 6. any Incomplete Trips, including reason for Trip interruption;
 7. Dwell Time at each Stop and Station;
 8. the Driver Trip and LRV Trip configuration for each Trip; and
 9. Train arrival and departure times at each Stop and Station, measured from LRV door locking for departure and LRV door unlocking at arrival.
- C. The OSC system shall automatically flag:
1. Any Full Trip for which the Travel Time exceeds the maximum one way Travel Time specified in Section 5.2 [*Travel Times*] of Schedule 7 [*O&M Performance Requirements*], by 20% or more;
 2. any Full Trip for which a Train fails to stop at each Stop and Station for the minimum Dwell Time specified in Section 5.3 [*Stop and Station Dwell Times*] of Schedule 7 [*O&M Performance Requirements*]; and
 3. any Early Departures and any Late Departures.
- D. OSC system reports shall be accessible and remotely retrievable at any time by authorized City Persons and shall provide user configurable querying and report generation, in accordance with Section 8 [*Remote Data Queries*] of Schedule 7 [*O&M Performance Requirements*].
- E. The OSC system shall:
1. be of non-Vital design;
 2. provide centralized data acquisition;
 3. allow remote command and control of all functionalities provided by the TRPS; and
 4. communicate to the TRPS via IP.
- F. The OSC system time shall be synchronized with the Master Clock system.
- G. The OSC system shall provide a real time data feed for reporting of Train locations, including unique Trip identifier, on a 15 to 30 second reporting basis, for interface and integration with the City's Trapeze™ TransitMaster™ transit trip planning system. Project Co may propose alternative methods for achieving an equivalent level of functionality for integrating with the TransitMaster™ transit trip planning system.

6-1.6 WAYSIDE EQUIPMENT AND ENCLOSURES

- A. All electronic Wayside Equipment shall be enclosed in Wayside Equipment Enclosures.
- B. All power equipment installed in any Wayside Equipment Enclosure shall have CSA/ULC compliance ratings. Each electrical load centre shall be equipped with a dedicated surge suppressor.
- C. Provide a separate Battery Ground Fault detector for each isolated energy source, within a Wayside Equipment Enclosure that contains energy sources for Vital equipment. All Battery Ground Fault condition alarms shall be reported to the OSC system.

6-1.7 SYSTEMS DUCT BANK AND ASSOCIATED INFRASTRUCTURE

- A. The Systems Duct Bank provides mechanical protection and access for City Conduit cables and for all electrical, communication and signalling cables required for Operation of the System.
- B. The Systems Duct Bank shall be located below grade, except where they are required to be concealed within the Elevated Guideway, and shall extend continuously along the full length of the LRT Corridor. Provide connections from the Systems Duct Bank to all Data Centres, Utility Complexes, Stations, Stops and to the Traffic Controllers located at the intersections listed in Table 6-3.3 [*Traffic Intersections*] of this Schedule.
- C. The Systems Duct Bank shall maintain a physical separation of at least 1m from the Traction Power Duct Bank.
- D. On the Elevated Guideways, the Systems Duct Bank shall be concealed within the Structure.
- E. Provide expansion fittings in the Systems Duct Bank at all deck joints on Elevated Guideways to accommodate movements.
- F. Provide appropriate fittings in the Systems Duct Bank, designed to accommodate all movements and prevent damage to the Systems Duct Bank, and the associated conduit, at any locations where rotations, horizontal displacements or vertical displacements may occur.
- G. Where Street Trees are provided along the LRT Corridor, locate the Systems Duct Bank away from the tree line to prevent tree root intrusion of the Systems Duct Bank.
- H. Electrical, communication and signalling cables required for Operation of the System shall be segregated into separate conduits along the full length of the LRT Corridor.
- I. The Systems Duct Bank shall include at least six (6) segregated and continuous 76 mm HDPE conduits from the west end of the 102 Avenue Tunnel Approach to the Muttart Stop and at least four (4) segregated and continuous 76mm HDPE conduits along the remaining length of the LRT Corridor, for exclusive use by the City (the "**City Conduits**").
- J. Each City Conduit shall be:
 - 1. swept and mandrelled after installation to ensure a clean and non-obstructed installation. No cable shall be installed prior to successful completion of these inspections;
 - 2. provided with one (1) nylon pull rope extending between opposing access points to the conduit;
 - 3. provided with HDPE bushings at all open conduit ends to protect cables;
 - 4. installed such that water will not accumulate in any section of the conduit. Each section shall be graded so that drainage will occur to the closest pull box or Access Vault location;
 - 5. labelled such that each conduit end is uniquely identifiable at each Access Vault and pull box; and
 - 6. provided with caps on all unused conduits.
- K. Provide Access Vaults to the Systems Duct Bank at:
 - 1. each Station and Stop;
 - 2. each end of all Elevated Guideways, Quarters Tunnel (or ends of a series of contiguous Transportation Structures carrying On-track Vehicles) and the Tunnel Approaches, placed in a

recessed location such that all Access Vault walls are accessible to the underground conduits, and such that only the Access Vault cover is visible;

3. each Utility Complex; and
 4. the main Data Centre and any back-up Data Centre(s) located along the LRT Corridor.
- L. Each Access Vault to the Systems Duct Bank shall:
1. be positioned to allow access to the Systems Duct Bank at any time, without impacting road traffic or Operation of the System;
 2. include space and mountings for outdoor-rated fibre splice enclosures and cable slack for segregated splicing of the City Fibre cable;
 3. include at least six (6) unused 76mm knockouts on each wall of the Access Vaults at the west end of the 102 Avenue Tunnel Approach and the Muttart Stop, and at least four (4) unused 76mm knockouts on each wall of all other Access Vaults. These knockouts shall be for the City's exclusive use; and
 4. include racking on all four inside walls for cable dressing and suspension of all cables to be housed. Designate one wall racking for City's exclusive use.
- M. All Systems Duct Bank pull boxes shall accommodate the City Conduits.
- N. Provide an enclosed and locked partition of minimum dimensions 800mm (width) x 450mm (depth) x 800mm (height), (the "**ETS LAN Cabinet**"), within the communications cabinet at each Stop and Station. Each ETS LAN Cabinet shall be supplied with:
1. padlocks, with all keys provided to City; and
 2. two (2) 120V 20A AC receptacles fed from a Level 1 "Emergency" load centre.
- O. Provide 76mm HDPE local conduits (the "**Local Conduits**"), between the nearest Systems Duct Bank Access Vault and each:
1. Traffic Controller located at the intersections listed in Table 6-3.3 [*Traffic Intersections*] of this Schedule – minimum one (1), and terminate in the Traffic Controller for shared Project Co and City use;
 2. Stop and Station – minimum one (1), and terminate in the ETS LAN Cabinet for City's exclusive use;
 3. main Data Centre and any back-up Data Centres located along the LRT Corridor – minimum four (4) and terminate on a main entry panel for City's exclusive use; and
 4. Utility Complex – minimum four (4); and terminate on a communications room entry panel for City's exclusive use.
- P. Each Local Conduit shall be:
1. installed at a minimum depth of 0.6m below grade, where horizontally placed outside a building;
 2. swept and mandrelled after installation to ensure a clean and non-obstructed installation;
 3. provided with one (1) nylon pull rope extending between opposing access points to the conduit;
 4. provided with HDPE bushings at all open conduit ends to protect cables;

5. installed such that water will not accumulate in any section of the conduit. Each section shall be graded so that drainage will occur to the closest pull box or Access Vault location;
 6. labelled such that each conduit end is uniquely identifiable at each Access Vault and pull box; and
 7. provided with caps on all unused conduits.
- Q. Promptly following installation and inspection of the Local Conduits, and associated Access Vaults, at the locations specified in Section 6-1.70 *[Systems Duct Bank and Associated Infrastructure]* of this Schedule, provide notice to the City and provide the City with access to the Local Conduits and associated Access Vaults in accordance with Section 1-1.3 *[City Works]* of this Schedule.
- R. Provide two enclosed data distribution cabinets, of minimum dimensions 800mm (width) x 1040mm (depth) x 42RU (height), with security lock, in each Data Centre and Utility Complex communications room, for the City's exclusive use (the "**City Cabinets**"). Each City Cabinet shall include:
1. two (2) 120V 20A AC receptacles fed from a Level 1 "Emergency" load centre; and
 2. dedicated overhead tray access to the entry panel where the four (4) Local Conduits are terminated.
- S. Promptly following installation of the City Cabinets and termination and inspection of the overhead cable trays and Local Conduits, provide notice to the City and provide the City with access the City Cabinets in accordance with Section 1-1.3 *[City Works]* of this Schedule.
- T. At the Churchill Connector Utility Complex, provide an unimpeded access path, at ceiling height, between the City Cabinet and the mezzanine of the existing Churchill Station to facilitate the City's installation of up to four (4) 76mm EMT conduits from the City Cabinet to the City's existing LRT communication rooms at the Churchill Station. Notify and provide access to the City once the access path is available, in accordance with Section 1-1.3 *[City Works]* of this Schedule.

6-1.8 FIBRE OPTIC BACKBONE

- A. The Fibre Optic Backbone refers to infrastructure designed to provide high capacity data connectivity between all communicating devices forming part of the System, and includes fibre optic cabling and cable assemblies, distribution frames, cabinets, splice enclosures, switches, routers, firewalls, and other devices providing local connectivity to end devices.
- B. Provide a fully redundant, scalable, Fibre Optic Backbone connecting all Data Centre(s), Utility Complexes, Stations, Stops, and Wayside Equipment Enclosures, extending throughout the full length of the Systems Duct Bank.
- C. In addition to the Fibre Optic Backbone, provide the following for the City's exclusive use:
1. a 144 strand SM fibre optic cable throughout the full length of one of the City Conduits;
 2. a 144 strand SM fibre optic cable from the Access Vault adjacent to the Churchill Connector Utility Complex to the associated City Cabinet via one of the Local Conduits;
 3. a 48 strand SM fibre optic cable from the Access Vault adjacent to the main Data Centre to the associated City-FDF via one of the Local Conduits;
 4. a 48 strand SM fibre optic cable from the Access Vault adjacent to any back-up Data Centre located along the LRT Corridor to the associated City-FDF via one of the Local Conduits; and

5. a 144 strand SM fibre optic cable from the Access Vault adjacent to the Utility Complex closest to Mill Woods Stop, to the associated City Cabinet via one of the Local Conduits,

(collectively, the "**City Fibre**");

D. The City Fibre shall include:

1. a minimum 15m cable figure-8 slack coil in each Access Vault;
2. a minimum 5m cable slack coil secured to the wall at each City-FDF and City Cabinet;
3. splices only within Access Vaults;
4. splice enclosures within Access Vaults, of the same make and model as those used for the Fibre Optic Backbone;
5. splicing of all strands such that:
 - a. strands 1-48 extend contiguously from the City Cabinet within the Utility Complex located closest to Mill Woods Stop, to the City-FDF in the main Data Centre;
 - b. strands 1-48 extend contiguously from the City Cabinet within the Churchill Connector Utility Complex, to the City-FDF in the main Data Centre;
 - c. strands 49-120 extend contiguously from the City Cabinet within the Utility Complex located closest to Mill Woods Stop, to the City Cabinet within the Churchill Connector Utility Complex; and
 - d. strands 121-144 extend in accordance with a splice schedule to be developed in coordination with the City.

Promptly following determination of all Access Vaults, provide notice to the City. Following receipt of notice, the City will develop its detailed splice schedule in accordance with Section 1-1.3 [*City Works*] of this Schedule.

- E. Within each shared use Local Conduit between the Traffic Controller locations and the nearest Access Vaults, provide a minimum four (4) strand SM fibre optic cable for City's exclusive use. Splice these four (4) strands to the City Fibre in the Access Vault in accordance with the splicing schedule developed in accordance with Section 6-1.8D.5.d [*Fibre Optic Backbone*] of this Schedule.
- F. Allocate two (2) dedicated fibre pairs within the Fibre Optic Backbone for the City's exclusive use for a dedicated ETS IP network. Configure these fibre pairs such that both pairs are extended to and terminate within:
 1. the City Cabinets at each Data Centre;
 2. the City Cabinets at each Utility Complex, and
 3. the ETS LAN Cabinet at each Stop and Station.

Promptly following installation and inspection of these fibre pairs, and the ETS LAN Cabinets, provide notice to the City and provide the City with access to the fibre pairs and the ETS LAN Cabinets in accordance with Section 1-1.3 [*City Works*] of this Schedule.

- G. All fibre optic cable shall:
1. comply with the *United States Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900 (PE-90)* and the requirements of *ANSI/ICEA Standard for Fiber Optic Outside Plant Communications Cable*, ANSI/ICEA S-87-640-2006 and GR-20-CORE. Fibre optic cables installed in Quarters Tunnel, Tunnel Approaches or any Confined Space (other than a pull box or Access Vault), shall be tested in compliance with *Boeing Specification Support Standard BBS-7239* toxicity ratings or other toxicity standards that, at the City's discretion, are deemed to be equivalent;
 2. be capable of supporting DWDM applications;
 3. adhere to the applicable manufacturer's minimum bending radius requirements at all times; and
 4. comply with GR-326-CORE.
- H. FDFs shall comply with GR-449-CORE.
- I. Fibre splice enclosures shall comply with GR-771-CORE.
- J. Fan outs shall comply with GR-2866-CORE.
- K. Outside plant fibre optic connectors shall be qualified in accordance with GR-3120.
- L. Terminate all fibre strands using SC terminations in Corning fibre enclosure modules:
1. 1U: Up to 24F SC, Holds 2 Bulkhead modules or splicing cassettes, P/N: CCH-01; and
 2. 2U: Up to 48F SC, Holds 4 bulkhead modules or splicing cassettes, P/N: CCH-02U.
- M. All terminated fibre strands described in Sections 6-1.8C, 6-1.8G.3 and 6-1.8F [*Fibre Optic Backbone*] of this Schedule shall be subjected to and pass the following post installation tests:
1. grading of all terminations by TIA/EIA-455-57B;
 2. end-to-end bi-directional power meter test at 1310 and 1550nm for single mode fibre;
 3. bi-directional OTDR test at 1310 and 1550nm for single mode fibre;
 4. optical spectrum analysis using the following criteria:
 - a. range: 1250-1650nm;
 - b. resolution: +/- 0.033nm;
 - c. accuracy: +/- 0.015nm; and
 - d. power accuracy: 0.4dB;
 5. chromatic dispersion analysis using the following criteria:
 - a. range: 1250 – 1650nm;
 - b. wavelength accuracy: 0.1nm; and
 - c. dispersion accuracy: 1.6ps/nm;
 6. polarization mode dispersion analysis (both 1st and 2nd order) using the following criteria:

- a. range: 0 – 115ps; and
 - b. accuracy: +/- (0.020 +/- 2 percent of PMD);
- N. Determine the following using the results of the tests performed in accordance with Section 6-1.8M [*Fibre Optic Backbone*] of this Schedule:
1. span loss (total loss of span from patch panel to patch panel);
 2. optical loss margin, defined as the additional loss that can be added to a fibre optic span without adding additional bit errors or packet loss to any given circuit on the optical multiplexer;
 3. return loss (as measured from a matching connector);
 4. splice loss;
 5. termination loss; and
 6. physical distance to all fibre features correlated with actual track positioning.

The following test values shall be used as pass criteria:

7. splices < 0.1dB loss;
 8. terminations < 0.25dB loss and > -55dB return loss (matching);
 9. total loss < calculated span loss; and
 10. optical loss margin > 10dB; and
- O. All test data shall be provided in:
1. static (hard copy) format; and
 2. dynamic (electronic) format, in native machine format suitable for additional analysis by City, along with all software necessary to interrogate and read the native format files.

Promptly following successful completion of the tests set out in this Section 6-1.8M [*Fibre Optic Backbone*], deliver all test results and software and provide notice to the City and provide the City with access to the terminated fibre strands in accordance with Section 1-1.3 [*City Works*] of this Schedule.

6-1.9 DATA CENTRES

- A. Provide a main Data Centre within the Gerry Wright OMF to serve as the main communication node for the System.
- B. Provide back-up Data Centre(s) as required to meet the operational and availability requirements of this Agreement.
- C. All Data Centre(s) shall be designed and constructed in accordance with ANSI/BICSI 002-2011. The main Data Centre shall be designed and constructed to Class F3.
- D. The architecture of all Data Centre(s) shall be modular.
- E. Within each Data Centre, provide an enclosed 2000 mm height Fibre Distribution Frame, equipped with a secured padlock, immediately adjacent to the City Cabinets described in Section 6-1.7

[*Systems Duct Bank and Associated Infrastructure*] of this Schedule, for the City's exclusive use (the "**City-FDF**"). Promptly following installation of the City-FDF, provide notice to the City and provide the City with access to the City-FDF in accordance with Section 1-1.3 [*City Works*] of this Schedule.

- F. Allocate one rack within each Data Centre as a firewall rack (the "**Firewall**"), from which all physical and virtual connections to the City and third party equipment shall be managed. Provide physical cross connections between the Firewall and the City-FDF. Promptly following installation of the cross connections, provide notice to the City and provide the City with access to the cross connections in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- G. In each back-up Data Center not located along the LRT Corridor, provide an MPLS service from the City-FDF to the City Cabinet in the Churchill Connector Utility Complex, with sufficient bandwidth to carry all network traffic between the Surveillance System and the ETS Transit Security Control Centre.

6-1.10 ELECTRICAL DESIGN AND CONSTRUCTION CRITERIA

6-1.10.1 Introduction

- A. This Section 6-1.10 [*Electrical Design and Construction Criteria*] sets out the electrical Design and Construction requirements for the System, Early Handover Items and the associated distributed loads, except Traction Power loads.

6-1.10.2 General

- A. All electrical distribution elements shall comply with the *Canadian Electrical Code, Part I, C22.1, and Canadian Electrical Code, Part II, C22.2*. All secondary and service-entrance cables shall also comply with *Canadian Electrical Code, Part II*.
- B. All transformers shall be dry-type.
- C. Provide a minimum 25% spare distribution capacity above the projected electrical loading requirements as at the Expiry Date for all transformers, switchgear and electrical distribution panels.

6-1.10.3 Calculations

- A. Perform short-circuit calculations to determine the Amps interrupting capacity rating of the electrical distribution system, based upon the actual available short-circuit value or per-unit impedance values obtained from the electric Utility Company at the electric service entrance or point of connection.
- B. System device coordination and selectivity shall be based on calculated short-circuit values and used for selection of ratings and settings of protection devices.
- C. Voltage drop calculations shall be completed for maximum loads, circuits and feeders and, where applicable, under motor starting conditions.
- D. Arc flash hazard calculations shall be completed for equipment that is required to be field marked for arc flash warning per CAN/CSA Z462. Values to be calculated shall include: (a) flash protection boundary in units of centimeter from equipment; (b) incident energy at 45.72cm working distance from equipment in units of calories per square centimeter (cal/cm²). The calculated values shall be permanently displayed on equipment arc flash hazard warning labels.
- E. Computations for service, feeder and branch circuit loads shall be based on the nominal system voltage used and applicable demand factors in accordance with the *Canadian Electrical Code*.

6-1.10.4 Electrical Load Classification

A. Electrical loads shall be classified as follows:

1. "Normal" electrical loads are any metered loads that are not classified as "Emergency", including non-essential loads which, if de-energized, have no effect on Passenger safety or System Operations; or
2. "Emergency" electrical loads are essential loads as defined by NFPA 130 and NFPA 110, and include:
 - a. Level 1 loads:
 - i. Ticket Vending Machines;
 - ii. ETS LAN Cabinets;
 - iii. emergency lighting;
 - iv. Vital signal system loads;
 - v. communication system loads (IP switches, PA amplifiers, telephones, Surveillance System);
 - vi. Emergency Alarm Stations;
 - vii. fire alarm systems;
 - viii. Building SCADA RTUs;
 - ix. any other metered load that cannot sustain momentary disruptions; and
 - b. Level 2 loads:
 - i. fire pumps;
 - ii. sump pumps;
 - iii. emergency ventilation and smoke removal systems;
 - iv. elevators and escalators; and
 - v. any other metered load that can sustain momentary disruptions but which requires redundant and diverse energy sources as determined in accordance with the Safety and Security Certification Program and the RAM Program.

6-1.10.5 Emergency and Standby Sources

- A. Provide standby power sources sized to energize all Level 1 and Level 2 "Emergency" electrical loads.
- B. Standby power sources shall be designed such that:
 1. Level 1 "Emergency" loads do not experience any interruption upon failure of any main electrical Utility feed; and

2. Level 2 “Emergency” loads shall not experience any interruption exceeding 2 minutes, or such shorter time as determined by the Safety and Security Certification Program and the RAM Program, upon failure of any main electrical Utility feed.
- C. Where standby power is provided by a second Utility feed, it shall be independently fed from an alternate Utility substation.
 - D. Standby power batteries shall not be located within a Pedestrian Priority Zone, unless housed within a Utility Complex that includes a TPSS.
 - E. Where standby power is provided by use of a mobile energy source, provide an electrically interlocked external connection point on the outside wall of the applicable electrical room, located within 10m of a parking stall or Roadway to allow access.
 - F. The electrical power supply to the tunnel ventilation system and Tunnel Ventilation SCADA system shall be designed such that no single failure of any part of either system can compromise the operation or capacity of the tunnel ventilation system.

6-1.10.6 Stop and Station Services

- A. Provide 3phase, 60Hz, incoming mains for each Stop and Station via a standard meter load or a transformer. Where installation of a transformer is required at a Stop it shall be located within a vault. Coordinate with the electric Utility Company for supply, installation and maintenance of electrical distribution equipment up to the demarcation point. The demarcation point between the electric Utility Company’s system and the System shall be as defined in the electric Utility Company’s Customer Connection Guide.
- B. At Davies Station, provide an electrical room and equip with:
 1. revenue class metering;
 2. switchboard;
 3. power distribution panels, including separate “normal”, Level 1 “Emergency”, and Level 2 “Emergency” load centres;
 4. feeders to all electrical loads;
 5. emergency and transfer equipment as described in Section 6-1.10.5 [*Emergency and Standby Sources*] of this Schedule;
 6. transformers;
 7. lighting control cabinet; and
 8. Station heating controls.
- C. At Stops, provide one (1) Platform mounted NEMA 4X enclosure, equipped with:
 1. revenue class metering;
 2. 120/208V 3 phase distribution panel complete with main breaker;
 3. feeders to all “normal” electrical loads;
 4. lighting controls; and
 5. Shelter heating controls.

6-1.10.7 Utility Complex Services

A. At each Utility Complex, provide within each associated electrical room:

1. electrical load centre panel, energized from a TPSS auxiliary feed in accordance with Section 6-2.4O [Mainline TPSS] of this Schedule;
2. transformers; and
3. such other electrical distribution equipment as required to support the functionality of the applicable Utility Complex.

B. External aerial feeder cabling within a Utility Complex is prohibited.

6-1.10.7.1 Stop and Station Electrical

A. The following requirements apply to all Stops and Stations:

1. all general purpose receptacles shall be ground fault indicating and shall have lockable covers. No more than five outlets shall be connected to any branch circuit;
2. provide electric heat tracing where hazardous accumulations of ice may otherwise occur in Passenger waiting and egress areas;
3. all "Emergency" electrical load service raceways and feeders shall be fire rated in accordance with CEC, NFPA 130 and NFPA 110 requirements;
4. all conduits shall be provided with a maximum pull box spacing of 30m;
5. where covers are floor mounted, they shall be slip resistant;
6. all unused conduit sections shall be provided with nylon pull strings;
7. conduits with an internal diameter of 50mm or less, shall not have any inside bend radius of less than six (6) times the internal conduit diameter;
8. conduits with an internal diameter of more than 50mm, shall not have any inside bend radius of less than ten (10) times the internal conduit diameter;
9. conduits penetrating exterior walls below grade, at grade floors, or below grade floors shall be sealed to prevent moisture migration; and
10. grounding-type expansion fittings shall be installed in raceways every 60 m or less of linear run, or wherever structural joints are crossed, to allow for expansion and contraction.

6-1.10.7.2 Grounding and Bonding

- A. The electrical distribution systems at Stops and Stations shall be solidly grounded and bonded in accordance with Section 1-2.5 [Grounding and Bonding] of Part 1 of this Schedule.
- B. The grounding electrode system shall be supplemented and bonded together with an embedded ground grid on each side of the Tracks at Davies Station.
- C. All non-current-carrying metal enclosures and all alternating current equipment shall be securely bonded to the grounding system at the applicable Stop or Station.
- D. Each metallic electrical equipment housing shall provide a welded boss for attaching a protective ground connection and shall be sized for expected trip currents.

- E. Any pipe connected to an active cathodic protection system shall not be connected to the grounding system, except where the design of the active cathodic protection system requires that the pipe be grounded.
- F. Feeder circuit grounding conductors shall be:
 - 1. housed in a separate conduit or run alongside the feeder cables; and
 - 2. shall be bonded to electrical equipment along the LRT Corridor, including metallic equipment enclosures.

6-1.10.8 Life safety

6-1.10.8.1 Electrical Safety Provisions

- A. Ground fault protection of equipment, as defined in the NEC (2014), shall be provided as required by the CEC. Ground fault “annunciation only” shall be provided where is required for equipment or feeders serving Level 2 “Emergency” electrical loads.
- B. Ground fault protection for personnel, as defined in UL 943, shall be provided on branch circuits that have equipment or outlets for which personnel protection is required by the CEC or Good Industry Practice.

6-1.11 MECHANICAL DESIGN AND CONSTRUCTION CRITERIA

- A. This Section 6-1.11 [*Mechanical Design and Construction Criteria*] sets out the mechanical Design and Construction requirements for Stops, Stations and Building Structures.

6-1.11.1 General Requirements

- A. Place floor-mounted mechanical equipment on reinforced concrete housekeeping pads with chamfered edges. The concrete pad shall be at least 100mm in thickness, and shall extend at least 100mm beyond the corresponding equipment dimensions.
- B. All piping systems shall be identified using a system that complies with CGSB 24.3, except where governed by code.

6-1.11.2 HVAC Design Requirements

6-1.11.2.1 General HVAC Design Requirements

- A. Indoor air temperature and relative humidity in all rooms and spaces shall comply with the requirements of the CEC and CSA B44 and shall meet any temperature and humidity requirements set by the manufacturers of equipment situated in such rooms or spaces.
- B. HVAC systems shall not use ethylene glycol.
- C. Shelters shall be electrically heated.

6-1.11.2.2 Stops Specific HVAC Design Requirements

- A. Provide automatic control for the heating system in each Shelter, such that:
 - 1. the heating system becomes activated within fifteen (15) seconds of the space becoming occupied and de-activated when the space becomes or remains unoccupied for more than three (3) consecutive minutes;

2. if the heating system has been de-activated, the Shelter shall reach a breath zone temperature of at least 4°C within five (5) minutes of being activated, with all doors closed, and maintain this minimum temperature while the space remains occupied.

6-1.11.2.3 Davies Station Specific HVAC Design Requirements

- A. Indoor environmental design parameters for spaces within the Davies Station shall be as detailed in Table 6-1.11.2.3 [Davies Station Indoor Design Conditions].

Table 6-1.11.2.3 – Davies Station Indoor Design Conditions

Space	Minimum Temperature (°C)	Maximum Temperature (°C)	Air Filtration (MERV)
Heated Waiting Areas	15	See Paragraph B	8
Security Office	21	24	8
Retail Kiosk	21	24	8
Public Washrooms	18	See Paragraph B	8
Operator Washrooms	18	See Paragraph B	8

- B. Space temperatures in heated waiting areas, public washrooms, and operator’s washrooms shall not be higher than 2°C above July 2.5% outdoor summer design dry bulb ambient temperatures given in the Alberta Building Code.

6-1.11.2.4 Churchill Connector Specific HVAC Design Requirements

- A. Indoor environmental design parameters for spaces within the Churchill Connector shall be as detailed in Table 6-1.11.2.4 [Churchill Connector Indoor Design Conditions].

Table 6-1.11.2.4 – Churchill Connector Indoor Design Conditions

Space	Minimum Temperature (°C)	Maximum Temperature (°C)	Air Filtration (MERV)
Sub-vestibule	4	See Paragraph B	8
Pavilion (at grade)	10	See Paragraph B	8
Landing Area (below-grade)	10	25	8
All other below-grade spaces accessed by the City	15	25	8

- B. Space temperatures in the sub-vestibule, and Pavilion shall not be higher than 5°C above July 2.5% outdoor summer design dry bulb ambient temperatures given in the Alberta Building Code.

6-1.11.3 Plumbing Design Requirements

6-1.11.3.1 General Plumbing Design Requirements

- A. All plumbing systems shall comply with the requirements of the *National Plumbing Code* and CSA B149.1.
- B. Where a cold water service is provided, it shall be serviced by at least one municipal water connection and shall be metered to the requirements of the applicable Utility Company. Each service shall have a main shut-off valve and backflow preventer.
- C. Dielectric couplings shall be provided for the connection of pipes of dissimilar metals, and in all metallic piping entering a Building Structure.
- D. Equip low points of domestic water distribution system with drain valves.
- E. Provide floor drains in all public and operator washrooms, janitor rooms and mechanical rooms.
- F. Where natural gas service is provided, it shall be serviced by one natural gas connection, metered and located to the requirements of the applicable Utility Company. The natural gas meter shall be located in an inconspicuous location.
- G. All plumbing fixtures shall comply with the *City of Edmonton Water Efficient Fixtures Bylaw 14571*.
- H. Plumbing piping shall not be embedded in concrete.
- I. Sleeves shall be provided wherever pipes penetrate a Structure.
- J. All sinks shall be provided with cold and hot water services.
- K. Piping exposed to outdoor temperatures shall be protected from freezing.
- L. All piping shall be insulated. Plumbing piping insulation shall comply with ASTM C547, Type I, Grade A, with factory-applied ASJ. The minimum insulation thicknesses and R-values shall be in accordance with ASHRAE 90.1.
- M. Pipe hangers and spacing shall comply with the applicable requirements of the ABC. Where copper piping is installed, hangers and supports in contact with the piping shall be made of copper.
- N. Cover all insulation with a canvas jacket except in ceiling spaces, crawl spaces and mechanical shafts.
- O. Buried joints in plumbing supply piping underneath a Structure shall not be permitted.
- P. Plumbing piping, except fire protection piping, shall not be routed through areas containing electrical, communication, or signalling equipment.
- Q. Equipment requiring drainage shall not be located directly over areas containing electrical, communication, or signalling equipment.
- R. Isolation valves shall be provided at the following locations:
 - 1. on each pressure main at building entrances;
 - 2. on each branch of distribution mains;
 - 3. at each plumbing fixture and group of fixtures; and

4. on both sides of in-line accessories and equipment that requires removal or isolation from the piping system for replacement, operation or maintenance.

6-1.11.3.2 Davies Station and Mill Woods Stop Specific Plumbing Design Requirements

- A. All toilets, urinals and sinks shall be of stainless steel construction and provided with running water.
- B. Toilets shall be completed with antimicrobial, extra heavy duty, open front seat and cover. Toilet seat and cover shall be injection molded of polypropylene with integrally molded permanent bumpers.

6-1.11.4 Fire Protection Design Requirements

6-1.11.4.1 General Fire Protection Design Requirements

- A. Provide fire extinguishers as, and where, required by the *Alberta Fire Code* and NFPA 10.
- B. Wherever the *Alberta Building Code* requires provision of a fire protection system, such systems shall comply with the requirements of NFPA 13.
- C. Fire protection systems in unheated spaces shall be protected from freezing.

6-1.11.4.2 Stops Specific Fire Protection Design Requirements

- A. At Stops, fire protection shall be provided via hydrant coverage.

6-1.11.4.3 Supply Air Exchange

- A. Provide a stand-alone-supply air and exhaust system and a hydrogen sensor in each room containing batteries designed to vent hydrogen.
- B. The supply air and exhaust system shall provide a minimum of five air-changes per hour in accordance with the requirements of NFPA-76.
- C. Upon sensing 1% or higher concentration of hydrogen in the air, the hydrogen sensor shall:
 1. provide an audible alarm;
 2. initiate operation of the exhaust air fan system; and
 3. report the alarm condition to the OCC through the Building SCADA system.
- D. The hydrogen sensor shall be capable of sensing within the range of 0.2% to 4% hydrogen concentrations in air.

6-1.12 SURVEILLANCE SYSTEM

6-1.12.1 General Surveillance Requirements and Coverage

- A. s.18

- B. The Surveillance System shall be designed to do the following:
1. mitigate safety and security threats identified in the Safety and Security Certification Program and in accordance with CPTED principles;
 2. provide visual evidence for incident and accident investigation;
 3. view and record the faces of persons entering and leaving any monitored area;
 4. provide video clarity for facial recognition on specific cameras as determined by a Surveillance Study;
 5. provide observance of general activity; and
 6. enable the City to satisfy its security obligations, as outlined in Section 2.2 [*City's Security Obligations*] of Schedule 29 [*Security Matters*].
- C. All information collected by the Surveillance System shall be collected, stored and used in compliance with the requirements of Schedule 18 [*Freedom of Information and Privacy Protection*] and all Applicable Laws, including the *Freedom of Information and Protection of Privacy Act* (Alberta).
- D. Prepare and submit a comprehensive surveillance study, including horizontal and vertical fields of view for each camera, with the Final Design of LRVs and of each facility referred to in Section 6-1.12.1E [*General Surveillance Requirements and Coverage*] (the "**Surveillance Study**"). The Surveillance Study shall demonstrate that the Surveillance System complies with the minimum coverage requirements set out in Sections 6-1.12.1E and 6-1.12.1F and the design requirements set out in Section 6-1.12.1B [*General Surveillance Requirements and Coverage*] of this Schedule.

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- G. If additional CCTV camera views are provided for operational or other purposes, they shall form part of, and be integrated with, the Surveillance System.

6-1.12.2 System Requirements

- A. Provide a head-end platform for the Surveillance System, which shall be comprised of the most recent version of “Genetec Security Center” in use by the City within six (6) months of the Service Commencement Date and provide the federation server necessary to permit interconnection of the Surveillance System with the City’s existing “Genetec Security Center” surveillance system.
- B. The Surveillance System shall provide:
1. camera organization and naming conventions which are consistent with the City’s camera organization and naming convention as at the Effective Date;
 2. harmonization of IP and multicast addressing with those adopted by the City as at the Effective Date, to facilitate easier connectivity to the City’s existing “Genetec Security Center” surveillance system;
 3. IP-based cameras in compliance with Section 6-1.12.4 [*CCTV Camera Requirements*] of this Schedule;
 4. dedicated application servers which control and manage every aspect of the Surveillance System, including video archives and corresponding databases. These servers shall be located in the Data Centre(s);
 5. seamless integration, such that the Surveillance System operation incurs no disruption, when cameras or workstations are added anywhere on the network, at any time;
 6. the ability for ETS Transit Security to synchronize live video and recorded video with alarms using a built-in HMI feature;
 7. support for up to sixty four (64) clients (users) simultaneously monitoring and managing live and recorded CCTV feeds deployed throughout the System, with no measurable degradation in performance;
 8. support for viewing a minimum thirty two (32) live feeds at 2 MP resolution at 10fps, from multiple servers on the same screen, with digital zoom and tracking;

9. identical copies of each video file on NAS storage devices, in secure encrypted format, at a minimum of two physical locations. Simultaneous transfer of secure encrypted digital video to each location shall be provided using multicast transport at the distribution level;
 10. video recording shall be secure, encrypted, digital, scalable and continuous;
 11. the capacity and functionality to accept and upload secure encrypted video images from any LRV located within the Gerry Wright OMF;
 12. selectable image rates up to 10 fps, on a per camera basis and for groups of cameras. Actual image rates shall be selectable by ETS Transit Security;
 13. regular, and on demand, retrieval of recorded video from edge devices where cameras have the capability to store video;
 14. ONVIF protocol and certification;
 15. user configurable alarm reporting to the ETS Transit Security Control Centre, including camera failure alarms;
 16. bathroom door camera IP streams, when requested, and directed to the ETS Transit Security Control Centre Jupiter Canvas™ system, for display on an overview video wall; and
 17. video recording and date/time and camera ID watermarks which shall be synchronized with the Master Clock system.
- C. Configure the Surveillance System, and provide integration with the City's existing "Genetec Security Center" surveillance system, to provide:
1. display of up to thirty two (32) live feeds at 2MP resolution at 10fps;
 2. simultaneous display of any combination of cameras;
 3. instant replay capability from any camera;
 4. digital zoom for clear identification;
 5. touch screen support; and
 6. retrieval and viewing of any Surveillance System stored video images.
- Notify the City, and provide such assistance as may be reasonably requested by the City to integrate the Surveillance System with the City's existing "Genetec Security Centre" surveillance system, in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- D. The Surveillance System is to be accessible from the existing security workstations at the ETS Transit Security Control Centre, at highest viewing and control priority of all Surveillance System workstations, such that viewing and control of any PTZ camera by others shall be disabled while the camera is under control of the ETS Transit Security Control Centre, until such time as control is relinquished by the ETS Transit Security Control Centre.
- E. Bandwidth management shall account for both the viewing and recording requirements.
- F. Video viewing access shall be strictly controlled and subject at all times to the requirements of Schedule 18 [*Freedom of Information and Protection of Privacy*].

6-1.12.3 Video Storage Requirements

- A. Provide a scalable and modular NAS storage solution with automatic load-balancing between added and existing disks. Video storage capacity shall be determined based on a twenty-one (21) day video retention policy, and archival strategy at maximum frame rates and resolution. All archived video shall be watermarked. Storage devices shall be secured in locked cabinets, accessible only to authorized City Persons. The storage cabinets shall be accessible to the authorized City Persons at all times. Provide all keys to the City's Representative.
- B. Retention of all video images on NAS storage devices, including images uploaded from LRVs, shall be for a duration of twenty-one (21) days, with automatic overwrite of stale images.
- C. All LRV Surveillance Subsystem camera images shall be digitally and securely encrypted and digitally stored on redundant on-board video storage devices, with a minimum of twenty-one (21) day storage capacity on each LRV. On-board video storage devices shall be NVR type with wireless capability to upload recorded video, on request, in secure encrypted format to the Surveillance System NAS storage devices within 24 hours of request.
- D. Each time the LRV returns to the Gerry Wright OMF, the LRV Surveillance Subsystem clock shall be synchronized with the Master Clock system.

6-1.12.4 CCTV Camera Requirements

- A. All CCTV cameras shall, as a minimum:
 - 1. utilize minimum H.264 encoding;
 - 2. be either stationary or pan tilt zoom, as determined by the Surveillance Study;
 - 3. be PoE capable;
 - 4. provide a minimum 2 Megapixel resolution;
 - 5. record colour images of sufficient clarity for facial recognition and video analytics under all controlled lighting conditions;
 - 6. be tamper proof and inconspicuous by blending in with the interior and exterior finishes;
 - 7. have sufficient sensitivity for any possible combination of controlled ambient and interior or exterior lighting levels, including emergency lighting; and
 - 8. have an adjustable field of view, via the use of standard hand tools after removal of tamper proof cover.
- B. Outdoor CCTV cameras and associated equipment shall operate and provide full functionality under all environmental conditions applicable to the location at which they are installed.
- C. Cameras placed in locations where lighting is uncontrolled and lighting conditions are insufficient to permit image quality required by Section 6-1.12.4A of this Schedule shall be provided with:
 - 1. infrared sensitivity;
 - 2. automatic switch from colour for daytime use, to ultra-sensitive black & white for night time surveillance;
 - 3. minimum sensitivity of 0.14 lux at F1.4 in colour mode, and 0.01 lux at F1.4 in black & white mode;

- 4. sensitivity enhancement of 32x for full colour surveillance in light as low as 0.01 lux; and
 - 5. built-in digital motion detector.
- D. Interface each LRT Surveillance Subsystem CCTV camera to the Fibre Optic Backbone through the nearest communications cabinet.
 - E. Where distances permit, LRT Surveillance Subsystem CCTV cameras shall be energized by Power over Ethernet using 60W PoE (UPOE). If distances are greater than standards allow, cameras shall be energized from a dedicated circuit extending in embedded conduit to the nearest Level 1 "Emergency" load centre.

6-1.13 RADIO SYSTEMS

- A. Provide radio systems, including hand held, mobile and LRV radios, base stations, antennas, power supplies, and OCC console equipment, required to provide wireless voice communications for operational, security, emergency and safety purposes throughout the LRT Corridor.
- B. Provide radio facilities for reliable wireless voice communications coverage for all users throughout the LRT Corridor at all times.
- C. Obtain necessary radio frequency licenses from Industry Canada to ensure interference-free communications for all radios, and renew all radio licenses on an annual basis.
- D. Radio repeater sites shall be provided as, and where, required to ensure uninterrupted coverage throughout the LRT Corridor, including within the Quarters Tunnel, the Tunnel Approaches, and in all underground facilities.
- E. Provide a radio interface for ETS Transit Security personnel operating in the 800 MHz bands as and where required to provide coverage for these bands throughout the LRT Corridor, including within the Quarters Tunnel, 102 Avenue Tunnel Approach, Tunnel Approaches and in all underground facilities. Notify the City once the radio interface is Available, and provide such assistance as may be reasonably requested by the City to interface to the radio interface, in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- F. Provide a radio interface for Emergency Services operating in the 700 MHz bands as and where required to provide coverage for these bands throughout the LRT Corridor, including within the Quarters Tunnel, 102 Avenue Tunnel Approach, Tunnel Approaches and in all underground facilities.
- G. Provide a recording system capable of storing a minimum of one (1) year of radio voice communications for incident management purposes. Recording storage devices shall be secured in locked cabinets in the Data Centre(s), accessible only to authorized City Persons. The storage cabinets shall be accessible to the authorized City Persons at all times. Provide all keys to the City's Representative. All radio channels shall be recorded and time stamped, with time synchronized by the Master Clock system. Recordings shall be retrievable by date and time.
- H. All information recorded by the radio systems shall be collected, stored and used in compliance with the requirements of Schedule 18 [*Freedom of Information and Privacy Protection*] and all Applicable Laws, including the *Freedom of Information and Protection of Privacy Act* (Alberta).

6-1.14 TELEPHONES

- A. Provide telephone systems as required for landline voice communications for operational purposes and for the convenience and safety of Passengers, including standard telephones, Passenger Assistance Intercoms, emergency life safety phones, emergency telephones, Emergency Alarm Stations, information phones, washroom access phones and elevator hands free help phones.

- B. Provide standard push button dial telephones, with hands-free feature, in all communications and signal equipment spaces, TPSS's, operations and equipment rooms. These telephone sets shall be featured for internal calling, and shall be capable of connecting to external parties through the Data Centre.
- C. Information phones connect Passengers directly to the City of Edmonton 311 Call Centre through a hands-free two way communication system. Provide one information phone on each Platform.
- D. Emergency Alarm Stations shall provide the functionality of "Blue Light Stations" as defined in NFPA-130 and shall be located at:
 - 1. the 102 Avenue Tunnel Approach;
 - 2. the North River Bank Tunnel Approach;
 - 3. the south end of the South River Valley Elevated Guideway;
 - 4. the end of each Platform in the Davies Station;
 - 5. at each end of the Davies Elevated Guideway; and
 - 6. at the below-grade landing area at Churchill Connector.

Each EAS shall:

- 7. automatically identify the location of the instrument when in use; and
 - 8. be located where they are not accessible to the public.
- E. Provide emergency telephones, identified as "blue light phones", at each Stop and Station. The emergency telephones shall be clearly visible, ADA compliant, hands free devices which automatically connect to the ETS Transit Security Control Centre. Such phones shall not provide a dial tone, but shall provide indication that the call is in progress. Activation of an emergency telephone shall automatically trigger the associated CCTV camera(s) to display live video images of the location to the ETS Transit Security Control Centre workstation. Emergency telephones shall time-out after 9 minutes if not properly hung up.
 - F. Provide washroom access phones outside all public washroom facilities. When activated, washroom access phones shall be automatically directed to the ETS Transit Security Control Centre. The washroom access phones shall time-out after 2 minutes if not properly hung up.
 - G. Provide washroom emergency phones on an inside wall of all public washroom facilities. The washroom emergency phones shall be clearly visible ADA compliant hands-free devices, located within arm's reach of the toilet fixture, which automatically connect to the ETS Transit Security Control Centre. The washroom emergency phones shall time-out after 9 minutes if not properly hung up.
 - H. Provide an emergency phone, equipped with a chain or other distinctive push button, in each operator washroom. The operator washroom emergency phones shall automatically connect to the ETS Transit Security Control Centre. The operator washroom emergency phones shall time-out after 9 minutes if not properly hung up.
 - I. Provide an elevator hands free help phone in each elevator. When activated, the elevator hands free help phones shall be automatically directed to the ETS Transit Security Control Centre. The elevator hands free help phones shall time-out after 9 minutes if not properly hung up.
 - J. Provide signage for all public phones (information, emergency, elevator help and washroom access) in English and Braille.

- K. Provide a recording system capable of storing a minimum of one (1) year of calls made to the ETS Transit Security Control Centre for incident management purposes. Recording storage devices shall be secured in locked cabinets in the Data Centre(s), accessible only to authorized City Persons. The storage cabinets shall be accessible to the authorized City Persons at all times. Provide all keys to the City's Representative. All recordings shall be time stamped, with time synchronized by the Master Clock system. Recordings shall be retrievable by date and time.
- L. All information recorded by the telephone systems shall be collected, stored and used in compliance with the requirements of Schedule 18 [*Freedom of Information and Privacy Protection*] and all Applicable Laws, including the *Freedom of Information and Protection of Privacy Act* (Alberta).
- M. Interface each telephone to the Fibre Optic Backbone through the nearest communications cabinet.

6-1.15 TRANSPORTATION AND BUILDING STRUCTURES SCADA

- A. Provide a Building SCADA system to centrally monitor and respond to conditions within the Building Structures. Provide a Tunnel Ventilation SCADA system to centrally monitor and control the tunnel ventilation system. The requirements of this Section 6-1.15 do not apply to the Traction Power SCADA System.
- B. The Building SCADA, Traction Power SCADA and Tunnel Ventilation SCADA functionality may be integrated into a single operating system provided that access to each of the functions is segregated and restricted to authorized personnel only.
- C. The Building SCADA system shall monitor each of the following:
 - 1. elevators;
 - 2. escalators;
 - 3. fire suppression & fire alarm;
 - 4. fire alarm health monitoring;
 - 5. hydrogen sensors;
 - 6. sumps;
 - 7. security and alarm (access);
 - 8. smoke control; and
 - 9. any other condition to be monitored or controlled, as determined in accordance with the Safety and Security Certification Program and the RAM Program.
- D. The Tunnel Ventilation SCADA system shall be compliant with NFPA-130 and shall monitor each of the following:
 - 1. fire suppression & fire alarm;
 - 2. fire alarm health monitoring;
 - 3. noxious or flammable gas sensors;
 - 4. tunnel ventilation system;
 - 5. sumps (if applicable);

6. security and alarm (access);
 7. smoke control; and
 8. any other condition to be monitored or controlled, as determined in accordance with the Safety and Security Certification Program and the RAM Program.
- E. Building SCADA and Tunnel Ventilation SCADA functionality shall be provided by:
1. use of conventional equipment, including a supervisory head end, a human/machine interface, remote terminals units, and programmable logic controllers; or
 2. means of the built-in NMS features of distributed IP devices installed throughout the LRT Corridor.
- F. Provide an RTU from Delta, P/N "DSC-1616E" in the City Cabinet at the Churchill Connector and provide monitoring points for City's exclusive use, for each of the following building infrastructure systems/elements:
1. Churchill Connector elevators; and
 2. Churchill Connector escalators.
- Notify the City once the RTU is installed, wired, and tested in accordance with manufacturer's requirements, and provide such assistance as may be reasonably requested by the City to integrate the RTU to the City's existing SCADA system, in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- G. All Building SCADA and Tunnel Ventilation SCADA system monitoring and control shall be managed from the OCC.
- H. Building SCADA and Tunnel Ventilation SCADA system functionality shall include a Data Historian application with remote user configurable querying and report generation in accordance with Section 8 [*Remote Data Queries*] of Schedule 7 [*O&M Performance Requirements*].

6-1.16 SECURITY AND ALARM

- A. Provide security and alarm systems to protect critical System facilities.
- B. Provide a centrally managed card access system, to be administered by Project Co, to provide restricted entry and intrusion detection for each protected area, including:
1. Utility Complexes, including TPPS buildings, signal rooms, communications rooms, and electrical rooms;
 2. Davies Station service rooms; and
 3. Gerry Wright OMF.
- Security alarming, including door intrusion detection shall automatically be reported to the OCC.
- C. Provide public washroom access by means of:
1. Remotely activated door locks, controlled from the ETS Transit Security Control Centre;
 2. an indicator light located at each washroom doorway to indicate which door has been remotely unlocked;

3. single occupancy washrooms shall also be lockable from the inside using a thumb latch which shall not be released by the remote door lock;
 4. an exterior lit "Occupied" sign for single occupancy washrooms, located near the washroom doorway and activated by motion sensor inside the washroom. The sign shall be visible to the ETS Transit Security Control Centre via CCTV; and
 5. an automatic door paddle located adjacent to the door inside the washroom allowing the remote lock to automatically release once the paddle is pressed. For single occupancy washrooms, the thumb latch shall also release once the door handle is turned.
- D. Provide access card readers, interfaced directly to City's C-Cure card access system, for restricting entry to:
1. the Existing Churchill Station from the Churchill Connector;
 2. the City Office within the Gerry Wright OMF; and
 3. Davies Station (ground level),

to be administered by City. Notify the City once the card readers are installed and tested in accordance with manufacturer's requirements, and provide such assistance as may be reasonably requested by the City to integrate the card readers with the City's C-Cure card access system, in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- E. Door security and access controls shall be interlocked with the fire alarm systems in accordance with the Alberta Building Code.
- F. Provide security motion detectors, and annunciate occupancy conditions to the ETS Transit Security Control Centre, at the following locations:
1. inside all public washrooms and the operator washrooms;
 2. all entrances to Davies Station; and
 3. access areas from Platform levels to concourse levels at Churchill Connector, between the existing Churchill Station and the Churchill Connector.
- G. Provide capability to allow automated disabling of alarm functions in public areas, based on pre-set occupancy schedules.
- H. Provide at least one smoke detector for each Utility Complex electrical room, communication room, and signal room, which shall be tied to the fire alarm panel in the nearest TPSS, as described in Section 6-2.4E.5 [*Mainline TPSS*] of this Schedule.

6-1.17 NETWORK MANAGEMENT SYSTEM

- A. Provide an NMS for centralized monitoring of all IP networked devices.
- B. Provide an integrated, COTS, NMS with the following features, to centrally monitor all network devices from the OCC:
1. NMS applications discovery to plug-in new/custom applications that need monitoring, and to support the management of multiple instances of an application;
 2. applications status polling to continuously monitor discovered applications to check their status and ensure optimal functioning;

3. host resources monitoring for usage criteria such as CPU, memory, disk utilization and system loading for all discovered devices on the network;
4. user defined alarm and event handling with real-time email and text message notification; and
5. remote I/O monitoring.

6-1.18 TICKET VENDING MACHINE INFRASTRUCTURE

- A. Provide all TVM infrastructure, including fixed infrastructure required to permit installation and operation of ticketing systems by the City.
- B. Provide the following spaces for TVMs of dimensions 1905mm (height) x 915mm (width) x 635mm (width) and Validators of dimensions 1335mm (height) x 300mm (width) x 300mm (depth) in accordance with Section 5-2.8.11 [*Passenger Interface Equipment*] of this Schedule:
 1. the base cabinet footprint for the TVM shall not be raised, and shall be 889mm (width) x 610mm (depth) with four (4) 0.50" anchor holes drilled to a depth of 51mm in a structural concrete slab. The TVM anchor hole spacing shall be 660mm (width) x 474mm (depth) and centered relative to the TVM cabinet. A total clearance of 1438mm (depth) x 1454mm (width) shall be provided to allow the TVM cabinet door to open fully; and
 2. confirm the Validator base plate dimensions and hole spacing with the City before drilling anchor holes.

TVMs and Validators shall be supplied and installed by the City.

- C. Provide a poke-through style floor box to surface within the footprint of the TVM cabinet, from Hubbell, P/N "S1PTFIT", positioned centered relative to the depth of the cabinet, and with the outside edge of the cover plate positioned at 165mm +/- 5mm from the door hinge side of the TVM cabinet edge.
- D. Provide a 120V 20A circuit in a dedicated 19mm embedded conduit to the TVM cabinet floor box from the nearest Level 1 "Emergency" load centre.
- E. Provide a dedicated 19mm embedded conduit to the TVM cabinet floor box from the ETS LAN Cabinet.
- F. Provide a dedicated 19mm embedded conduit to the TVM cabinet floor box from the associated Validator.
- G. Promptly following installation of all TVM and Validator spaces, floor boxes and associated cabling and conduits at each Stop and Station and at the Churchill Connector, provide notice to the City and provide the City with access to the spaces and associated infrastructure in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- H. Provide a dedicated 19mm embedded conduit for future smart card ticketing use from the ETS LAN Cabinet, extending approximately 95% of the full length of each Platform, and placed approximately 1m from the back edge of the Platform. Provide a sealed, recessed access box at each end of the conduit and at 90° bends where the conduit crosses the Tracks at side-loading Platforms.
- I. Provide a dedicated 19mm embedded conduit for future smart card ticketing use from the nearest Level 1 "Emergency" load centre, extending approximately 95% of the full length of each Platform, and placed approximately 1m from the back edge of the Platform. Provide a sealed, recessed access box at each end of the conduit and at 90° bends where the conduit crosses the Tracks at side-loading Platforms.

6-1.19 SCREENS AND SIGNAGE

- A. Notify and provide access to the City once all the infrastructure required for advertising screens, signs and panels as described in this Section 6-1.19 [*Screens and Signage*] of this Schedule are available, in accordance with Section 1-1.3 [*City Works*] of this Schedule.

6-1.19.1 ETS TV Screens

- A. Provide two (2) back to back screen enclosures, for installation of four (4) City provided 1390mm LCD screens, on each Platform in accordance with Section 5-2.8.11.7 [*ETS TV screens*] of this Schedule. The screen enclosures shall be suspended from the Canopy and perpendicular to the Tracks. Dimensions of the enclosure shall be 1390mm (width) x 990mm (height) x 250mm (depth). Provide structural support brackets from the Canopy, sufficient to support the enclosure weight plus total monitor weight of 70Kg under Building Code Climatic Data wind load for 1:50 years.
- B. Provide a concealed 19mm EMT conduit from each back to back screen enclosure to the nearest concrete surface, and extend through 19mm embedded conduit to the ETS LAN Cabinet.
- C. Provide a 120V 20A circuit in concealed 19mm EMT conduit from each back to back screen enclosure to the nearest concrete surface, and extend through 19mm embedded conduit to the nearest "Normal" electrical load centre.

6-1.19.2 Corporate Advertising

- A. Provide 19mm embedded conduit from each corporate advertising screen, placed in accordance with Section 5-2.8.11.8 [*Corporate Advertising Screens*] of this Schedule, to the ETS LAN Cabinet.
- B. Provide a 120V 20A circuit in concealed 19mm EMT conduit from each corporate advertising screen to the nearest concrete surface, and extend through 19mm embedded conduit to the nearest "Normal" electrical load centre.

6-1.19.3 Global Wayfinding

- A. Provide 19mm embedded conduit from each Global Wayfinding Map, placed in accordance with Section 5-2.8.11.6 [*Global Wayfinding Maps*] of this Schedule, to the ETS LAN Cabinet.
- B. Provide a 120V 20A circuit in embedded 19mm conduit from each Global Wayfinding Map to the nearest "Normal" electrical load centre.

6-1.19.4 Information Panels

- A. Provide 19mm embedded conduit from each Information Panel, placed in accordance with Section 5-2.8.11.5 [*Information Panels*] of this Schedule, to the ETS LAN Cabinet.
- B. Provide a 120V 20A circuit in embedded 19mm conduit from each Information Panel to the nearest "Normal" electrical load centre.

6-1.20 AUTOMATIC GRADE CROSSING WARNING SYSTEMS

- A. Prepare a comprehensive Hazard analysis of each Grade Crossing in accordance with the Safety and Security Certification Program and Good Industry Practice, to identify:
 - 1. all Hazards to persons and property, including the System, other infrastructure, Passengers, pedestrians, motorists, cyclists and other members of the public; and
 - 2. all design, construction and operational options available to mitigate the identified Hazards;

taking into account all applicable variables, including sightlines, Train speed, motor vehicle speeds, grades, pedestrian count, proximity of playground/school zones, and clearance distances (each, a "**Grade Crossing Hazard Analysis**"). Submit each Grade Crossing Hazard Analysis together with the applicable Final Design, in accordance with Schedule 4 [*Design and Construction Protocols*].

- B. Provide an Automatic Grade Crossing Warning System only at those Grade Crossings for which the Hazards identified pursuant to Section 6-1.20A.1 [*Automatic Grade Crossing Warning Systems*] of this Schedule cannot be satisfactorily mitigated by any combination of:
1. the mitigation measures identified pursuant to Section 6-1.20A.2 [*Automatic Grade Crossing Warning Systems*] of this Schedule; and
 2. the permitted Traffic Control Devices listed in Section 6-3.4.5 [*Grade Crossing Traffic Control Devices*] of this Schedule.
- C. Where an Automatic Grade Crossing Warning System is required, it shall:
1. be designed to mitigate the Hazards identified pursuant to Section 6-1.20A.1 [*Automatic Grade Crossing Warning Systems*] of this Schedule and ensure the safety of persons and property;
 2. operate such that any failure of the Grade Crossing warning device shall automatically activate the red flashing lights and cause all equipped gate arms to descend;
 3. be designed in accordance with *Transport Canada Grade Crossing Standards, July 2014*, except as modified herein;
 4. be activated by AF Track Circuits or Wheel Counters placed to allow adequate warning time for approaching Trains in accordance with AREMA C&S Manual Part 3.3.10, *Recommended Instructions for Determining Warning Time and Calculating Minimum Approach Distance for Highway-Rail Grade Crossing Warning Systems*;
 5. have all associated equipment housed in Wayside Equipment Enclosures meeting the requirements of Section 6-1.6 [*Wayside Equipment and Enclosures*] of this Schedule;
 6. be energized directly from a Vital DC operating bank. The operating bank shall consist of an AC charging rectifier and a standby battery bank. The AC charging rectifier shall be rated for sufficient amperage to continuously operate the activated Grade Crossing warning system without relying on battery bank reserves. The battery bank shall be rated at adequate capacity to operate all activated Grade Crossing warning equipment for a period of at least eight (8) hours in the event of AC power loss;
 7. have each Vital operating bank isolated from earth ground and all other DC power sources. Power off or ground fault conditions shall be alarmed to the OSC system;
 8. not employ bells; however traffic signal intersection pedestrian audible signals shall be provided in accordance with Section 6-3.3.4A.5 [*Traffic Signal Fixtures*] of this Schedule;
 9. be designed such that if a second Train will arrive at the Grade Crossing within 10 seconds after the first Train clears, the gate arms shall remain in the lowered position;
 10. include a Pre-emption interface to the associated Traffic Controller to coordinate Train, vehicular and pedestrian movements through the Grade Crossing, which shall:
 - a. allow road traffic queued near the crossing surface to clear the Tracks before the arrival of the Train;

- b. allow completion of any conflicting pedestrian crossings before the arrival of the Train. The approach warning times shall be sufficiently long to allow clearing times for pedestrians walking at a speed of 1.1 m/s across the widest portion of conflicting streets and medians; and
 - c. restrict vehicle and pedestrian traffic towards the Grade Crossing when the Train is approaching;
11. include an external switch on each applicable Wayside Equipment Enclosure that can be used to manually activate the crossing gate equipment. The switch shall require a key for access/operation and shall be situated such that the switch operator has a clear view of the crossing signals it controls. The switch shall be equipped with an additional position which shall allow for the complete deactivation of the Automatic Grade Crossing Warning System. Provide a means to ensure the switch cannot be inadvertently left in the deactivation position and alarm the deactivation condition to the OCC; and
 12. include a means to delay crossing warning activation for a Train that is held at a Stop or Station, as required in advance of Grade Crossings that are subject to the requirements of Section 6-3.5L [*Transit Signal Priority*] of this Schedule, until the associated Traffic Controller has released the Hold in Station condition.
- D. Where Automatic Grade Crossing Warning Systems are not required in accordance with Section 6-1.20B [*Automatic Grade Crossing Warning Systems*] of this Schedule, provide the necessary clearances for future installation of Automatic Grade Crossing Warning Systems, designed in accordance with Section 6-1.20C [*Automatic Grade Crossing Warning Systems*] of this Schedule, at the following locations:
1. McIntyre Road;
 2. Roper Road;
 3. 51st Ave;
 4. Whitemud Drive Westbound ramp; and
 5. Whitemud Drive Eastbound ramp;

so that the Automatic Grade Crossing Warning Systems can be constructed without obstructing or requiring re-alignment of any Track, road lanes or SUPs.

6-1.21 PUBLIC ADDRESS/VARIABLE MESSAGE SIGNS

6-1.21.1 System Requirements

- A. The PA/VMS system provides centrally controlled, automated, audible and text, fire command post, Train arrival and other Passenger announcements at each Station, Stop and within the Churchill Connector.
- B. Prepare and submit a comprehensive study with the Final Design of each Stop, Station and the Churchill Connector to demonstrate the PA subsystem complies with the acoustic coverage and intelligibility requirements of this Section 6-1.21 [*Public Address/Variable Message Signs*] (each, a "**Coverage Study**").
- C. The PA/VMS system shall employ a common PA/VMS head end to generate and control all messaging. The PA/VMS head end shall be designed to deliver messages to the audible (PA) and text (VMS) subsystems at each Station, Stop and within the Churchill Connector on an individual, grouped or zoned basis.

- D. PA/VMS system shall be IP-based.
- E. Subject to the emergency messaging requirements of NFPA-72, provide remote access to the PA subsystem to allow ETS Transit Security to make priority security related announcements from the ETS Transit Security Control Centre, either by means of a dedicated microphone at each ETS Transit Security Control Centre desk for this purpose, or through a secure text to voice web portal to allow messages to be textually entered. The remote access to the PA subsystem shall provide all-zone, configurable zone groups and individual zone selection capability.
- F. Promptly following installation and testing of the remote access to the PA subsystem, provide notice to the City and provide the City with access to the PA subsystem in accordance with Section 1-1.3 *[City Works]* of this Schedule.
- G. PA/VMS infrastructure shall support:
 - 1. zoning such that messages can be directed to either a single or any user selectable combination of Stops, Stations and the Churchill Connector;
 - 2. monitoring and remote diagnostics, including automatic fault finding, detection of open or shorted loudspeakers and, failure of VMS; and
 - 3. full functionality under all environmental conditions applicable to the location at which the infrastructure is installed.
- H. Related audible and text messages shall be coordinated so that playback to the public occurs simultaneously. Unrelated audible and text messages shall be capable of being transmitted independently of each other.
- I. The VMS subsystem shall display predetermined, ad-hoc (from typed input), and automated (pre-programmed inputs from the OSC and/or TRPS) text messages.
- J. PA zoning shall allow for all-zone, configurable zone groups and individual zone selection capability. The PA subsystem shall broadcast predetermined, ad-hoc (operator entered or from typed input), and automated (based on inputs from the OSC and/or TRPS) audible messages.
- K. Message types shall be prioritized with live messages having the highest priority, ad hoc (from typed input) second, automated third and pre-recorded messages the lowest priority. Higher priority messages shall pre-empt lower priority messages, with a user configurable option to continue a pre-empted message or not. Live messages originating from the ETS Transit Security Control Centre shall be at the highest priority and pre-empt all other messages that do not otherwise have precedence in accordance with the emergency messaging requirements of NFPA-72.
- L. Provide local input to both audible and text portions of the PA/VMS system at Davies Station, from the Davies Station communications room.
- M. Synchronize all time dependent PA/VMS events with the Master Clock system.

6-1.21.2 Variable Message Signs

- A. Variable Message Signs shall have a minimum array 48 x 144 LED matrix with two (2) lines of static text and third line scrolling capability. Minimum text height shall be 100mm. Words and numbers displayed on the VMS shall contrast with their background and not be red in colour. Enclosure shall be NEMA 4 rated, double faced.
- B. VMS scrolling speed shall be such that messages containing any Stop or Station names (which may be abbreviated) and any other complete words or messages shall be displayed for a minimum of two (2) seconds.

- C. VMS horizontal scrolling shall have a scrolling speed not exceeding six (6) characters per second.
- D. VMS characters shall be displayed in lower case with capitalization, with ascenders and descenders having a minimum size ratio of 20% to upper case characters.
- E. Each VMS shall be visible and legible under all lighting conditions.
- F. Provide VMS's at the locations specified in Section 5-2.8.11 [*Passenger Interface Equipment*] of this Schedule.
- G. Each VMS, except those at Terminus Stops, shall:
 - 1. provide information for Trains only on the Track it serves; and
 - 2. display the status of the next two revenue service Trains scheduled to arrive on the Track it serves, including Trip identifier, arrival time (accurate to within 30 seconds for the first Train to arrive, and 120 seconds for the second), arrival Track, and Train destination.
- H. Each VMS at Terminus Stops shall:
 - 1. provide information for Trains only on the Track it serves; and
 - 2. display the status of the next two revenue service Trains scheduled to depart from the Track it serves, including Trip identifier, departure time, departure Track and Train destination.
- I. Interface each VMS to the Fibre Optic Backbone through the nearest communications cabinet.

6-1.21.3 Public Address

- A. The Public Address subsystem shall comply with City of Edmonton Community Standards Bylaw 14600.
- B. The PA subsystem shall annunciate fire command post announcements, automated revenue service Train arrival announcements and centrally controlled Passenger announcements. Revenue service Train arrival announcements shall be made 30 seconds prior to arrival and at time of arrival. Announcements shall include the arrival Track and Terminus stop location of the next approaching revenue service Train, provided that where two trains are arriving at the same time, the announcements shall be staggered to avoid simultaneous message announcements.
- C. Provide PA loudspeakers at all Stop, Stations and within the Churchill Connector to provide uniform audio coverage of all Passenger areas.
- D. Interface each PA amplifier to the Fibre Optic Backbone through the nearest communications cabinet.
- E. Provide cabling from PA amplifiers to loudspeakers in concealed EMT conduit and/or embedded conduit.
- F. PA amplifiers shall be equipped with automatic gain control with local sound sensing devices. Outdoor mounted components shall operate and provide full functionality under all environmental conditions applicable to the location at which they are installed.
- G. The PA subsystem shall conform to the least restrictive of the following audio requirements and the requirements of Bylaw 14600:

Table: 6-1.21.3.1 – PA Audio Requirements

Sound Levels	6-10 dBa
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Typical Ambient Sound Pressure Levels (SPL)	75 dBa (+/- 22 dB) at 1.2 m above floor level.
Reverberance Level	< 1.0 seconds @ 500 Hz
Overall System Hum and noise	<-70 dBm
Harmonic Distortion	< 2% measured at stated operating sound pressure levels and specified frequency response.
PA Subsystem Frequency Response	Uniform from 200Hz to 6000 Hz +/- 2 dB measured with a 1/3 octave broadband signal.
Automatic Gain and Compression	Speech levels from loudspeakers to public areas remain constant within +/- 2 decibels SPL
Speech Transmission Index (STI) Min Performance Value	> 0.55

6-1.22 WIRE AND CABLE

- A. The requirements of this Section 6-1.22 *[Wire and Cable]* apply to all wire and cabling required for the Rail Systems described within Section 6-1 *[Rail Systems]* of this Schedule, except fibre optic cabling described in Section 6-1.8 *[Fibre Optic Backbone]* and Traction Power System cabling described in Section 6-2.9 *[Traction Power Cabling]*.
- B. Wire and cable installed in the Quarters Tunnels, 102 Avenue Tunnel Approach, Tunnel Approaches or in Confined Spaces, not including pull boxes or Access Vaults, shall be tested in compliance with *Boeing Specification Support Standard BBS-7239* toxicity ratings or other toxicity standards that, at the City's discretion, are deemed to be equivalent.
- C. All wire and cable shall comply with the Canadian Electrical Code, Table 19, except as modified herein.
- D. All exterior cable shall be installed in underground or embedded local conduit or duct bank conduits.
- E. All interior cable routed through exposed areas shall be encased in conduit or in flexible, non-metallic, liquid tight, electrical tubing.
- F. No conduit or duct shall exceed a 40% wire/cable fill ratio.
- G. Wire and cable for Vital applications shall comply with AREMA Communications and Signals Manual Part 10.3, *Recommended Wire and Cable*. Wherever a conductor forming part of a Vital system is subject to vibration, stranded copper conductors shall be used.
- H. All conductors and cable inner/outer jacketing installed within Quarters Tunnels and Tunnel Approaches, or in Confined Spaces shall be flame test rated FT4. Notwithstanding the preceding sentence, all conductors and cable inner/outer jacketing which forms part of a Vital application shall comply with the more stringent of:
 1. flame test rated FT4; and
 2. the requirements of AREMA C&S Manual Part 10.3.

- I. Install all cables in one contiguous length, without splices, between termination points.
- J. Provide minimum 15m slack loops for all cables in Access Vaults.
- K. Cable bend radius limitations, as specified by the applicable manufacturer, shall not be exceeded.

6-1.23 WIFI INFRASTRUCTURE

- A. Provide all infrastructure, required to permit installation and operation, by others, of WiFi access points at each Stop and Station and in the Churchill Connector, including:
 - 1. fixed infrastructure mounting space for a WiFi communications cabinet of dimensions 300mm (width) x 700mm (height) x 270mm (depth), to be provided by others:
 - a. immediately next to the Shelters at each Stop, such that the space is provided:
 - i. at the back of the Platform for side-loading Platforms; and
 - ii. in the longitudinal centreline of the Platform for centre-loading Platforms;
 - b. immediately next to the elevators at Davies Station;
 - c. in the Churchill Connector; in the below grade landing area, adjacent to the TVMs;
 - 2. one (1) dedicated 120V 20A circuit in 19mm embedded conduit from the WiFi communications cabinet mounting space to the nearest "Normal" electrical load centre;
 - 3. one (1) concealed 25mm EMT conduit between future WiFi access points at each of the opposing topmost corners of each Canopy or roof structure, to the nearest concrete surface, and extend through 25mm embedded conduit to the WiFi communications cabinet mounting space; and
 - 4. one (1) 35mm embedded and underground conduit between the WiFi communications cabinet mounting space and the Access Vault serving the Stop, Station or the Churchill Connector, as applicable, for cable entrance. Cable will be installed by others.
- B. Provide all infrastructure, including fixed infrastructure, required to permit installation and operation, by others, of WiFi access points on one street light pole, or OCS pole on Elevated Guideways, every 200m - 400m along the LRT Corridor, including two (2) 35mm conduits from each pole to the nearest Access Vault.
- C. Provide all infrastructure, including fixed infrastructure, required to permit installation and operation, by others, of WiFi coverage in the Quarters Tunnel, 102 Avenue Tunnel Approach and Tunnel Approaches, including two (2) 35mm conduits from each tunnel end to the nearest Access Vault.

6-1.24 MASTER CLOCK SYSTEM

- A. This section describes the requirements for a Master Clock system; to be utilized for synchronizing all time based event logging and reporting across the System.
- B. Provide a Master Clock system utilizing COTS network equipment and distribution methods, which shall:
 - 1. operate autonomously and provide software configuration options for time zone offsets and automatic daylight saving time corrections without scheduled operator intervention or maintenance;
 - 2. be configurable via software control with password security;

3. allow for remote monitoring and interrogation in accordance with Section 8 [*Remote Data Queries*] of Schedule 7 [*O&M Performance Requirements*];
4. operate with an internal reference time that is set to UTC via a built-in SNTP client, from at least two NTP timeservers, with automatic selection of the primary and secondary servers, configurable by either static IP address or DHCP provided IP address configuration methods;
5. be accurate to within 50 milliseconds of the UTC time reference provided by the NTP server(s), at all times;
6. periodically, and at least one time each 24 hours, update all Traction Power SCADA and Rail Systems devices such that all internal clocks are synchronized and accurate to within 1 second of UTC time at all times. In the event of failure to update any Traction Power SCADA or Rail Systems device over any 24 hour period, the Master Clock system shall provide an NMS alarm, indicating the failure and affected device; and
7. utilize an internal, maintenance free, rechargeable battery backed real-time clock to retain the internal time in the event of a power outage or for conditions when the NTP servers are not available, referred to as “free-wheeling periods”. During free-wheeling periods the Master Clock system shall provide an NMS alarm, indicating that the device is relying on the internal oscillator and is not currently synchronized to the network timeservers.

SECTION 6-2 – TRACTION POWER SYSTEM

6-2.1 INTRODUCTION

A. This Section sets out the requirements for:

1. the Traction Power System;
2. the Traction Power Substations for the Mainline;
3. the Traction Power Substations within the Gerry Wright OMF, including both the Yard Track and Shop Track areas;
4. the systems for distribution of Traction Power from the TPSS to the LRV, including:
 - a. the Overhead Contact System, if required; and
 - b. any non-OCS systems for distribution of Traction Power;
5. Traction Power cabling; and
6. the Traction Power SCADA System.

6-2.2 APPLICABLE CODES STANDARDS AND REGULATIONS

A. Without limiting Section 1-1.7 [*Reference Documents*] of this Schedule and except as otherwise specified herein, the Traction Power Systems and all associated infrastructure shall comply with the following codes, standards and regulations, to the extent applicable:

1. Alberta Building Code, provided that any electrical facilities, infrastructure and systems that are not subject to the Alberta Building Code shall comply with Section 6-4 [*Transportation Electrical Service Plan*] of this Schedule;
2. ANSI/IEEE Standard C37.2 Standard Electrical Power System Device Function Numbers and Contact Designations;
3. AREMA C&S Manual;
4. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings;
5. Canadian Electrical Code Part I;
6. Canadian Electrical Code Part II;
7. EN 50122-1 Railway Applications - Fixed Installations - Electrical Safety, Earthing and the Return Circuit - Part 1: Protective Provisions Against Electric Shock;
8. IEC 62271-202 High Voltage/Low Voltage Prefabricated Substation;
9. IEEE 80 Guide for Safety;
10. IEEE 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems;
11. IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems;
12. IEEE 1653.2 Standard for Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output;

13. TPSS equipment specific standards set out in Section 6-2.4J [*Mainline TPSS*] of this Schedule; and
14. Alternative Traction Power Distribution equipment standards set out in Section 6-2.8A [*Alternative Traction Power Distribution Systems*] of this Schedule.

6-2.3 TRACTION POWER – GENERAL

- A. The Traction Power System encompasses all equipment necessary to produce and deliver LRV propulsion energy.
- B. The Traction Power System shall be developed and assessed using computer simulation software intended for the purposes of Traction Power System modelling.
- C. Provide a Traction Power System that shall:
 1. enable the System to operate in full compliance with this Agreement under all Service Levels;
 2. sustain a fully loaded operation, with maximum consist length, for the Operating Headways provided in Table 5.4 [*Operating Headways*] of Schedule 7 [*O&M Performance Requirements*], with full auxiliary loads and passenger loads, maintained 24 hours a day, seven days a week, in both normal and Contingency Conditions at the Maximum Service Level, along the entire LRT Corridor;
 3. wherever Traction Power is delivered from a TPSS to the LRV by OCS, the Traction Power System shall operate using a 750V or 1500V DC Traction Power Distribution system, with a floating traction return system where the rail shall be normally kept isolated from ground everywhere except the Shop Track;
 4. comply with the requirements of IEEE 519 for harmonic disturbance;
 5. constrain Stray Current effects in the parallel electrical resistance of the negative conductive path to ground, in accordance with the Stray Current Sub-plan;
 6. not exceed the limits specified in EN 50122-1, for voltages present on the running rails under either normal operating conditions or Contingency Conditions, without reliance on bonding of the running rails to ground. Demonstrate compliance via software simulation, and validate with field measurements;
 7. apply VLDs to automatically and temporarily bond the running rails to ground, only under fault conditions. All instances of VLDs engaging shall be automatically reported to the OCC; and
 8. be provided with electrical protection, at a minimum interval of every TPSS location, to enable isolation of the Traction Power distribution system in the event of electrical faults.

6-2.4 MAINLINE TPSS

- A. Provide Mainline TPSS's along the LRT Corridor as required for operation of the System. TPSS may be located anywhere within the boundaries of the City Lands, subject to the following restrictions:
 1. if a Mainline TPSS is required between 95th Street and 103rd Street, it shall be built-in-place, underground, within the Churchill Connector and shall form part of the Churchill Connector Utility Complex; and
 2. if one or more Mainline TPSS's are required within the NSRV they shall be located as specified in Section 2-9.9 [*Utility Complexes*] of this Schedule, and shall form part of the 95th Street Utility Complex and the Muttart Utility Complex, as applicable.

- B. Pre-fabricated TPSS buildings shall comply with IEC 62271-202.
- C. All TPSS's, whether pre-fabricated or built-in-place, shall:
 - 1. provide sufficient ventilation to ensure that all equipment is maintained within its specified operating temperature under all operating conditions;
 - 2. prevent unauthorized access to the TPSS;
 - 3. ensure that all persons are protected from exposure to Hazards, including exposure to hazardous voltages, arc flashes, toxic/harmful liquids and gases and explosion risks; and
 - 4. be designed such that any piece of equipment in the TPSS can be safely and reliably maintained and where required, can be removed, replaced, reinstalled, commissioned and returned to full operation as required by the RAM Program.
- D. All TPSS electrical equipment shall be CSA or UL/ULC approved.
- E. Each TPSS shall include:
 - 1. AC switchgear in compliance with the requirements of Section 6-2.4J.1 *[Mainline TPSS]* of this Schedule, to isolate the incoming AC supply;
 - 2. a traction transformer and rectifier in compliance with the requirements of Section 6-2.4J.2 *[Mainline TPSS]* of this Schedule;
 - 3. DC switchgear in compliance with the requirements of Section 6-2.4J.3 *[Mainline TPSS]* of this Schedule, to isolate the rectifier from the DC busbar and to isolate the DC busbar from each of the feeder cables. The DC switchgear shall include line and bypass switches in compliance with the requirements of Section 6-2.4J.4 *[Mainline TPSS]* of this Schedule, to enable off-load reconfiguration of the Traction Power Distribution system;
 - 4. feeder cables in compliance with the requirements of Section 6-2.9 *[Traction Power Cabling]* of this Schedule;
 - 5. a fire alarm panel utilizing smoke detector alarm contact(s) to operate a lockout trip relay and to report to OCC via the Building SCADA system or Traction Power SCADA system; and
 - 6. smoke detectors at strategic locations to detect smoke or products of combustion. The operation of the circuit breakers shall not activate the smoke detection system.
- F. Wherever an OCS is used, the minimum and mean useful voltages present between the OCS and the running rails shall remain within the limits specified in EN 50388 for a 750V or 1500V DC Traction Power System, under all system configurations and states of wear and under all Service Levels.
- G. All built-in-place Mainline TPSS's shall use Traction Power equipment of consistent make, model and ratings.
- H. All pre-fabricated Mainline TPSS's shall use Traction Power equipment of consistent make, model and ratings.
- I. Each TPSS transformer and rectifier shall be rated as a unit to operate at 100% rating continuously and for the following overload duty cycle (in percent of rated full load current, after reaching stabilized temperature while operating at 100% rated load) in accordance with IEEE 1653.2:
 - 1. 150% for two hours, with five superimposed periods of 1 minute duration at 300% of rated current each, evenly spaced throughout the 2-hour period; and

2. 450% for 15 seconds at the end of the 2-hour period.

J. TPSS power equipment shall comply with the following standards, to the extent applicable:

1. AC Switchgear:

- a. IEEE C37.20 Standard for Metal Clad Switchgear;
- b. IEEE C37.04 Standard Rating Structure for AC High-Voltage Circuit Breakers;
- c. IEEE C37.06 AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis- Preferred Ratings and Related Required Capabilities;
- d. IEEE C37.09 Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis;
- e. IEEE C37.20.4 Standard for Indoor AC Switches Used in Metal Clad Switchgear; and
- f. NEMA SG-4 Alternating Current High-Voltage Circuit Breakers.

2. Transformers and Rectifiers:

- a. IEEE C57.12.01 Standard General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings;
- b. IEEE C57.12.91 Test Code for Dry-Type Distribution and Power Transformers;
- c. IEEE C57.18.10 Standard Practices and Requirements for Semiconductor Power Rectifier Transformers;
- d. IEEE 1653.2 Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 V DC Nominal Output;
- e. IEEE 1653.4 DC Traction Power System Field Testing and Acceptance Criteria for System Applications up to 1500 V DC Nominal;
- f. EN 50122-1 Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock; and
- g. EN 50328 Railway applications - Fixed installations - Electronic power converters for substations.

3. DC Switchgear:

- a. EN 50123-1 Railway applications - Fixed installations - D.C. switchgear - Part 1 : general;
- b. EN 50123-2 Railway applications - Fixed installations - D.C. switchgear - Part 2 : D.C. circuit breakers;
- c. EN 50123-3 Railway applications - Fixed installations - D.C. switchgear - Part 3 : indoor D.C. disconnectors, switch-disconnectors and earthing switches;
- d. EN 50123-4 Railway applications - Fixed installations - D.C. switchgear - Part 4 : outdoor D.C. disconnectors, switch-disconnectors and earthing switches;
- e. EN 50123-5 Railway applications - Fixed installations - D.C. switchgear - Part 5 : surge arresters and low-voltage limiters for specific use in D.C. systems;

- f. EN 50123-6 Railway applications - Fixed installations - D.C. switchgear - Part 6 : D.C. switchgear assemblies;
 - g. EN 50123-7 Railway applications - Fixed installations - D.C. switchgear - Part 7-1 : measurement, control and protection devices for specific use in D.C. traction systems - Application guide;
 - h. IEEE C37.20.1B Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear Amendment 2: Additional Requirements for Control and Auxiliary Power Wiring in DC Traction Power Switchgear; and
 - i. IEEE C37.14 Standard for Low-Voltage DC Power Circuit Breakers Used in Enclosures.
4. Line and Bypass Switches
- a. EN 50123-3 Railway applications - Fixed installations - D.C. switchgear - Part 3 : indoor D.C. disconnectors, switch-disconnectors and earthing switches; and
 - b. EN 50123-4 Railway applications - Fixed installations - D.C. switchgear - Part 4 : outdoor D.C. disconnectors, switch-disconnectors and earthing switches.
- K. Provide ANSI/IEEE Standard C37.2 protection equipment for all TPSS's, in conjunction with the AC and DC switchgear, to meet the associated requirements contained herein. The protection equipment shall comply with the requirements of this Schedule under the most adverse combinations of System configuration and states of wear on distribution conductors, rails and OCS under all Service Levels. Each TPSS shall be provided with:
1. AC switchgear, with protective relays, for the protection of individual circuits from transient over-voltage, under-voltage, short circuit, over-current, thermal overload and ground fault. Provide digital protective relays with data logging, event recording, and waveform recording capability for all relays other than relays used for repeating or lockout operations;
 2. DC main breaker and feeder breakers, with protective relays equipped with automatic recloser equipment, over-current, transfer trip, adjustable series trip and rate of rise protection. Provide the main breaker with reverse current protection, and intertrip scheme with the AC rectifier breaker. Provide digital protective relays with data logging, event recording, and waveform recording capability for all relays other than relays used for repeating or lockout operations;
 3. transformer winding temperature gauges with two-stage contacts. The first stage contacts shall provide alarm annunciation and the second stage shall provide tripping of circuit breakers and associated alarm annunciation;
 4. a current limiting fuse to disconnect each diode in a parallel rectifier string in case of diode failure, for protection of the other rectifier components. Diode fuses shall have current ratings sufficient to ride through all external DC faults and rectifier loading conditions. Provide each diode fuse with a blown-fuse indicator and contacts to trigger alarms upon failed diodes and blown fuses; and
 5. a VLD at each TPSS to monitor the rail to ground potential, and provide automatic grounding of the negative by activating a high current GTO thyristor when the voltage exceeds preset limits. Two-stage protection shall be provided to alarm at ± 30 VDC and solidly ground the rail at ± 40 VDC. Voltages and time delays shall be user adjustable. The thyristor circuit shall open if the current drops to zero or upon polarity reversal.
- L. Make arrangements with, and obtain primary power connection to each TPSS from the electric Utility Company. Confirm TPSS equipment compatibility and interoperability in compliance with the electric Utility Company's Customer Connection Guide.

- M. Coordinate the design of the Traction Power System protection scheme with the electric Utility Company to achieve margins between all levels of protection systems sufficient to ensure that all schemes and time current characteristics allow for full use of the rated capacity of all equipment.
- N. Provide pad mounted switchgear within each Utility Complex containing a TPSS, for the incoming AC feed, equipped with controlled access and security fencing to limit access, and terminated in accordance with the electric Utility Company's requirements. Construct all infrastructure and cabling elements from the TPSS structure to the pad mounted switchgear, including metering compartment, duct banks, foundations, grounding, and maintenance hole, in accordance with the electric Utility Company's standards.
- O. Provide auxiliary power supplies for non-Traction Power equipment housed in Utility Complex rooms which are co-located with the TPSS. The auxiliary power supplies shall be rated for the equipment to be supplied.
- P. Provide a ground mat at each TPSS for step and touch potential protection, and to allow control and measurement of Stray Currents and rail-to earth potentials. The ground mat shall be contained within the Utility Complex and shall comply with IEEE 80. Enclosures and metal components, except those specifically required to be ungrounded, shall be electrically bonded and solidly grounded to the ground mat.

6-2.5 SHOP TPSS AND YARD TPSS

- A. The Traction Power Systems within the Gerry Wright OMF shall be segregated into a Yard Track Traction Power System and a Shop Traction Power System.
- B. The Yard Track Traction Power System shall provide DC power for LRV movements on all Yard Track and shall be fed from a Yard TPSS, sized to satisfy all Operations and Maintenance activities on the Yard Tracks.
- C. The Yard Track Traction Power System shall be of the same arrangement and design, and from the same manufacturer(s), as either of the prefabricated or built-in-place Mainline TPSSs.
- D. The positive circuits and negative rail returns for the Yard Track Traction Power System shall be electrically isolated from the positive circuits and negative rail returns of the Shop Traction Power System. The negative rail returns for the Yard Track Traction Power System shall be a floating system, electrically continuous throughout, and shall be directly connected to the negative return of the Yard TPSS.
- E. The power supply for the Yard Track Traction Power System shall be designed, and have sufficient capacity, to support the Maximum Service Level.
- F. The Shop Traction Power System shall provide DC power for LRV movements and associated auxiliary power within the Shop and shall be fed from a Shop TPSS, sized to satisfy all Operations and Maintenance activities on the Shop Tracks at the Maximum Service Level.
- G. The running rails on all Shop Tracks shall be deliberately and permanently grounded in accordance with IEEE 142 – *Recommended Practice for Grounding of Industrial and Commercial Power Systems*.
- H. The Shop Traction Power System shall be connected to each Shop Track contact wire through an isolation switch. The isolation switch shall be wall-mounted for manual operation and shall be interlocked through any crane, lifting jacking, maintenance device (wheel truing) and other device that may cause injury or damage if Traction Power should be left unintentionally energized.
- I. The Shop Traction Power System shall be interlocked throughout the Shop through a resettable visual and audible emergency trip system which automatically de-energizes the power supply to the Shop Traction Power System in the event of a trip caused by a fault condition.

- J. Make arrangements with, and obtain primary power connection to each TPSS from the electric Utility Company. Confirm TPSS equipment compatibility and interoperability in compliance with the electric Utility Company's Customer Connection Guide.
- K. Coordinate the design of the Traction Power System protection scheme with the electric Utility Company to achieve margins between all levels of protection systems sufficient to ensure that all schemes and time current characteristics allow for full use of the rated capacity of all equipment.
- L. Provide pad mounted switchgear for the incoming AC feed, equipped with controlled access and security fencing to limit access, and terminated in accordance with the electric Utility Company's requirements. Construct all infrastructure and cabling elements from the TPSS structure to the pad mounted switchgear, including metering compartment, duct banks, foundations, grounding, and maintenance hole, in accordance with the electric Utility Company's standards.

6-2.6 TRACTION POWER DISTRIBUTION ARRANGEMENT

- A. The Traction Power distribution arrangement encompasses all systems necessary to deliver Traction Power from the TPSS's to the LRV equipment over the entire LRT Corridor, including the Gerry Wright OMF.
- B. The Traction Power distribution arrangement shall:
 - 1. be suitable for transferring power from the TPSS's to the LRV under all operating conditions and Service Levels; and
 - 2. be designed to minimize Stray Current in accordance with the Stray Current Sub-Plan.
- C. Wherever the System uses:
 - 1. an Overhead Contact System for distribution of Traction Power to the LRVs from the TPSS's, the OCS shall comply with the requirements of Section 6-2.7 [*Overhead Contact System*] of this Schedule; or
 - 2. an alternative (non-OCS) means for distribution, or capture and re-injection, of Traction Power to the LRVs from the TPSS's, such alternative Traction Power distribution system(s) shall comply with the requirements of Section 6-2.8 [*Alternative Traction Power Distribution Systems*] of this Schedule.

6-2.7 OVERHEAD CONTACT SYSTEM

- A. The OCS shall:
 - 1. include all interface equipment between the DC Traction Power supply equipment at the TPSS and the pantograph equipment on the LRVs, including foundations, poles, cantilevers, bridge arms, shop building supports, system conductors, hangers, jumpers, terminations, tensioning devices sectioning equipment, equipment for intersection of the High Load Corridor, and other equipment;
 - 2. be double-insulated, so as to create a safe working zone between energized and grounded equipment;
 - 3. provide uninterrupted Traction Power collection by all LRV pantographs for the operating speed range along the relevant section of OCS;
 - 4. operate without fault or failure under the dynamic pantograph characteristics created by the LRVs; and
 - 5. be designed to function without fault or failure under the following wind and ice loading conditions:

- a. LRVs operating, with ice, wind speed 65kph;
- b. LRVs operating, without ice, wind speed 95kph; and
- c. no LRVs operating, without ice, wind speed 150kph.

Ice loading shall be based on 12.5mm of ice on all conductors, supports and registrations, and all other OCS equipment.

- B. The traction current return from the LRVs to each TPSS shall be via any combination of the running rails and parallel underground feeder cables.
- C. Where LED lighting is provided on OCS poles, provide electrical energy to LED lighting caps from the nearest Utility Complex via buried conduit and through the interior of the poles.
- D. OCS pole spacing and stagger shall be determined using a pantograph security analysis in accordance with Good Industry Practice. Provide maximum span length and stagger (i.e. least number of support structures) required to ensure pantograph de-wirement does not occur.
- E. OCS poles shall be installed plumb with a one degree allowable lean tolerance.
- F. Prior to installation, any damage to galvanized OCS pole finished surfaces, if applicable, shall be repaired in accordance with ASTM A780 using the following methods:
 - 1. ASTM A780 - Method A2 – where damage to the galvanized surface is 6mm x 150mm or smaller; and
 - 2. ASTM A780 – Method A3 - where damage to the galvanized surface is greater than 6mm x 150mm.
- G. Stagger the contact wire on both tangent and curved tracks to achieve uniform wear of the pantograph. Where messenger wire is required it shall also be staggered and the messenger wire shall be positioned over the contact wire.
- H. The minimum contact wire height shall comply with the Canadian Electrical Code, Part I, Twenty-second Edition, C22.1–12, and shall not exceed the maximum working height of the pantograph.
- I. The gradient of the contact wire, relative to the gradient of the rail, shall not exceed the following values:

Table 6-2.7: Contact Wire Gradients

Maximum Design Speed	Maximum Contact Wire Gradient
≤ 30kph	+/- 1.3%
<30kph to ≤ 50kph	+/- 0.8%
<50kph to ≤ 80kph	+/- 0.6%

- J. The maximum contact wire gradient change from one span to the next shall not exceed one-half the maximum gradient for Maximum Design Speed of the applicable span.
- K. Foundations for OCS poles that contain feeder or utility cables shall use concealed conduits.
- L. Foundations for OCS poles shall be reinforced concrete and shall be:

1. embedded in the earth;
 2. provided as part of other Structures forming part of the System, such as Elevated Guideways; or
 3. an integral part of the track slab Structure.
- M. All OCS poles shall be solidly grounded.
- N. The contact wire, if applicable, shall be Structure-affixed for the full extent of:
1. the Canopy at Davies Station;
 2. the Quarters Tunnel; and
 3. the overhead Structures at the 102 Avenue Tunnel Approach.
- O. Where the OCS wires pass within a 3.4m radial clearance from an accessible space, including any adjacent building, bridge or structure, provide CEC compliant screening or fencing to prevent exposure to live parts.
- P. Operational across-Track live load deflection of the OCS pole at contact wire height shall not exceed 50mm.
- Q. OCS poles shall not deflect more than 2% of their length when rated maximum bending load is applied 600mm from the top of pole.
- R. Provide a pole cap or finial to prevent water ingress into the top of OCS poles.
- S. Provide sealed cable spouts wherever wires or cables are run inside an OCS pole.
- T. Cantilever arm assemblies shall be used to vertically support the OCS along at-grade sections of Trackway and Elevated Guideway sections. The cantilever arm assemblies shall vertically support, and horizontally regulate the contact wire and any messenger wire. Cantilever arm assemblies shall be mounted directly to the OCS poles by brackets or directly fixed to walls, depending on the required application.
- U. Cross spans or head spans between two OCS poles may be used to support the OCS where a pole cannot be placed between the Tracks or where the distance between the Track and the nearest OCS pole is too great.
- V. The OCS shall be divided into tension sections with each tension section having an overlap with each adjacent section. Overlaps between adjacent tension sections at TPSS locations shall be insulated to provide isolation points.
- W. OCS terminations shall be completed with a balance weight anchor pole, a fixed termination pole, or a spring tensioner.
- X. Midpoint anchor assemblies shall be used to prevent longitudinal movement of the OCS along the Track. Midpoint anchors shall be placed as close as possible to the midway point between each set of tensioning devices.
- Y. The contact wire and any messenger wire shall be maintained at a constant tension using a tensioning device which shall incorporate safety features to prevent unauthorized personnel from accessing the system. Pneumatic or hydraulic tensioning devices are not permitted.
- Z. Insulated overlaps or section insulators shall be located so that power can be supplied independently to the line segments on either side of each TPSS.

AA. Not used.

BB. At crossovers, contact wires shall not cross from one Track to the other, and shall be regulated using insulated knuckles.

CC. Provide surge arresters to protect the OCS from damage due to over-voltages and lightning. Surge arrestors shall:

1. be rated to withstand the maximum system voltage and maximum voltages that could be induced from any paralleling high-voltage transmission lines onto the OCS conductors;
2. be capable of discharging the energy resulting from lightning strikes without damage to the System;
3. at a minimum, be provided:
 - a. adjacent to each TPSS;
 - b. in all areas of reduced OCS clearances, such as at overhead bridges or buildings;
 - c. at all high points in the LRT Corridor, such as Elevated Guideways;
 - d. at the end of Track; and
 - e. at each side of disconnect switches.

DD. Where the LRT Corridor crosses the High Load Corridor, the OCS shall be designed such that it can be disarranged and rearranged as, and when, required so as to provide unrestricted height clearance across the entire turning radius for all Over-Dimensional Vehicles in accordance with Section 1-2.9 [*High Load Corridor*] of this Schedule.

EE. Provide common grounding of OCS support poles on Elevated Guideway through electrical connection to either bonded (welded) reinforcing steel in the deck or to each other and a common ground electrode system.

FF. The OCS pole foundations shall be designed to account for the structure loading and soil conditions. The supporting structure foundations shall be designed to accept bolted base poles and structure grounding.

GG. All metallic OCS pole foundation components, inclusive of the pole baseplate, that will be embedded in, or otherwise come in contact with, concrete surfaces shall be coated with a sacrificial/barrier coating. The sacrificial/barrier coating shall be applied to the entire component and shall extend a minimum of:

1. 150mm into the concrete; and
2. 15mm above the surface of the concrete.

6-2.8 ALTERNATIVE TRACTION POWER DISTRIBUTION SYSTEMS

A. Alternative Traction Power Distribution Systems shall:

1. be service proven, as an integrated system, with a minimum of 100,000 hours of revenue service in a climate designated as Koppen classification Dfb, and having at least three months per year of ice and snow cover;
2. be safe for use in urban, in-street running, Low Floor, LRT applications;

3. comply with the following standards, to the extent applicable:
 - a. Canadian Electrical Code, Part I, Twenty-second Edition, C22.1–12;
 - b. Canadian Electrical Code Part II, 2010 Edition, C22.2-No 0-10;
 - c. Canadian Electrical Code Part II, 2009 Edition, C22.2-No 52-09;
 - d. EN 50121-3-2 Electromagnetic compatibility;
 - e. EN 50124-1 Dielectric strength and insulation;
 - f. EN 50153 Protection measures for electrical risks;
 - g. IEC/EN 60850 Supply voltages of traction networks;
 - h. EN 60529 IP protection grades;
 - i. IEC/EN 61373 Vibration and impact test;
 - j. EN 61287-1 Power converter type tests;
 - k. EN-45545 Fire and smoke performance; and
4. provide the following, if the design of the System requires the lowering and raising of the pantograph:
 - a. a means of automatic detection/operation of the pantograph to reduce the risk of operator error;
 - b. automatic detection of contact wire; and
 - c. arc-free lowering and raising of pantograph.

6-2.9 TRACTION POWER CABLING

A. The requirements of this Section 6-2.9 [*Traction Power Cabling*] apply to all cabling:

1. within each TPSS;
2. between each TPSS and the running rails/Traction Power Distribution system; and
3. between each TPSS and the associated pad mounted switch gear for the incoming AC feed,
(collectively, the "***Traction Power Cable***").

B. Traction Power Cabling shall:

1. be suitable for the application and rated for the load and fault currents to which it may be subjected, and where applicable, the de-rating effects when multiple cables are grouped together; and
2. have insulation selected to ensure that emission of harmful products is avoided in the Quarters Tunnel, the Tunnel Approaches, or in Confined Spaces by the use of low smoke zero halogen cabling which shall be tested in compliance with *Boeing Specification Support Standard BBS-7239* toxicity ratings or other toxicity standards that, at the City's discretion, are deemed to be equivalent.

- C. All conductors forming part of the Traction Power Distribution system shall be electrically rated for the maximum load and fault currents to which they may be subjected under all environmental conditions applicable to the location at which they are installed.
- D. Where negative return current is passed through the rails, provide impedance bonds between each set of adjoining Track Circuits, with center taps and high current carrying cables to carry the Traction Power return current from Track to Track and back to the TPSS rectifiers. Cable connections shall be corrosion protected. Un-tuned impedance bonds shall comply with the requirements of AREMA C&S Manual Part 8.4.5, *Recommended Design Criteria for Low Frequency Untuned Impedance Bonds*. Tuned impedance bonds shall comply with the requirements of AREMA C&S Manual Part 8.4.9, *Recommended Design Criteria for Low Frequency Tuned Impedance Bonds*.
- E. Provide a label at each end of each Traction Power Cable to identify the type, size and function of the cable.

6-2.10 TRACTION POWER DUCT BANK

- A. Provide manholes in Traction Power Duct Banks where required for access to, or installation of Traction Power Cable, and at a minimum spacing of 120m.
- B. Where Street Trees are provided along the LRT Corridor, locate the Traction Power Duct Bank away from the tree line to prevent tree root intrusion of the Traction Power Duct Bank.
- C. Provide Traction Power Duct Banks from each TPSS exiting point to the intersect point of the Traction Power Distribution system. Traction Power Duct Banks shall:
 1. be constructed of non-conductive material;
 2. be encased in concrete;
 3. be sloped at a minimum of 1 to 250 towards manholes;
 4. be provided with a utility marking tape (with magnetic tracer), placed at a maximum 330mm above each underground raceway;
 5. include at least one (1) spare empty duct;
 6. maintain a minimum separation of 1m from the Systems Duct Bank;
 7. on the Elevated Guideways, the Traction Power Duct Banks shall be concealed within the Structure;
 8. be provided with expansion fittings at all deck joints on Elevated Guideways to accommodate movements; and
 9. be provided with appropriate fittings, designed to accommodate all movements and prevent damage to the Traction Power Duct Bank, and the associated conduit, at any locations where rotations, horizontal displacements or vertical displacements may occur.

6-2.11 TRACTION POWER SCADA

- A. Provide a Traction Power SCADA System for remote control and monitoring of all Traction Power equipment from the OCC. The Traction Power SCADA System shall have capacity for all control and monitoring points, with an additional 25% local I/O expansion capacity at each TPSS location and with corresponding processing capacity of the head end equipment at the Data Centre(s).

- B. Traction Power SCADA System functionality shall include a Data Historian application with user configurable querying and report generation in accordance with Section 8 [*Remote Data Queries*] of Schedule 7 [*O&M Performance Requirements*].
- C. Provide a PLC-based control and interface system for the Traction Power System which shall monitor the following:
 - a. AC current transducer (A-B, B-C, C-A);
 - b. AC voltage transducer (A-B, B-C, C-A);
 - c. rectifier current transducer;
 - d. rail to ground voltage alarm;
 - e. rail to ground voltage trip; and
 - f. any other condition to be monitored or controlled, as determined in accordance with the Safety and Security Certification Program and the RAM Program.

SECTION 6-3 TRAFFIC SIGNALS

6-3.1 INTRODUCTION

- A. This section sets out the Design and Construction requirements for Traffic Signal Equipment and Traffic Control Devices to be provided at designated intersections along the LRT Corridor, and the requirements for Transit Signal Priority so as to safely and efficiently manage the interaction between competing modes of transportation at Grade Crossings.

6-3.2 APPLICABLE CODES STANDARDS AND REGULATIONS

- A. Without limiting Section 1-1.7 *[Reference Documents]* of this Schedule and except as otherwise specified herein, the Traffic Signal Equipment and all associated infrastructure shall comply with the following codes, standards and regulations, to the extent applicable:
1. Alberta Building Code, provided that any Traffic Signal electrical facilities, infrastructure and systems that are not subject to the Alberta Building Code shall comply with Section 6-4 *[Transportation Electrical Service Plan]* of this Schedule;
 2. Alberta Electrical Utility Code;
 3. Alberta Electrical Communications Utility Code;
 4. APTA TCRP Report 69 Light Rail Service: Pedestrian and Vehicular Safety;
 5. APTA TCRP Research Results Digest 84 – Audible Signals for Pedestrian Safety in LRT Environments;
 6. ATPA TCRP Report 137 – Improving Pedestrian and Motorist Safety Along Light Rail Alignments;
 7. AREMA C&S Manual;
 8. Canadian Electrical Code Part I;
 9. Canadian Electrical Code Part II;
 10. Canadian Electrical Code Part III;
 11. City of Edmonton Construction Specification for Portland Cement Concrete for Structural Footings;
 12. Transportation Association of Canada Manual on Uniform Traffic Control Devices; and
 13. US DOT Manual on Uniform Traffic Control Devices.

6-3.3 TRAFFIC SIGNAL EQUIPMENT

- A. Provide all new Traffic Signal equipment, at the intersection locations listed in Table 6-3.3 *[Traffic Intersections]* of this Schedule, including Traffic Controllers, cantilever structures, poles, arms, davit extensions, LRT Traffic Signal heads, Road Traffic Signal heads, backboards, LED signal modules, pedestrian count-down timers, pedestrian push buttons, audible signals, active signs, passive signs, overhead signs, crosswalk signals, Utility power, standby power, vehicle detectors, foundations, junction boxes, vaults, ducts, cabling, detector loops, loop sealant, and signal assembly materials consisting of stainless steel strapping and buckles, anchor bolts, tenons, cover plates, grommets, arm flanges, hand holes, identification decals, base plates, fixture brackets, guywires, preforms, machine bolts, eye nuts, hex nuts, washers, saddle clamps, strain insulators, and davit arm hangars, all designed in accordance with MUTCD (Canada) and the requirements set out in Section 6-3.4 *[Traffic Intersection Design]* of this Schedule, (collectively the “**Traffic Signal Equipment**”).

Table 6-3.3: Traffic Intersections

No	Traffic Intersection Location	Existing Signals	Priority	Grade Crossing	Traffic Controller Type	Notes
1	102 Ave. & 102 St.	Yes	Full*	Yes	P2	
2	102 Ave. & 101 St.	Yes	Partial*	Yes	P2	
3	102 Ave. & 100A St.	Yes	Full*	Yes	P2	
4	102 Ave. & 100 St.	Yes	Partial*	Yes	P2	
5	102 Ave. & 99 St.	Yes	Full*	Yes	P2	
6	102 Ave. & 97 St.	Yes	Partial*	Yes	P2	
7	102 Ave. & 96 St.	Yes	Partial*	Yes	P2	Note 1
8	Jasper Ave. & 95 St.	Yes	N/A	No	P2	Note 2
9	South Muttart Access	Yes	Full	Yes	P2	
10	98 Ave. & Muttart Access	Yes	N/A	No	P2	Note 2
11	Connors Rd. & Cloverdale	Yes	Full	Yes	N/A	Note 3
12	95 Ave. & Connors Rd.	Yes	Full	Yes	P2	
13	95 Ave. & 92 St.	No	Full	Yes	P2	
14	95 Ave. & 89 St.	No	Full	Yes	P2	Note 4
15	95 Ave. & 88 St.	No	Full	Yes	P2	Note 4
16	95 Ave. & 87 St.	Yes	Full	Yes	P2	
17	95 Ave. & 85 St.	Yes	Full	Yes	P2	
18	93 Ave. & 85 St.	No	Full	Yes	P2	
19	90 Ave & 83 St. / 85 St.	No	Partial	Yes	P2	
20	83 St. & 85 Ave (Future St)	Yes	Full	Yes	P2	
21	86 Ave. N. of & 83 St.	Yes	Full	Yes	P2	
22	84 Ave. & 83 St.	Yes	Full	Yes	P2	
23	South Bonnie Doon Stop	No	Full	Yes	See Note 5	
24	82 Ave. & 83 St.	Yes	Partial	Yes	P2	
25	83 St. & 78 Ave.	Yes	Full	Yes	P2	Note 4
26	76 Ave. & 83 St.	Yes	Full	Yes	P2	
27	73 Ave. & 83 St.	Yes	Full	Yes	P2	
28	69A Ave. & 83 St.	No	Full	Yes	P2	
29	Argyll & 83 St.	Yes	N/A	No	P2	Note 2
30	Wagner Rd. & Davies Rd.	No	N/A	No	P2	Note 2
31	Wagner Rd & 75 St.	Yes	N/A	No	P2	Note 2
32	Transit Centre & 75 St.	No	N/A	No	P2	Note 2
33	McIntyre Rd. & 75 St.	No	Full	Yes	P2	
34	Roper Rd. & 75 St.	Yes	Partial	Yes	P2	
35	51 Ave. & 75 St.	Yes	Full	Yes	P2	
36	Whitemud Dr. (WB ramp)	Yes	Partial	Yes	P2	

No	Traffic Intersection Location	Existing Signals	Priority	Grade Crossing	Traffic Controller Type	Notes
37	Whitemud Dr. (EB ramp)	Yes	Partial	Yes	N/A	Note 6
38	66 St. & 41 Ave.	No	Full	Yes	P2	Notes 4,7
39	North Millbourne Stop	No	Full	Yes	See Note 5	
40	66 St. & 38 Ave.	Yes	Full	Yes	P2	
41	66 St. crossing, South of 38 Ave.	No	Full	Yes	P2	Notes 4,7
42	66 St. & 36A Ave.	No	Full	Yes	P2	
43	66 St. & 34 Ave.	Yes	Full	Yes	P2	
44	North Grey Nuns Stop	No	Full	Yes	See Note 5	
45	66 St. & 31 Ave.	Yes	Full	Yes	P2	
46	66 St & fire hall access north of 28 Ave. (Fire Intersection)	Yes	Full	Yes	P2	Note 8
47	66 St. & 28 Ave.	Yes	Full	Yes	P2	
48	28 Ave. & commercial access West of Mill Woods Stop	No	Full	Yes	P2	
49	28 Ave. & Hewes Way	Yes	N/A	No	P2	Note 2

Notes:

- * *Intersections in the Downtown Character Zone may use a green wave approach to TSP in accordance with Section 6-3.5 [Transit Signal Priority]*
- 1. *Existing architectural poles and signal fixtures at the 102 Ave. and 96 St intersection to be re-used*
- 2. *Trackway does not cross this intersection; no priority to Trains*
- 3. *Traffic Signals can be slaved to 95 Ave. & Connors Road Traffic Controller*
- 4. *Provide pedestrian activated crossing signals only (across Roadway and Trackway)*
- 5. *Provide pedestrian crossing signals only (across Trackway) by use of pedestrian signals and count-down timers driven by a P2 Traffic Controller, or alternatively driven by means of a direct interface to the TRPS*
- 6. *Traffic Signals are, and can remain, slaved to Whitemud Drive Westbound ramp Traffic Controller*
- 7. *Provide separate pedestrian activated cycles for Roadway crossing and Trackway crossing*
- 8. *Fire priority Traffic Signal provided across 66 Street, refer to Section 6-3.3.2D [Traffic Controller] of this Schedule for specific fire truck intersection requirements*

B. Where any of the following existing Traffic Signal materials are removed as part of the Construction they shall be protected from damage and delivered to the City (with unloading device), within two (2) weeks of removal, at 130 Avenue - 56 Street NW (hours of operation are Monday to Friday 9:00 am to 3:00 pm, except statutory holidays):

1. cantilever structures;
2. poles, arms, and davit extensions;
3. luminaires; and
4. overhead signs.

6-3.3.1 Qualifications

- A. The following Traffic Signal Equipment installation tasks shall be performed by Project Co Persons having at minimum a Tech I qualification as defined in Section 10.9.3 [*Traffic Signal Maintenance Staff Qualifications*] of Schedule 7 [*O&M Performance Requirements*]:
1. installation of signal pole bases and signal poles;
 2. Traffic Controller cabinet base installation;
 3. backfilling;
 4. Traffic Controller cabinet placement; and
 5. installation of cables.
- B. The following Traffic Signal Equipment installation tasks shall be performed by Project Co Persons having at minimum a Tech II qualification as defined in Section 10.9.3 [*Traffic Signal Maintenance Staff Qualifications*] of Schedule 7 [*O&M Performance Requirements*]:
1. Traffic Controller cabinet prewiring;
 2. Traffic Controller cabinet bench testing;
 3. termination of all cables; and
 4. testing and commissioning of signals.

6-3.3.2 Traffic Controller

- A. Subject to the following amendments, provide fully configured Traffic Controller cabinets, in accordance with the document *Specifications for the Supply of TS2 Type 1 Traffic Actuated Intersection Control Equipment, 2015 Signal Program, Revision May 2015*, a copy of which is included as in the Disclosed Data, at the intersections specified in Table 6-3.3 [*Traffic Intersections*]:
1. Traffic Controller shall be "TS2 TYPE 1 - 42CCT P2 CABINET ASSEMBLY";
 2. Traffic Controller shall be fully interoperable with the City's existing Centracs® traffic management system, whose specifications are contained in document *Centracs Software and System Specifications*, a copy of which is included in the Disclosed Data;
 3. each cabinet shall be provided with minimum two (2) hour battery standby for all equipment other than the heater and fan such that full operation of the intersection shall be maintained in the event of a Utility power failure;
 4. each cabinet shall indicate Utility power failure alarm to the OCC, including the location(s) of the affected intersection(s);
 5. each cabinet shall indicate low ambient temperature alarms to OCC when the ambient temperature within the cabinet drops below -20°C, including the location(s) of the affected intersection(s);
 6. integrate each cabinet with the TRPS;
 7. each cabinet layout shall include signal outputs to energize all LRT Traffic Signal fixtures at the relevant intersections;

8. each cabinet layout shall include one Polara 2 wire Navigator Central Control unit for every 12 audible pedestrian push button stations;
 9. each cabinet layout shall be designed to accommodate future installation by others of an IP switch with the following dimensions 150mm (h) x 55mm (w) x 100mm (d). Provide a 24V DC 9W power source for the future IP switch, energized from the standby battery;
 10. each cabinet layout shall incorporate termination of all conduits described in Section 6-1.7O.1 [*Systems Duct Bank and Associated Infrastructure*] and Section 6-3.3.5 [*Traffic Signal Equipment Cable*] of this Schedule;
- B. Mount each Traffic Controller cabinet on a precast concrete P2 Traffic Controller cabinet base, from H.O. Concrete, P/N MK99. Install cabinet bases as follows:
1. set hole at 1.2m depth with no disturbed soil at the base;
 2. install sand layer at the base to a maximum of 300mm;
 3. place two (2) 30mm x 150mm pressure treated wood planks on the levelled sand; and
 4. set base on the planks.
- C. Install each Traffic Controller cabinet as follows:
1. where existing Traffic Controller cabinets are removed as part of the Construction they shall be protected from damage and delivered to the City, within two (2) weeks of removal, at 13410 - St Albert Trail NW (hours of operation are Monday to Friday 9:00 am to 3:00 pm, except statutory holidays);
 2. pre-wire and bench test the Traffic Controller cabinet at a Project Co test facility, configured to operate per the applicable Final Design, including timing, phasing and additional control logic to incorporate the signal timing logic described in Section 6-3.4.3 [*Signal Timing*] of this Schedule. The Traffic Controller cabinet shall then be remote bench tested by the City via a suitable data connection to be established by Project Co between the City Traffic Management Centre and the Project Co test facility, such that a minimum of 48 contiguous hours shall pass with no failure or errors, after which the City shall issue a Signal Timing Acceptance Certificate for the Traffic Controller cabinet. Notify the City once the Traffic Controller cabinet is available to be remotely bench tested, and co-ordinate this testing in accordance with Section 1-1.3 [*City Works*] of this Schedule;
 - a. if notified of failure or error during remote bench testing by City, provide a modified wiring design and/or control logic to remedy the failure or error. Failure to provide a remedy within 2 Business Days of notification will give cause for the City to terminate the remote bench testing, and in which case notify the City once the Traffic Controller cabinet is available again to be remotely bench retested, and co-ordinate this retesting in accordance with Section 1-1.3 [*City Works*] of this Schedule;
 3. provide an unmetered power feed to each Traffic Controller from the City's electric Utility Company. The power feed shall be compliant with the electric Utility Company's Customer Connection Guide;
 4. upon receipt of the Signal Timing Acceptance Certificate, the Traffic Controller cabinet can be installed. Bolt the Traffic Controller cabinet to the cabinet base after backfilling is complete. The cabinet shall be level and oriented in accordance with the applicable Final Design. Shims shall not be used to level the cabinet. Apply silicon on the outside of the cabinet where the base of the cabinet meets the concrete base. Apply foam sealant to form an air tight seal at the opening of the precast base where the conduits enter the cabinet;

5. install copper clad ground rods and fully ground the cabinet in accordance with the Canadian Electrical Code;
6. provide notice to the City when fibre optic connectivity between the main Data Centre and the applicable Traffic Controller is Available, and provide the City with access to the Traffic Controller in order to establish data connectivity to the City Traffic Management Centre in accordance with Section 1-1.3 *[City Works]* of this Schedule;
7. notify the City once each Traffic Controller is ready for testing and commissioning, and co-ordinate and perform testing and commissioning, to be witnessed by the City in accordance with Section 1-1.3 *[City Works]* of this Schedule, such that:
 - a. the City shall identify to Project Co the date and time that the signals will be placed into "flashing" and "full" activation;
 - b. "full" activation of a signal shall typically follow successful "flash" activation by a minimum of 3 days;
 - c. upon placing the signals into "flashing" activation, complete a "Flashing Operation" checklist in a form provided by the City;
 - d. once the traffic signals are placed into full activation, immediately perform an onsite activation test to include:
 - i. manufacturer recommended tests;
 - ii. vehicle detector test;
 - iii. pushbutton test;
 - iv. lamp inspection; and
 - v. operational compliance with timing sheet designs;
 - e. upon placing the signals into "full" operation, complete a "Full Operation" checklist provided in a form by the City; and
 - f. provide the City with access to the Traffic Controller, and such on-site assistance as may be reasonably requested in order to confirm interfaces with the City Traffic Management Centre in accordance with Section 1-1.3 *[City Works]* of this Schedule.
- D. Provide an Interim Design to the City for the fire hall intersection at 66 St and the fire truck access north of 28 Ave for the City to integrate a GPS receiver priority notification device in accordance with Section 1-1.3 *[City Works]* of this Schedule. Configure the P2 Traffic Controller at this intersection with the City supplied GPS receiver priority notification device. The Traffic Controller priority level of the fire call notification shall be configured as the highest priority.
- E. Project Co shall be responsible for Maintenance of each Traffic Controller and Traffic Signal Equipment from the date on which it is first installed.

6-3.3.3 Traffic Signal Poles and Bases

- A. Provide Traffic Signal poles and bases as follows:
 1. galvanized davit assemblies from Nova Pole International or Valmont West Coast Engineering in accordance with assembly drawing # "2.44m(8') DAVIT", a copy of which is included in the Disclosed Data;

2. galvanized 4978mm pole assemblies from Nova Pole International or Valmont West Coast Engineering, in accordance with assembly drawing "2-110-16TP2", a copy of which is included in the Disclosed Data. This pole assembly shall be capable of supporting:
 - a. three (3) non-illuminated street signs, 762mm x 762mm; and
 - b. two (2) quad light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1312mm;
3. galvanized 8534mm arm / 356mm BCD cantilever structures from Nova Pole International or Valmont West Coast Engineering, in accordance with assembly drawing "CCL-8.534m(28)", a copy of which is included in the Disclosed Data. These structures shall be capable of supporting:
 - a. one (1) non-illuminated street sign, 610mm x 1829mm;
 - b. one (1) 90 degree double arm streetlight extension complete with luminaries;
 - c. one (1) tri light 305mm fixture c/w 127mm bordered backboard, 584mm x 1321mm;
 - d. two (2) quad light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1626mm;
 - e. two (2) 762mm x 762mm illuminated traffic signs; and
 - f. one (1) set Walk/Wait fixture, 457mm x 457mm;
4. galvanized 10668mm arm / 356mm BCD cantilever structures from Nova Pole International or Valmont West Coast Engineering, in accordance with assembly drawing "CCL-10.668mm(35)", a copy of which is included in the Disclosed Data. These structures shall be capable of supporting:
 - a. one (1) non-illuminated street sign, 610mm x 1829mm;
 - b. one (1) 90 degree double arm streetlight extension complete with luminaries;
 - c. two (2) tri light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1321mm;
 - d. two (2) quad light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1626mm;
 - e. two (2) 762mm x 762mm illuminated traffic signs; and
 - f. one (1) set Walk/Wait fixture, 457mm x 457mm;
5. galvanized 15240mm arm / 394mm BCD cantilever structures from Nova Pole International, or Valmont West Coast Engineering, in accordance with assembly drawing "CCL-15.240m(50)", a copy of which is included in the Disclosed Data. These structures shall be capable of supporting:
 - a. one (1) non-illuminated street sign, 610mm x 1829mm;
 - b. one (1) 90 degree double arm streetlight extension complete with luminaries;
 - c. two (2) tri light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1321mm;
 - d. two (2) quad light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1626mm;
 - e. two (2) 762mm x 762mm illuminated traffic signs; and
 - f. one (1) set Walk/Wait fixture, 457mm x 457mm;
6. galvanized 18288mm arm / 508mm BCD cantilever structures from Nova Pole International or Valmont West Coast Engineering, in accordance with assembly drawing "CCL-18.288m(60)", a copy of which is included in the Disclosed Data. These structures shall be capable of supporting:

- a. one (1) non-illuminated street sign, 610mm x 1829mm;
 - b. one (1) 90 degree double arm streetlight extension complete with luminaries;
 - c. two (2) tri light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1321mm;
 - d. two (2) quad light 305mm fixtures c/w 127mm bordered backboard, 584mm x 1626mm;
 - e. two (2) 762mm x 762mm illuminated traffic signs; and
 - f. one (1) set Walk/Wait fixture, 457mm x 457mm;
7. one per unit precast concrete base c/w four (4) 36mm dia. x 2591mm long Dywidag anchor rods, from H.O. Concrete, for each 4978mm pole assembly with following part numbers:
 - a. "LTP1" for 254mm BCD;
 - b. "LTP2" for 280mm BCD; and
 - c. "LTP3" for 292mm BCD;
 8. one per unit cage base c/w four (4) 36mm dia. x 2591mm long length Dywidag anchor rods, hex nuts, lock nuts, washers and spacers, from Harris Rebar, P/N "14161" for each 356mm BCD cantilever structure;
 9. one per unit cage base c/w four (4) 36mm dia. x 2591mm Dywidag anchor rods, hex nuts, lock nuts, washers and spacers, from Harris Rebar, P/N "14162" for each 394mm BCD cantilever structure;
 10. one per unit cage concrete base c/w six (6) 32mm x 2057mm Dywidag anchor rods, hex nuts, lock nuts, washers and spacers, from Harris Rebar, P/N "14324" for each 508mm BCD cantilever structure; and
 11. safety bases from Safety Base Ltd. for pedestal poles that are located on center median.
- B. Install all poles and bases such that:
1. all surveys are performed to confirm proper location and orientation;
 2. they are placed in accordance with the applicable Final Design, including the pole location, orientation, grade and slope;
 3. reinforced anchor rod cages are installed in accordance with the individual pole designs. All Traffic Signal poles intended for mounting Road Traffic Signals shall utilize 1" diameter Dywidag type anchor rods unless otherwise indicated on the pole designs;
 4. conduits installed in the pole base shall match that of the Final Design;
 5. all bases are levelled and all nuts are torqued in accordance with manufacturer instructions. Shimming and use of levelling nuts shall not be permitted;
 6. all Sonotube shall be stripped back such that it is not visible above final grade;
 7. all poles are grounded in accordance with the Canadian Electrical Code; and
 8. horizontal and vertical clearances from the signal pole to any high voltage lines comply with the Canadian Electrical Code and Alberta Electrical Utility Code.

6-3.3.4 Traffic Signal Fixtures

A. Provide all Road Traffic Signal fixtures as follows:

1. polycarbonate Traffic Signal heads, with yellow housing and black doors, from Fortran, P/N 330700;
2. LED signal modules, from Dialight, as follows:
 - a. red P/N "433-1210-003XL";
 - b. amber P/N "433-3230-901XL";
 - c. green P/N "433-2220-001XL";
 - d. arrow P/N "430-2374-0E1"; and
 - e. pedestrian countdown P/N "430-6479-001X";
3. 406mm pedestrian signal housings from McCain P/N "M31466";
4. louvered vacuum formed ABS backplates from Pelco Products on all overhead and sidemount fixtures with the following part numbers:
 - a. backboard 3L x 305mm horizontal louvered "BK-6003-FT-PNC";
 - b. backboard 3L x 305mm vertical louvered "BK-5003-FT-PNC";
 - c. backboard 4L x 305mm horizontal louvered "BK-6004-FT-PNC"; and
 - d. backboard 4L x 305mm vertical louvered "BK-5004-FT-PNC"; and
5. audible pedestrian push button stations from Polara, product line "EZ Comm APS Solutions", with specific configurations as determined in accordance with the applicable Grade Crossing Hazard Analysis.

B. Install Road Traffic Signal fixtures such that:

1. the signal configuration to be installed at each location shall be as indicated on the Final Design, including fixture element types, location, size, orientation, visors and louver types;
2. all steel mounting hardware shall be brushed aluminum;
3. all installations shown utilizing band-it type steel wrapping shall be installed such that a minimum of 2 wraps are utilized;
4. vertical four light and five light fixtures on cantilevers and pedestals shall utilize the astra-bracket type of mounting;
5. all pedestrian signals shall be mounted between 2.13m and 3.05m above the sidewalk;
6. all pedestrian push buttons shall be mounted between 1.07m and 1.22m above the sidewalk;
7. audible pedestrian signals shall be mounted as per the Final Design drawings utilizing hose clamps; and
8. all signals shall be appropriately bagged or covered prior to activation to minimize confusion for motorists.

6-3.3.5 Traffic Signal Equipment Cable

- A. All cabling between traffic fixtures shall be provided in underground ducts. The use of direct buried or overhead cable is prohibited.
- B. Traffic Signal Equipment duct and conduit materials shall use:
 - 1. Scepter rigid PVC conduit;
 - 2. IPEX black poly conduit;
 - 3. PVC glue;
 - 4. black PVC electrical tape; and
 - 5. Scepter PVC pull boxes and junction boxes.
- C. Install Traffic Signal Equipment duct and conduit such that:
 - 1. installation is in compliance with the CEC and the Alberta Electrical Utility Code;
 - 2. all conduits are marked with a 300mm cover of sand and utility marking tape (with magnetic tracer);
 - 3. separate 50mm conduits are provided for power, detection, telecommunication and control;
 - 4. 50mm conduits are provided from the Traffic Controller cabinet to each traffic pole;
 - 5. pull boxes are provided for long conduit lengths. Multiple bends in opposing directions are not permitted. Conduit entrances into pull boxes shall be installed such that conduit designated for communications is capable of accommodating a minimum 23cm bend radius and a minimum of 30cm clearance from the top of the cable bend to the top of the pull box;
 - 6. a pull string is provided in every conduit; and
 - 7. all unused conduits are capped.
- D. Traffic Signal Equipment cable shall be XLPE PVC 600 volt CSA rated control cable and shall comply with CSA C22.2 #239 and CSA C22.2 #38 Specifications. Outside cable jacket shall be marked and numbered at 1m intervals. Conductor insulation shall be consistently colour coded. Cable consists shall be:
 - 1. solid 2c#12 with 1c #10 bare solid ground;
 - 2. solid 3c#14 with 1c #14 bare solid ground;
 - 3. solid 7c#14 with 1c #14 bare solid ground;
 - 4. solid 16c#14 with 1c #14 bare solid ground;
 - 5. solid 21c#14 with 1c #14 bare solid ground; and
 - 6. solid 28c#14 with 1c #14 bare solid ground.
- E. Install Traffic Signal Equipment cable such that:
 - 1. splicing of signal control cables occurs only within the base of poles. Splices are not permitted within junction boxes, handholes, pull boxes, signal fixtures or within conduits;

2. weatherproof connectors are provided for audible pedestrian signal cables where they enter the pedestrian signal fixtures;
3. no signal control cables shall be installed through overhead structures;
4. a minimum 6 conductor, 14 AWG IMSA colour coded Traffic Signal control cable c/w 1 bare 14 AWG ground wire shall be provided for each individual signal fixture, and shall be grounded to each individual fixture in accordance with the Canadian Electrical Code;
5. slack and strain relief are provided in the signal cabinet for all cables and conductors. Securely terminate all conductors on terminal blocks; and
6. rubber grommets are applied to prevent abrasion to the signal cables for cable entrances and exits from the poles.

6-3.3.6 Road Vehicle Detection

- A. Provide separate road vehicle detection for each vehicle travelled lane at each intersection, by means of loop detection.
- B. Provide road vehicle detectors for stop line detection and approximately 100m upstream of the stop line for advance detection.
- C. Detectors shall be NTCIP compliant.
- D. Stop line detectors shall provide both presence and passing (counting) detection.
- E. Advance detectors shall provide passing (counting) detection.
- F. Install loop detectors using the following procedures:
 1. prior to the final lift of road pavement being placed, make an outline of loops and loop tails with chalk or spray paint prior to cutting. The saw cut depth shall be such that a minimum level of cover is placed above the loop wires with a minimum:
 - a. 25mm of cover for concrete; and
 - b. 50mm of cover for asphalt;
 2. apply the angle cut method for all corners, ensuring that the angle cut does not create an open "isolated triangle" of pavement that may become unstable relative to the surrounding pavement;
 3. ensure there are no splices in the "tail" portion of the vehicle detection loop assembly, which consists of the loop wire that extends from the loop portion in the pavement to the nearest junction box;
 4. ensure there are no splices between the loop tail and the loop;
 5. twist the loop tail at a minimum rate of 16 turns per metre;
 6. splice the shielded lead in cable to the loop tail at the junction box. Solder and encapsulate the two wires and seal with a waterproof sealant; and
 7. label loops according to the approach and lane. Place labels within all splice boxes and within the Traffic Controller cabinet.

6-3.4 TRAFFIC INTERSECTION DESIGN

- A. Design all traffic intersections, including all Traffic Signal Equipment, in accordance with the requirements of this Section 6-3.4 [*Traffic Intersection Design*], which shall apply and prevail if in conflict with the requirements of MUTCD (Canada).

6-3.4.1 Signal Displays

- A. Provide at least 2 Road Traffic Signal fixtures for each approach. For protected left or right turns, provide a single fixture with two red lenses along with a “no left/right turn on red” sign.
- B. Backboards (black) shall be used on all primary fixtures and are permitted on secondary and auxiliary fixtures.
- C. Louvers shall be installed on overhead green signal lenses to prevent incorrect interpretation of signals at closely spaced intersections.
- D. 300mm LED lenses shall be used in all fixtures.
- E. Auxiliary far-left fixtures shall be used to supplement the primary left turn fixtures at wide or complex intersections.
- F. Overhead fixtures shall be mounted horizontally for through lanes, right turn lanes, and where a shared fixture is used for through and left turning traffic. Vertical fixtures shall be used where a separate fixture is provided for an exclusive left turn lane, and for pole mounted secondary and auxiliary fixtures. “Left turn signal” signs shall not be used.

6-3.4.2 Pedestrian and Audible Signals

- A. Pedestrian countdown signals shall count down during the “flashing don’t walk” interval only.
- B. Pedestrian pushbuttons shall be provided with directional arrows in the direction of the crossing.
- C. Pedestrian audible pushbuttons shall be provided in accordance with the document *Audible Pedestrian Signal (APS) Design and Installation Guidelines*, a copy of which is included in the Disclosed Data.
- D. The following pedestrian crossings shall be automatically initiated and shall be provided with an exclusive audible signal pushbutton on the side of the pole parallel to and entering each crosswalk, with a sign above the pushbutton stating “Push Button for Audible Signal Only”:
 - 1. 102 Ave. & 102 St.;
 - 2. 102 Ave. & 101 St.;
 - 3. 102 Ave. & 100A St.;
 - 4. 102 Ave. & 100 St.;
 - 5. 102 Ave & 99 St.;
 - 6. 102 Ave. & 97 St.;
 - 7. 102 Ave. & 96 St.; and
 - 8. Jasper Ave. & 95 St..

Configure the Traffic Controllers at these intersections to automatically initiate pedestrian calls on every traffic cycle through recall settings in the Traffic Controller.

E. The following pedestrian Grade Crossings:

1. South Bonnie Doon Stop;
2. North Millbourne Stop; and
3. North Grey Nuns Stop,

shall be:

4. automatically initiated and provided with an exclusive audible signal pushbutton on the side of the pole parallel to and entering each crossing, with a sign above the pushbutton stating "Push Button for Audible Signal Only";
 5. configured, via the Traffic Controller or TRPS, to:
 - a. automatically display a permissive pedestrian signal unless a Train is within 20 seconds of arrival at the crossing;
 - b. provide 12 seconds of "flashing don't walk" interval before displaying a pedestrian stop signal; and
 - c. display an LRT-Stop signal in both directions of LRT travel whenever the corresponding pedestrian signal is not displaying a pedestrian stop signal.
- F. At all intersection locations listed in Table 6-3.3 [*Traffic Intersections*] of this Schedule, except those listed in Sections 6-3.4.2D and 6-3.4.2E [*Pedestrian and Audible Signals*], provide a pushbutton on the side of the pole parallel to and entering each crosswalk with a sign above the pushbutton stating "Push Button for WALK (symbol only) Hold for Audible Signal", and configure the Traffic Controllers for pushbutton initiated pedestrian calls.

6-3.4.3 Signal Timing

- A. Road Traffic Signals shall be operated as semi-actuated where minor movements are actuated using loop detection.
- B. Inter-green time shall be included in the pedestrian clearance time.
- C. Adequate time for pedestrians to safely cross the entire Roadway at 1.1m/sec in one cycle shall be provided. Two (2) staged crossings shall not be used across Roadways.
- D. The amber and all red intervals shall be calculated using the method outlined in the Canadian Capacity Guide for Signalized Intersections (using an amber overrun time of $i=A-1.0$).
- E. All left and right turns that cross the Tracks shall have fully protected phasing (no right turn on red permitted).
- F. Protected/prohibited left turn phasing shall also be implemented wherever:
 1. inadequate sighting exists;
 2. there is a high opposing through speed (> 60 kph);
 3. three (3) or more opposing lanes need to be crossed; or
 4. there is more than one (1) left turn lane.

- G. Signal timing at all Grade Crossings shall be configured by Project Co, prior to the Target Service Commencement Date, to provide Transit Signal Priority (TSP), in accordance with Section 6-3.5 [Transit Signal Priority] of this Schedule.
- H. After the Service Commencement Date, the City may elect to perform modifications to the signal timing at all Grade Crossings at its discretion, provided all of the signal timing constraints defined in Section 6-3.5 [Transit Signal Priority] of this Schedule are maintained.
- I. Signal timing at the other signalized intersections, as listed in Section 1-1.2.4C [Systems] of this Schedule, shall be configured by Project Co, prior to the Target Service Commencement Date, to achieve the design MOE's set out in Section 1-2.7 [Measures of Effectiveness] of Part 1 of this Schedule, and after the Service Commencement Date, the City may elect to perform modifications to the signal timing at these intersections at its discretion.
- J. Provide a timing mode switch to enable alternate signal timing and control logic which inhibits TSP, for use at all vehicular Grade Crossings where Traffic Signal Equipment will be installed and commissioned prior to the Target Service Commencement Date. The timing mode switch shall facilitate transition to TSP operation during Commissioning of the System. Disable the timing mode switch after Service Commencement.

6-3.4.4 LRT Traffic Signals

- A. Provide LRT Traffic Signals at all Grade Crossings. Where Track clearances provide a minimum 100mm clearance between all outside edges of the LRT Traffic Signal and the Dynamic Envelope, the LRT Traffic Signal shall be installed between the Tracks on a pedestal or OCS pole or at the end of a traffic cantilever arm. In all other cases, the LRT Traffic Signal shall be installed at the end of a traffic cantilever arm.
- B. Provide a minimum of two LRT Traffic Signals for each direction of travel with one placed on either side of the intersection as shown in Figure 6-3.4.4 [Typical LRT Traffic Signal Configuration].



Figure 6-3.4.4: Typical LRT Traffic Signal Configuration

- C. Where an LRT Traffic Signal could be misinterpreted by road traffic as a Road Traffic Signal, provide an additional passive sign to indicate that the LRT Traffic Signal is for LRT use only.
- D. Provide two heads with each LRT Traffic Signal. The top head shall display a horizontal lunar bar aspect to convey a stop indication, ("**LRT-Stop**"). The bottom head shall display a vertical lunar bar aspect to convey a proceed indication, ("**LRT-Proceed**"). Proceed signals shall be used in flashing mode to convey a prepare to stop indication, ("**LRT-Prepare-to-Stop**").
- E. The LRT Traffic Signals shall be operated by the Traffic Controllers, with timing to be integrated with the TRPS, as described in Section 6-3.5A [Transit Signal Priority] of this Schedule.

- F. Provide a consistent method of visually differentiating LRT Traffic Signals from Block Signals and repeater signals.
- G. The LRT Traffic Signal shall have sighting and conspicuity such that the LRT Traffic Signal, or a Vital repeater signal, can be seen at the Sighting Distance in advance of the LRT Traffic Signal, by a person having normal 6/6m vision, under normal daylight conditions.

6-3.4.5 Grade Crossing Traffic Control Devices

- A. Except where an Automatic Grade Crossing Warning System is determined to be necessary in accordance with Section 6-1.20 [*Automatic Grade Crossing Warning Systems*] of this Schedule, traffic control at Grade Crossings shall be managed using only the following Traffic Control Devices:
 1. tactile paving, passive signs and markings, including intersection pavement markings, railroad warning markings, pedestrian warning signs, "Railroad Ahead" warning signs, and regulatory traffic signs;
 2. striped channelization including median pedestrian refuges, enhanced crosswalks, vehicle channelization and Dynamic Envelope markings;
 3. Traffic Signals, including Road Traffic Signals, LRT Traffic Signals, pedestrian indications with countdown timers, pedestrian audible signals, protected left turn arrows, protected right turn arrows, LRT blank out signs, active no right turn signs, and second train approaching signs;
 4. LRV on-board audible devices;
 5. barrier channelization including pedestrian channelization, vehicle channelization, fencing, bollards and chains;
 6. other pedestrian protection devices including flashers; pedestrian activated crossing signals, and swing gates;

each as defined in MUTCD (Canada) or, if not defined therein, as defined in MUTCD (US DOT). Where a Traffic Control Device is not defined in either MUTCD standard, such device shall be as defined by Good Industry Practice, as documented in the applicable APTA publications issued by the United States Federal Transit Administration.

- B. The specific device(s) required for safe and efficient traffic control at each Grade Crossing shall be determined on the basis of the applicable Grade Crossing Hazard Analysis.
- C. Provide active LRT blank out signs or no right turn signs on the traffic pole and/or cantilever arm nearest the turning lane at each Grade Crossings where road traffic may legally turn onto the Track.

6-3.5 TRANSIT SIGNAL PRIORITY

- A. Provide Transit Signal Priority, to manage the interaction between LRV's, road traffic, and pedestrians, to safely achieve Operational Availability and schedule adherence at the applicable Service Level, and to achieve the design MOE's set out in Section 1-2.7 [*Measures of Effectiveness*] of Part 1 of this Schedule.

This Section 6-3.5 [*Transit Signal Priority*] defines the principles of operation for managing Transit Signal Priority outside the Downtown Character Zone. These principles of operation may also be applied in the Downtown Character Zone, or an alternative green wave TSP approach may be applied subject to meeting the requirements of this Section which apply to:

1. pedestrian cycle skipping in accordance with Section 6-3.5H;
2. movements of other On-track Vehicles in accordance with Section 6-3.5I; and

3. cycle recalls in accordance with Section 6-3.5K.
- B. Configure all Grade Crossing Traffic Controllers to provide either Full Priority or Partial Priority, Transit Signal Priority as specified in Table 6-3.3 [*Traffic Intersections*] at Service Commencement, unless the Grade Crossing is equipped with an Automatic Grade Crossing Warning System. Traffic Controllers at Grade Crossings equipped with an Automatic Grade Crossing Warning System shall be configured to provide traffic Pre-emption in accordance with Section 6-1.20C.10 [*Automatic Grade Crossing Warning Systems*] of this Schedule.
 - C. The TRPS shall work in concert with each Grade Crossing Traffic Controller, and subject to the requirements of Section 6-3.4.3 [*Signal Timing*] of this Schedule, shall provide Transit Signal Priority by means of:
 1. an advance notification, (the "**Check-in**"), to the intersection Traffic Controller to condition it to provide the Train with an LRT-Proceed aspect such that:
 - a. at Full Priority intersections, the Traffic Controller shall adjust the timing and phasing to permit unrestricted passage of the Train through the intersection. An LRT-Proceed aspect shall be displayed a minimum 5 seconds prior to the time the Train is calculated to arrive at the intersection, on the basis of the Run Time, when travelling at the Maximum Operating Speed, between the Check-in point and the intersection Check-in-B point (the "**Approach Run Time**"), and the LRT-Proceed aspect shall be solidly displayed until cancelled as specified below; and
 - b. at Partial Priority intersections, the Traffic Controller shall adjust the timing and phasing to accommodate the passage of the Train through the intersection, which may require an LRT-Stop aspect to be displayed for a period of time (the "**Stop Time**"), after the Approach Run Time. An LRT-Proceed aspect shall then be solidly displayed until cancelled as specified below;
 2. an arrival notification (the "**Check-in-B**"), to the Traffic Controller, to confirm the Train's arrival at the intersection. Failure of the Train to arrive at Check-in-B within 20 seconds after the LRT-Proceed aspect has been displayed shall permit the Traffic Controller to:
 - a. cancel the LRT-Proceed aspect by displaying a LRT-Prepare-to-Stop aspect for 6 seconds;
 - b. subsequently display an LRT-Stop aspect;
 - c. initiate a new timing sequence to accommodate the passage of the Train through the intersection once notification is received of the Train's arrival at the Check-in-B point; and
 - d. the new timing sequence shall be calculated as though the notification had been received from the associated Check-in point, and a subsequent Check-in-B notification will not be necessary to confirm arrival; and
 3. an exit notification, (the "**Check-out**") once the rear of the Train is clear of the intersection. Upon receipt of the Check-out notification, the Traffic Controller shall cancel the LRT-Proceed aspect by displaying an LRT-Stop aspect.
 - D. The total aggregate Stop Time for a Train travelling one-way between the Terminus Stops shall not exceed 150 seconds. For purposes of calculating the aggregate Stop Time, the TRPS shall provide a timer for each Train, which shall be reset upon the Train leaving the Origin Stop, and upon arrival at the Destination Stop:
 1. the timer shall be incremented by the interval between the Train's arrival at the Check-in-B point and the time the LRT-Proceed aspect was displayed; and

2. in the event of late Train arrival whereby the LRT-Proceed aspect was cancelled and a new timing sequence was initiated, the timer shall be incremented by the interval between the Train's arrival at the Check-in-B point and the time the LRT-Proceed aspect was displayed, to the extent this time was in excess of the Approach Run Time.
- E. The Check-in-B and Check-out points shall be located no farther than one Train length from the nearest curb of the intersection to which they apply.
 - F. The Check-in, Check-out and Check-in-B notifications shall be provided by the TRPS through either a data, direct I/O, or loop interface to the local Traffic Controller.
 - G. Selection of Check-in points shall provide sufficient notification time, at the Maximum Operating Speed, to permit a minimum pedestrian walk display time of seven (7) seconds, plus the clearing time for pedestrians walking at a speed of 1.1m/s across the widest portion of conflicting streets and medians in crosswalks.
 - H. Configure all Traffic Controllers to service all pedestrian calls on every traffic cycle, except where the skipping of a pedestrian cycle(s) is required to service Pre-emption request(s), or TSP request(s). Notwithstanding the preceding sentence, under no circumstance shall a Traffic Controller skip pedestrian calls for more than two (2) successive traffic cycles, unless a Train is delayed in arriving at the intersection, and a new timing sequence is required to accommodate the passage of the Train through the intersection.
 - I. Transit Signal Priority shall only apply to Trains. Movements of other On-Track Vehicles across intersections shall be governed by normal traffic sequencing without the application of Transit Signal Priority.
 - J. At intersections with an exclusive "LRT only" traffic phase (such as at intersections where the geometry of the Tracks are diagonal relative to the cross streets), provide a means of initiating a non-priority call for the LRT traffic phase:
 1. in the event of TRPS failure; and
 2. to permit On-Track Vehicles, other than Trains, to safely traverse the intersection.
 - K. The Traffic Controller at each Grade Crossing shall be configured to initiate a (4) four minute countdown timer each time a Train has cleared the intersection. A subsequent Transit Signal Priority request initiated by a Train travelling in the same direction as the previous Train shall not be serviced until expiration of this timer.
 - L. Where the MOE's cannot otherwise be complied with on account of traffic Pre-emption at Automatic Grade Crossing Warning System locations, provide a holding feature ("**Hold in Station**") to hold an approaching Train at a designated Stop or Station to allow the Traffic Controller sufficient time to adjust the traffic sequencing so as to achieve the MOE's before allowing the Automatic Grade Crossing Warning System to activate.

SECTION 6-4 TRANSPORTATION ELECTRICAL SERVICE PLAN

6-4.1 INTRODUCTION

- A. All electrical facilities, infrastructure, systems and sub-systems that are not subject to the Alberta Building Code shall comply with this Section 6-4 [*Transportation Electrical Service Plan*].

6-4.2 TESP PROCESS FORM

- A. Develop a TESP process form to record the following information for each electrical installation that is not governed by the ABC:
1. all applicable Final Designs, including all Design Data and relevant Design Certificates, have been submitted and accepted in accordance with Schedule 2 [*Submittal Review Procedure*];
 2. work coordination and modifications with Utilities;
 3. applicable meter applications, Utility Agreements and Project Approvals;
 4. applicable inspection and test procedures; and
 5. a final electrical inspection report, in accordance with Section 6-4.5 [*Final Electrical Inspection Report*] of this Schedule.

(the "TESP Process Form").

6-4.3 TESP DOCUMENTATION

- A. For each electrical installation that is not governed by the ABC, compile a TESP binder, which shall include:
1. the applicable TESP Process Form;
 2. any Canadian Electrical Code, Part 1 and Part 3 variances granted in accordance with Section 6-4.4 [*Application for Electrical Code Variance*] of this Schedule;
 3. a copy of all applicable electrical Project Approvals;
 4. a copy of applicable Utility Agreements;
 5. copies of all applicable inspection and test reports; and
 6. copies of metering applications (if applicable).
- B. The applicable TESP binder shall be submitted along with each applicable Construction Certificate submitted in accordance with Section 12.1 [*Construction Certificates*] of Schedule 4 [*Design and Construction Protocols*].

6-4.4 APPLICATION FOR ELECTRICAL CODE VARIANCE

- A. Where a variance to the CEC, Part 1 or Part 3 is required, Project Co shall submit a variance request to the City. Each variance request shall include the following information:
1. date of request;
 2. Project Co's name, along with the name of the entity submitting the variance request;
 3. CEC section to be varied;

4. details of requested variance;
 5. reason for requested variance;
 6. supporting documentation (proof of equal or better safety performance);
 7. address or legal description upon which the subject-matter of the variance is located;
 8. authority under which the requested variance may be issued; and
 9. signature of Project Co's Representative and of the Person submitting the variance request.
- B. Each CEC variance request shall be submitted to the City under Schedule 2 [*Submittal Review Procedure*], provided that the Review Period shall be extended to 30 days.

6-4.5 FINAL ELECTRICAL INSPECTION REPORT

- A. The final electrical inspection report shall be:
1. prepared and sealed by a Professional Engineer acceptable to the City, acting reasonably; and
 2. in the same form, and containing the same content and level of detail, as required for a final electrical inspection report under the ABC.