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SCHEDULE 15-2
DESIGN AND CONSTRUCTION

PART 4
DESIGN AND CONSTRUCTION REQUIREMENTS – VEHICLES AND SYSTEMS

ARTICLE 1 INTRODUCTION

1.1 General Overview

(a) Schedule 15-2, Part 4, Design and Construction Requirements – Vehicles and Systems is written using design standards typical of North America. Project Co may use comparable European standards as the basis for their LRT vehicle and systems design. Project Co shall declare and apply the selected standard consistently throughout the full range of their LRT vehicles and systems designs. The Work shall be performed in accordance with the Project Agreement and major deviations or variances to the application of the selected standard shall be approved by the City.

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

(i) Light Rail Vehicles;

(ii) Non-Revenue Vehicles;

(iii) Traction Power Supply System;

(iv) Overhead Catenary System;

(v) Train Control System; and

(vi) Communications Systems.

(c) Vehicles and systemsfor the OLRT and where applicable, associated Bus facilities, shall be designed and constructed in accordance with Transport Canada rules and regulations, including but not limited to the following Canadian Transportation Agency Codes of Practice:

(i) Passenger Rail Car Accessibility and Terms and Conditions of Carriage by Rail of Persons with Disabilities

(ii) Removing Communication Barriers for Travelers with Disabilities

(iii) Passenger Terminal Accessibility

(iv) Intercity Bus

1.2 LRVs and MSF

(a) Low floor LRV's, capable of operating in multi-vehicle train consists, are the preferred and modeled means of transportation and shall provide sufficient passenger capacity to allow the City to achieve its expected ridership targets as detailed in Part 1 Article 2 – Operational Performance Requirements. The LRV Design shall be suitable for the City, meet the branding requirements of the City. The LRV selection shall be based upon its ability to meet operational targets and its flexibility to automatically operate within a fully segregated Alignment as well as operate under manual control in partially segregated rights-of-ways with level crossings. The Design of the LRV shall ensure that its systems and subsystems have a high availability, is easily maintainable and that the passengers experience a high quality comfortable ride and commuting ambience described in Part 4 Article 3 – Revenue Vehicles.

(b) An MSF shall be located at Belfast Road where the LRVs shall be maintained and stored.

1.3 Non-Revenue Vehicles

(a) A fleet of support Non-Revenue Vehicles shall be procured by Project Co to operate and maintain the OLRT System.

(b) The fleet of Non-Revenue Vehicles required for sufficient operational and maintenance support of the OLRT System is defined in this Part 4 Article 4.

1.4 Traction Power System

(a) The Traction Power supplies shall provide a dual end fed DC voltage into the OCS. The TPSS shall be placed alongside the Alignment at locations dictated by the Train performance criteria, available property and availability of utility power connection. The Traction Power System shall be modular in Design and shall be easily accessible for performing Maintenance Services for the largest piece of Equipment within the TPSS. The Design and positioning of the TPSS shall take into account any environmental, political and aesthetic constraints resulting from their chosen locations. The TPSS shall also conform to modern EMI & EMC practice and ensure that the Traction Power negative rail return system minimizes stray current through compliance with the corrosion standards set forth in the Part 1 Article 14 – Corrosion Control.

1.5 Overhead Catenary System

(a) The OCS Design shall accommodate running in the Guideway, Tunnel and the MSF. The OCS shall be designed to have a low visual impact, high reliability, provide safe operation and maintenance and operate within the climatic performance constraints described in Part 4 Article 8 – Overhead Catenary System and Pantograph.

1.6 Train Control System

(a) The Train Control System shall be based around a proven CBTC architecture which allows automatic operation of the LRV under manual supervision in a segregated

Guideway at 80 to 90 second Headways. The Train Control System shall provide the ability to also operate the Vehicle manually (Line of Sight). The Train shall bi-directionally communicate to the wayside Equipment through a high availability communications medium. The Design of the Train Control System shall be failsafe to maximize the Safety and security of all personnel and Passengers.

(b) The Train Control System is a safety critical computer based control system for:

(i) Vehicle identification;

(ii) Vehicle location control and monitoring;

(iii) Maintaining safe headway between vehicles;

(iv) Vehicle speed control;

(v) Maintaining safe brake rates;

(vi) Vehicle route selection and fleet management;

(vii) Interlocking control; and

(viii) Power consumption optimization.

1.7 Communications Systems

(a) The communications systems comprise all of the elements utilized for communications from the TSCC and BCC to the Stations, TPSS, CIH and security and safety systems along the wayside and includes but is not limited to the following:

(i) Passenger Station PA system communicating public announcements;

(ii) PIDS visually displaying informational announcements;

(iii) CCTV providing operational and security visual observation;

(iv) IAC providing security control and monitoring;

(v) Telephone and intercom system providing voice communications;

(vi) SCADA providing remote monitoring and control of power and signal facilities to/from the TSCC;

(vii) System-wide radio communications providing voice communications to mobile radios through use of the Public Safety Service Radio System as provided by others;

(viii) BMS, BAS providing remote monitoring and control of facility functions within Stations, station electrical rooms, fan rooms and pump rooms along the Alignment;

(ix) Fare collection system provided by Operator and any communication and control requirements as described in Part 4 Article 7 – Fare Collection;

(x) Advertising media provisioning space and Infrastructure for future advertising in Station areas;

(xi) TSCC providing the integrated command, reporting and control of all operations functions along the Alignment to a central location;

(xii) CTS providing the Infrastructure for all devices and elements to report and be controlled by the TSCC; and

(xiii) Train-to-wayside wireless systems providing wireless data transmission for CBTC and Train diagnostics.

(b) Each subsystem Design shall be configured to maximize reliability and availability, have common interfaces, and meet common standards. Project Co shall ensure that Equipment chosen can be easily replaced or upgraded.

(c) Operations, security, Safety and maintenance functions are provided through the communication systems. The Design of the communication systems shall allow additional expansion of the OLRT System to accommodate and support the expected ridership capacity detailed in Part 1 Article 2 – Operational Performance Requirements.

(d) The objective of the communications systems shall be to facilitate the interchange of data and voice communications and security between the following OLRT facilities and subsystems:

(i) Stations, Platform Equipment and supporting station facilities;

(ii) TPSS;

(iii) CIH;

(iv) Trackside Equipment;

(v) BCC;

(vi) YCC and MSF;

(vii) Existing Bus system OCC also known as TSCC;

(viii) The City's secure data facility;

(ix) LRV; and

(x) The City's IT Infrastructure, fare collection and back office.

ARTICLE 2 TRACTION POWER SUPPLY

2.1 Introduction

(a) The Traction Power supply system shall consist of a network of TPSS and all Equipment between the interface point with HOL and the interface point with the catenary and the negative return systems. This section provides the performance objectives for the Traction Power system. The Traction Power system shall be designed to be an integrated system for supplying power to the Vehicles, switch heaters, and related equipment in order to meet the OLRT Project Operational Performance Requirements provided in Part 1 Article 2 – Operational Performance Requirements. These criteria govern the Design, performance, and installation requirements of the Traction Power. The system shall provide safe, efficient and continuous operation of the LRT System in all operational and environmental conditions. The Traction Power system and associated components shall perform to the environmental characteristics defined in Schedule 15-2 Part 1 Article 4. In areas where the Traction Power equipment presents high risk of visual intrusion Project Co shall provide design enhancements to minimise or mitigate visual impact. In all other areas, the equipment shall be of a style and appearance similar to that used by comparable transit systems.

(b) The Equipment includes, but is not limited to the following: AC cables and raceway systems, AC switchgear, transformer-rectifier unit, DC switchgear, positive and negative raceway systems, positive and negative cables, negative drainage panel and cables, rail to ground monitoring Equipment, prefabricated substation housing (or dedicated space in or adjacent to a station facility) and foundation, grounding system, protective device systems, communications interface systems, auxiliary power supply system, climate, control, UPS system, intrusion access control system, MV lightning arresters, high voltage protection, alarm, control, and monitoring health and safety equipment, and SCADA Equipment.

2.2 Code, Standards and Manuals

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

(i) ANSI;

(ii) NEMA;

(iii) CSA;

(iv) City of Ottawa Codes and By-Laws;

(v) IEEE;

(vi) IEC;

(vii) UL and ULC;

(viii) IBC;

(ix) ICEA;

(x) EIA;

(xi) ASTM;

(xii) NETA;

(xiii) NECA;

(xiv) OEC;

(xv) AREMA;

(xvi) APTA; and

(xvii) NFPA.

2.3 Traction Power System Requirements

(a) The Traction Power system for the OLRT Project shall be a fully integrated system of TPSSs which shall support normal and contingency operations with no degradation of performance. Normal and contingency operation shall be defined as:

(i) Normal: The Traction Power supply system is in full operation with all feeder breakers in closed positions. All scheduled service is running in accordance with the Headway and consist with all civil speeds applied; and

(ii) Contingency: The Traction Power supply system shall maintain full performance service with any one TPSS rectification power completely out of operation and the DC breakers remain closed or the DC disconnect switches are closed thereby utilizing the substation as a DC tie station.

(b) The Traction Power system shall be designed and constructed to perform satisfactorily under the environmental conditions identified in Schedule 15-2 Part 1 Article 4.

(c) The Traction Power system for the OLRT shall be a high resistance grounded system, meaning the running rails are insulated from ground and there is no intentional connection to ground (earth potential).

(d) The traction return shall be through both running rails cross-bonded as necessary and include appropriately sized negative cables between the running rails and the TPSS.

(e) The basis of the Design and analysis of the TPSS locations and ratings and voltage shall be confirmed by load flow studies performed by Project Co. The studies shall be real time computer generated simulations of the electrical system utilizing validated traction system software and performance based upon the operational performance requirements in Operational Performance Requirements. The study shall utilize the final LRT Alignment, LRV and operating plan (consist sizes, Headways and Passenger loadings). The load flow study shall be performed for normal and contingency operation scenarios and be based upon worst case DC system loading. The load flow shall analyze negative rail potentials for the entire Alignment focusing on touch potentials for areas in within 2m of the track. Regenerative braking shall be a function supported by the OLRT Traction Power system but not utilized during the performance of the simulation. Regeneration, natural receptivity and wayside based energy storage may be utilized during contingency operation simulation scenarios.

(f) The Traction Power system for the MSF shall be electrically separate and isolated under normal operations from the remainder of the Traction Power system. This shall apply to both the positive and negative sides of the Traction Power systems. However, provision shall be made to tie the MSF together with the remainder of the Traction Power system to allow backup power supply between the two sections and provisions to power the shop DC supply during an outage.

(g) The electrical limits of the Traction Power system (excluding OCS) shall be the OLRT side of the HOL disconnect switch on the Utility side and up to and including the OCS disconnect switches on the OCS distribution side. The installation limits shall include the HOL switch foundation and Infrastructure in compliance with utility standards.

(h) All TPSS Equipment shall be CSA or UL/ULC approved.

(i) The Traction Power system shall meet the requirements set out in IEEE 519 for harmonic disturbance and any requirement outlined by HOL.

(j) Project Co shall develop a protective device coordination plan and relay settings for the Traction Power system.

(k) The supply voltage selected by Project Co shall be supported by a complete computer simulation and engineering analysis.

(l) Significant effort has been made during Preliminary Engineering in working with HOL and in capacity and planning delivery of power feeders to supply points (X – Y coordinates) across the Alignment. Project Co shall make every effort to utilize these power supply points during Detailed Design. Any changes in HOL supply points locations as a result of Detailed Design shall be borne by Project Co.

2.4 Traction Power Substations

(a) The TPSS shall be located as close to Passenger Stations and the Guideway as possible.

(b) Negative rail voltage rise shall be limited to 50V under normal operation and 70V under outage conditions. Rail to ground sensing devices shall be implemented to monitor the negative voltage to ground and "clamp" the rails to ground upon exceeding preset limits.

(c) Minimum Train voltage shall be coordinated with the Vehicle manufacturer.

(d) All TPSS Equipment shall be standardized, and allow for interchanging of Equipment and spare parts and shall be the sole responsibility of one manufacturer.

(e) Each TPSS shall be furnished internally with emergency trip stations adjacent to each entrance. The emergency trip station shall, upon activation, de-energize the entire TPSS and its associated line sections and the DC sections at adjacent TPSS backfeeding into the TPSS.

(f) Mass trip function shall be provided through TPSS SCADA which will remove power from the overhead catenary system for the entire alignment. The human machine interface shall be operated from the TSCC.

(g) Building Structures and Foundations

(i) The TPSS shall be completely factory assembled, pre-wired, pre-tested, and installed in a compact, climate controlled, self-supporting, transportable enclosures or provided in Passenger Station rooms designed for the application. The TPSS shall be ready for connection to the Utility interface and outgoing DC feeders prior to shipment. The TPSSs shall include all elements necessary to provide Traction Power including the following:

A. TPSSs shall be designed to minimize their impact on the areas where they will be installed. Architectural treatment, to provide an acceptable appearance, may be required for TPSS located in sensitive areas such as those located on or adjacent to Federal Lands;

B. The TPSS enclosure shall at a minimum consist of a structural steel frame, double sided walls and thermal /acoustic insulation;

C. Removal of all large Equipment (rectifier transformer, circuit breakers) shall be accommodated without structural modifications;

D. Interior and exterior lighting shall be provided. Generator connection point shall be provided on the exterior of the TPSS enclosure; and

E. Intrusion access control shall be provided to selectively limit access to the TPSS.

(ii) TPSS located in Station facilities shall contain identical manufacturer switchgear to pre-fabricated TPSS. Performance, testing and environmental requirements for TPSSs located in Station facilities or other areas shall match those indicated for pre-manufactured TPSSs indicated in Part (i) above.

(iii) Foundations shall be designed and constructed based upon local, national and international standards and codes and the structural loading (live and dead loads) of the TPSS during installation, normal operation, maintenance and faults. The foundation shall be coordinated with the TPSS and distribution elements.

(iv) Maintenance access, both pedestrian and vehicular, shall be provided.

(h) Hydro Ottawa Limited Switchgear

(i) Project Co shall be responsible for all permanent connection works in coordination with HOL from the supply point as described in HOL Condition of Service specification ECS0012. Project Co shall provide the foundations for a pad mounted system, and terminate a pad mounted switch (switch and metering to be provided by HOL through Project Co) in accordance with HOL codes and standards.(HOL Drawing Reference 92006563 E1 / E2).

(ii) Controlled access and security fencing shall be provided to limit access to the pad mounted switch.

2.5 Traction Power Rectifier Units

(a) The Traction Power transformer and associated traction rectifier shall be Designed and production tested as an integral unit.

(i) TPSS shall have a silicon diode type, 12 pulse rectifier unit (ANSI C34.2).

(ii) The TPSS locations have been coordinated with and made available to HOL in determining the power feed requirements based on a 3MW TPRU. Project Co shall evaluate and confirm through a load flow study the suitability of these assumptions and coordinate with HOL. The displacement power factor of the TPRU shall be 95% or greater.

(iii) The TPRU shall be protected from damage due to surges and transients transmitted through the utility network with MV surge protection.

(iv) The overall efficiency of the TPRU shall be greater than 97.5%.

(v) The TPRU shall comply with ANSI C57.12.10.

(vi) The noise generated by the TPRU shall not exceed 55dBA at full load inside the substation through the use of rectifier load balance, coupling, or interphase transformer, or other alternative method to reduce audible noise.

(vii) The rectifier transformer shall be dry type, vacuum pressure impregnation or cast coil construction, convection cooled with no forced cooling necessary to meet the extra-heavy duty operations requirement and two-stage temperature monitoring.

(viii) The rectifier transformer shall be equipped with a no-load tap changer and 5 taps, +/- 2.5%.

(ix) The TPRU shall be designed for extra-heavy duty operation with no damage or degradation of performance. Extra-heavy duty is defined in IEEE 1635.2-2009:

A. Imbalance in the rectifier caused by loss of one diode per phase shall not reduce the overload capability of the TPRU.

(x) The rectifier shall be furnished with a negative disconnect switch, two-stage temperature monitoring, two-stage diode monitoring, two-stage enclosure monitoring as a minimum.

(xi) Each rectifier shall be furnished with a NGD which shall monitor the potential between the negative bus and the TPSS ground grid.

(xii) The TPRU shall be furnished with digital metering for:

A. DC rectifier current;

B. DC Voltage; and

C. Winding and rectifier over-temperatures.

(xiii) Rectifier enclosure energized/grounded protection shall be provided which shall detect when the enclosure has a positive to frame fault or when grounded. Upon detection of a positive to frame fault the substation shall be automatically shut down. There shall be a local audio – visual warning which will be communicated along the SCADA to the TSCC.

(b) TPSS AC Switchgear shall meet the following requirements:

(i) Drawout, metal clad (as defined by ANSI C37) switchgear which prevents the accidental contact of live parts by maintenance personnel;

(ii) Circuit interrupting devices which do not have load- break capabilities and doors equipped with interlocks to prevent unsafe operations;

(iii) Adequate space for removal and maintenance of both AC and DC circuit breakers;

(iv) Multifunction protective devices for phase imbalance, overcurrent, undervoltage, diagnostics, alarming, monitoring, data storage and power metering;

(v) Equipment to test the AC and DC breakers in the TPSS after it has been removed from its cubicle;

(vi) Digital metering for:

A. AC voltage;

B. AC current; and

C. Power; and

(vii) AC switchgear shall also contain the auxiliary power transformer supplying "house" power for the TPSS building, with appropriate protection and disconnect devices on the primary and secondary. The auxiliary transformer shall supply power to the AC distribution panel.

(c) DC Switchgear shall meet the following requirements:

(i) DC switchgear shall be metal enclosed single pole, draw-out type feeder breakers equipped with load measuring auto-reclosing systems, rated to interrupt maximum available fault current;

(ii) The major elements of the TPSS DC switchgear shall consist of a main cathode circuit breaker, high speed DC feeder circuit breakers, and PLC based controller with protection functions;

(iii) PLC based protection and data storage devices shall be provided for the DC circuit breakers. These devices shall perform all the functions of overcurrent protection, breaker control, breaker monitoring, data storage, transfer trip, alarm summary storage, event summary storage, ammeter, voltmeter, SCADA interface, HMI interface for establishing and adjusting breaker protective parameters and visual display of metering.

A. Main Cathode Circuit Breaker shall meet the following requirements:

i. Protect against reverse current;

ii. Include a DC enclosure device to detect enclosure faults;

iii. Provide an interlock to the AC breaker; and

iv. Include a lockout device.

B. Feeder Circuit Breakers shall meet the following requirements:

i. PLC based circuit breaker protection with instantaneous, long time and rate of rise overcurrent protection;

ii. A transfer trip scheme to ensure all feeder circuit breakers supplying power to a faulted section shall trip and de-energize the faulted section; and

iii. Equipment shall be metal clad as defined by the C37 series of ANSI specifications and shall prevent the accidental contact of live parts by maintenance personnel.

(iv) Digital metering shall be provided for:

A. DC bus voltage; and

B. On each feeder circuit breaker through the PLC based protective device and controller displaying DC feeder voltage, and feeder current.

(v) Each TPSS shall be furnished with a negative grounding device which shall monitor the potential between the negative bus and the substation ground grid. The NGD shall provide an open circuit when the potential is at an acceptable level. The NGD shall close if the pre-set potential is exceeded. Once the potential has decreased below the pre-set level the NGD will automatically open. Status points will be provided from the NGD to the SCADA system.

(vi) DC enclosure energized/grounded protection shall be provided which shall detect when the switchgear has a positive to frame fault or when grounded. Upon detection of a positive to frame fault the substation shall be automatically shut down. There shall be a local audio – visual warning which will be communicated along the SCADA to the TSCC.

(vii) Equipment shall be metal clad as defined by the C37 series of ANSI specifications and shall prevent the accidental contact of live parts by maintenance personnel.

(viii) The main cathode circuit breaker and the negative disconnect switch shall be interlocked such that the cathode circuit breaker cannot be closed when the negative disconnect switch is open and the negative disconnect switch cannot be opened when the cathode circuit breaker is closed.

(d) Utility Power

(i) HOL have identified Supply Points across the Alignment to supply power, both traction and facility. HOL shall terminate MV power supply feed at the pad mounted switchgear.

(ii) Utility power needs, codes and requirements shall be coordinated with HOL.

(iii) Revenue metering shall be provided by HOL at each pad mounted switchgear.

(iv) All Infrastructure and cabling elements (duct banks, foundations, grounding, maintenance holes) to facilitate the HOL supply point switchgear, serving the TPSS and/or facilities shall be by Project Co and shall be constructed to meet HOL standards and require HOL approval.

Utility power from HOL supply point switchgear to the TPSS shall be configured such that no two electrically adjacent TPSS are supplied from a feeder sourced from the same bus at a HOL substation.

(e) Control Power

(i) Control power in the TPSS shall be used for TPSS controls, relaying, SCADA and other functions. The system shall consist of a step down transformer, battery bank, battery charger, DC distribution panels and all necessary Equipment to provide a complete control power system.

A. The battery shall be capable of supplying TPSS demand to support control power for 8 hours and to support duration as identified in a failure mode analysis.

B. The battery shall be sized based upon a load calculation incorporating TPSS switching operations and all static TPSS loads during normal and contingency operation.

C. The battery charger shall include a ground detection system and alarm function reporting to the SCADA system.

(f) Control Requirements

(i) The TPSS shall be designed for unattended operation with remote supervision and control from all control centres through the SCADA system.

(ii) Local control shall be provided for all elements of the TPSS through a HMI and computer based TPSS control unit (PLC). Remote control shall be disabled when in local control. Local control shall be enabled by means of a "local/remote" switch. This switch shall enable and disable local control of the entire TPSS excepting circuit breaker trip functions. All TPSS indication and alarms shall be provided to the HMI.

(iii) HMI located in each TPSS shall be the local TPSS status screen annunciator. The HMI/PLC shall provide all information to SCADA at the TSCC. This includes alarms, Equipment status and real-time metering values. The default screen shall be a representation of the TPSS single line indicating the current status.

(g) SCADA Requirements

(i) TPSSs shall be provided with a TPSS SCADA monitored and controlled reporting directly to TSCC.

(ii) The TPSS shall be provided with a TPSS SCADA RTU that shall interface with the SCADA systems specified in Part 4 Article 6 – Communications for the purposes of transmitting the information and control to TSCC.

(iii) The following status and control points, at a minimum, shall be incorporated into the TPSS SCADA system functionality:

A. AC switchgear – Status and control:

i. Protective devices – Status; and

ii. Lockout device – Status;

B. Loss of utility power – Status;

C. Rectifier transformer:

i. Winding over temperature – Status;

D. Rectifier:

i. Over temperature – Status;

ii. Negative disconnect switch position – Status;

iii. Negative overvoltage – Status;

iv. Diode failure – Status;

v. Surge suppressor failure – Status;

vi. Reverse current trip – Status;

vii. Enclosure energized alarm – Status; and

viii. Enclosure grounded alarm – Status;

E. DC Switchgear:

i. Cathode (main) breaker – Status and control;

ii. Feeder breakers – Status and control;

iii. Transfer trip trouble/failure – Status;

iv. Feeder breaker reclosure failure – Status;

v. Feeder breaker protective relay trouble/failure – Status;

vi. Lockout relay trip – Status;

vii. Enclosure energized alarm – Status;

viii. Enclosure grounded alarm – Status; and

ix. OCS section energized – Status;

F. Negative Grounding Device:

i. Closed – Status;

ii. High Current – Status; and

iii. Failure – Status;

G. TPSS Local Control Enabled – Status;

H. Loss of station auxiliary power – Status;

I. Intrusion Detection – Status; and

J. Fire alarm:

i. Trouble – Status;

ii. Power Supply – Status; and

iii. Alarm – Status;

K. Loss of control power – Status;

L. Battery charger trouble/failure – Status;

M. Climate Control – Status;

N. TPSS air temperature – Status;

O. Emergency trip activated – Status; and

P. Mass trip control – Status.

(iv) 25% additional status and control point spare capacity shall be provided at each TPSS.

(v) Communication between the local SCADA system and the TSCC shall be redundant via the CTS.

(h) Climate Control

(i) All TPSS shall include a climate control system which shall maintain indoor temperature and humidity to allow for PLC and SCADA Equipment operational performance to be maintained throughout all expected external temperature variations. The climate control system shall be designed to continuously maintain the temperature within the TPSS and provide status to the TPSS SCADA system.

(i) Communications

(i) Connection panel to the CTS for redundant data and telecommunication shall be provided.

(ii) Telephone connection to TSCC shall be provided for local control and emergency functions.

(j) Intrusion Detection

(i) Each substation shall be equipped with an intrusion detection system which shall allow keyed and keyless access and upon unauthorized access provide a local audible and visual alarm as well as remote notification. The IAC system shall be compatible with the IAC system provided for in Schedule 15-2 Part 4 Article 6

(k) Fire/Smoke Detection System

(i) Each TPSS shall be equipped with a fire alarm system which shall detect and alarm upon detection of a smoke or fire event and report to TSCC through SCADA. Activation of the fire alarm system shall trip and lockout the TPSS.

(l) TPSS Grounding

(i) A TPSS grounding system shall be provided for life Safety and fault detection purposes. The grounding system shall be designed in accordance with IEEE Standard 80 or IEC equivalent specification.

(ii) Any metallic structures exterior to the TPSS shall be connected to the ground grid.

(iii) Surge protection shall be provided for all cables entering and exiting the TPSSs as follows:

A. All non-current carrying parts of the TPSS shall be isolated from ground and connected to the ground grid through a ground fault detection system. The ground fault detection system shall, upon detection of a grounded condition, disconnect the substation from sources of power and annunciate an alarm locally and at the TSCC; and

B. Security fencing, lamp stanchions shall be connected to the ground grid. This includes any conductive hardware where public can inadvertently come in contact with high voltages.

(m) DC Feeder System

(i) The DC feeder system shall be provided and consists of all raceways, cabling and switching Equipment necessary to connect the TPSS to the OCS and rail returns. All cable ampacity ratings shall be based upon the worst case maximum RMS currents indicated in the load flow studies with any necessary de-rating due to duct bank/raceway routing and appropriate temperature rise. The positive DC feeder system shall be designed to provide adequate ampacity and to maintain the electrification voltage within acceptable limits. The DC negative feeder system shall include any necessary Equipment to interface with the running rail traction return so as not to interfere with the Train control system. The negative feeder system shall be designed to maintain a low rail to ground voltage and provide sufficient ampacity. The negative feeder system shall be designed to be continuous through the four running rails including interlockings at all locations.

(n) A stray current monitoring system shall be provided.

(o) Drainage Feeder System

(i) Provision shall be made for the monitoring and control of stray current through the use of drainage panels. The drainage panels shall provide a means of permitting metallic utilities to connect to the substation negative bus. Provisions shall be made to provide a raceway system to a demarcation pullbox for utility company drainage cables to be connected to the drainage system.

(p) AC Feeder System

(i) The medium voltage AC feeder system shall be provided and consist of all raceways, cabling maintenance holes, foundations, ground rods and switching Equipment necessary to connect the TPSS to the HOL utility supply switchgear in accordance with utility requirements.

(q) Duct banks and Raceways

(i) Duct banks shall be provided from the TPSS exiting point to the intersect point of the distribution system and constructed of non-conductive material encased in concrete.

(ii) All underground raceways shall have a utility marking tape (with magnetic tracer) installed 0.33 meters above the raceways.

(iii) Positive and negative feeders shall not be installed in the same raceway, pullbox or maintenance hole.

(iv) Ten percent (10%) spare duct shall be included in each duct run.

(r) Communication Raceway System

(i) Duct banks shall be provided from the TPSS exiting point to the intersect point of the communication CTS system and constructed of non-conductive material encased in concrete.

(s) Sectionalization

(i) The Traction Power distribution system (OCS) shall be circuited into manageable electric sections. These sections are redundantly fed from two adjacent TPSSs to maintain reliability, continuity of service, fault discrimination and distribution of loading.

(t) Yard TPSS(s)

(i) TPSS(s) shall be provided in the MSF yard to provide DC power to support the operation of the yard. The TPSS(s) shall be sized to satisfy all traction loading for Train movements to storage Tracks, storage, yard lead Tracks operation and Train movements to car wash facilities and movements into and out of the shop.

(ii) Yard TPSS and TPSS Equipment shall be of the same arrangement and Design and manufacturer as the mainline TPSS.

(iii) Yard Traction Power positive circuits and negative rail returns shall be electrically isolated from the mainline Traction Power positive circuits and mainline negative rail returns.

(iv) Yard Traction Power positive circuits and negative rail returns shall be electrically isolated from the shop Traction Power positive circuits and shop negative rail returns.

(v) Yard Traction Power ductwork and cabling shall be installed to the respective demark maintenance hole system provided.

(vi) Yard TPSS shall have sufficient quantity and size DC circuit breakers to service the sectionalizing requirements and provide sufficient quantity and size circuit breakers for growth of the yard to the ultimate build out.

(vii) Yard TPSS shall be controlled and monitored through TPSS SCADA by TSCC.

(viii) Yard negative rail system shall be electrically continuous through and be directly connected to the Yard TPSS negative return.

(u) Shop TPSS

(i) TPSS shall be provided in the MSF shop to provide DC power to support the operation and sectionalization of the shop Tracks. The TPSS(s) shall be sized to satisfy the traction loading for Train movements to, into and out of each Track,

and Train loads during repair, testing and maintenance through an auxiliary quick connect system to interface with the Vehicle auxiliary power receptacle.

(ii) Shop TPSS and TPSS Equipment shall be of the same Design and manufacturer as the mainline TPSS and shall provide an interlocked contactor system for circuiting each Track and respective auxiliary quick connect distribution system.

(iii) Shop Traction Power system to each Track contact wire shall be through an isolation switch, wall-mounted for manual operation, and be interlocked for Safety through any crane, lifting jacking or maintenance device (wheel truing) or other device that may cause serious injury or damage if Traction Power remains energized.

(iv) Shop Traction Power system shall be interlocked throughout the shop through a resettable visual and audible emergency trip system reporting directly to the YCC and resettable only by YCC.

(v) Shop TPSS shall be provided with a SCADA system reportable and controllably only through YCC through the MSF BMS SCADA.

(vi) Shop negative rail system shall be continuous throughout and grounded.

(v) Cabling Identification System

(i) All cables shall be identifiable at each end including type, size and function.

ARTICLE 3 REVENUE VEHICLES

3.1 Introduction

(a) The LRV shall be a minimum 70% low floor LRV, 2.65m to 3m wide, no less than 28m long, with low floor heights of 356mm to 550mm above top of rail (see Section 3.6 Vehicle Dimensions) and shall be in accordance with the following criteria:

(i) The LRV (and resulting train consist) is fully compliant with the ridership and capacity requirements outlined in Schedule 15-2, Part 1 Article 2 – Operational Performance Requirements;

(ii) The vehicle characteristics (weight, width, length and floor height), its dynamic envelope and the required station platform widths shall fit within the limitations of the right of way;

(iii) The vehicle characteristics (weight, width, length and floor height) shall be consistent with the City's decision for the OLRT Project to protect for a future unified low-floor rail network;

(iv) An existing Service Proven Vehicle design suitable for the OLRT Project; and

(v) Project Co shall be responsible for coordinating Platform width and height with LRV dimensions to meet the ridership requirements and comply with all applicable building and safety codes.

(vi) Project Co shall ensure that vehicle weight, axle loads and resonant frequency are compatible with new and existing infrastructure.

(vii) Percent low floor shall be based on the linear vehicle length of the Passenger compartment, from cab wall to cab wall. If a single cab per LRV is provided, the additional length of the non-cab end shall not reduce the low floor percentage.

(b) 30 metre Vehicles shall be fitted with a cab in one or both ends of the Vehicle. The non-cab end shall include a hostler panel for limited operation, including yard moves. If vehicles longer than 40 metres are proposed, cabs shall be provided on both ends.

(c) Foldable or retractable couplers shall allow the use of coupler covers at the extreme ends of the consists while still affording quick coupling and uncoupling. The coupler cover movement and coupler extension shall be manually operated. Coupling (mechanical and electrical) shall be automatic.

(d) The Vehicles shall utilize CBTC for ATO with ATP. Drivers shall be able to manually control the opening and closing of the doors. The Driver may pull back on the master controller at any time to decelerate the Train. Emergency braking shall also be available through the emergency brake pushbutton on the drivers control panel and from the TSCC.

(e) Future expansions of the System could involve operation in a partially segregated right-of-way with level crossings. Manually controlled ATP operation shall be utilized in these sections of the Alignment and the Vehicles shall be capable of operating in such conditions.

3.2 Vehicle Capacity

(a) The design of the vehicle in conjunction with other system elements shall support the requirements outlined in Article 2 Operational Performance Requirements.

(b) Doorways shall be located such that all doors of the consist align with the Platform at all times without undue tolerance restrictions on consist position at any Station.

(c) Vehicles shall be designed with features to limit dwell time and maximize Passenger capacity. Wide double leaf doors and seats arranged for maximum aisle width shall accelerate boarding and alighting times.

3.3 Operating Environment

(a) The Vehicle shall be compatible with and designed to operate safely and reliably over the OLRT Alignment. Project Co shall ensure that the requirements and interfaces of the System are adhered to with specific emphasis on the following articles:

(i) Part 2 – Guideway;

(ii) Part 3 – Tunnels;

(iii) Part 4 Article 2 – Traction Power;

(iv) Part 4 Article 5 – Train Control;

(v) Part 4 Article 6 – Communications;

(vi) Part 4 Article 8 – Overhead Catenary System;

(vii) Part 5 – Stations; and

(viii) Part 6 – Maintenance and Storage Facility.

(b) Any conflicts between these documents shall be brought to the attention of the City for resolution.

3.4 Environmental Conditions

(a) The Vehicle shall be capable of operation at the performance levels stated in this Article under the following environmental conditions and the requirements of Schedule 15-2 Part 1 Article 4:

(i)	Thermal shock temperature change	58°C;
(ii)	Humidity	10 to 100%;
(iii)	Continuous rain fall rate	60mm/hr;
(iv)	Continuous snowfall rate	55mm/hr;
(v)	Freezing rain accretion	5mm/hr;
(vi)	Maximum daily freezing rain accretion	30mm; and
(vii)	Fording	
	A. Water	75mm above top of rail; and
	B. Snow	40cm above top of rail.

(b) The Vehicle shall be resistant to water intrusion under any combination of wind, rain or snow and any Vehicle speed. This shall include passage of the Vehicle through the car wash facility.

3.5 Vehicle Design Requirements

(a) Vehicles shall be equipped with automatic couplers on each end. To couple Vehicles together, the Driver shall manually raise the front bumper of the Vehicle to expose the coupler. Once the cover is raised, manual unfolding of the coupler may be followed by automatic coupling. The raised position of the front bumper/coupler cover shall not obstruct the driver's vision to accomplish safe coupling or foul the body during turns on super elevated Track. In the closed position, the coupler cover shall blend seamlessly with the cab side skirts.

(i) If Project Co elects to operate pairs, or triplets, as coupled consists, at all times during Revenue Service, coupled ends of Vehicles may be fitted with standard automatic couplers and the requirement for a coupler cover may be omitted. Exposed ends of the consist shall always be fitted with a folded coupler and coupler cover.

(b) Vehicles shall include intra-car barriers between coupled ends to prevent inadvertent access between cars. Alternatively, platforms may be arranged with barriers located at all intra-car locations of all consist arrangements for Revenue Service.

(c) LRVs shall be arranged in articulating body sections supported by independent trucks. Brake discs shall be provided on all axles. The vehicles shall be fitted with Track brakes.

(d) In order to meet the Operational Performance Requirements, the seating shall be arranged with longitudinal seating throughout the length of the low floor section of the LRV, to the maximum extent possible.

(e) Flip seats shall be provided adjacent to all vestibules to provide clear floor space to accommodate wheelchairs, baby carriages, bicycles and the other passenger requirements. Flip seats shall be arranged to revert to the stowed position with less than 20N of force. Lowering the flip seats into position shall require not more than 40N.

(f) Hand holds, grab bars and stanchions shall be arranged to provide comfort for standees.

(g) The door design shall be supported by passenger flow calculations, schedule and dwell times. A minimum of eight dual leaf, electrically operated sliding plug doors shall be provided for every 30 metres of Vehicle length.

(h) Each LRV shall include load levelling. Project Co shall ensure the height and Platform gap are within the limits of the ADA, as referenced in the AODA. Project Co shall provide a method to adjust Vehicle height for wheel and rail wear. The height adjustment device shall provide clear indication of the level of adjustment provided on both sides of the truck.

(i) Each LRV shall be powered from an OCS by a pantograph.

(j) The LRV shall be designed for maximum availability, be capable of operating reliably for a minimum of 100,000km per year and provide a minimum service life of 30 years.

3.6 Vehicle Dimensions

(a) Vehicle dimensions shall be in accordance with the requirements of Table 4-3.1.

Table 4-3.1

Description	OLRT LRV
Width at threshold	2,650mm to 3,000mm
Vehicle maximum width (not including side mounted lights, cameras, etc)	3,000mm
Height over roof shrouds, maximum. ATOR	3,600mm
Height over roof Equipment, maximum. ATOR	3,800mm
Height to top of low floor (with new wheels) ATOR	356mm to 550mm
Minimum Aisle width at articulation joints	1,200mm
Minimum Aisle width	600mm
Aisle width at accessible areas, minimum (AODA/ADA requirement)	813mm
Side door width with doors open, minimum	1,220mm
Height – floor to top of door opening, minimum	2m

Description	OLRT LRV
Height floor to ceiling, low floor, minimum	2,200mm
Height floor to ceiling, high floor, minimum	2,000mm
Door protrusion from Vehicle when open, maximum	75mm
Maximum Truck wheel base	2,000mm
Wheel Diameter new	600mm to 700mm
Wheel wear allowable, minimum diameter reduction	50mm

Note: The Vehicle dimensions (length, width and floor height), its dynamic envelope and platform widths required by code shall fit within the limitations of the right of way.

3.7 Clearance Requirements

(a) Clearance dimensions shall be in accordance with the requirements of Table 4-3.2.

Table 4-3.2

Description	OLRT LRV
Underfloor Equipment, minimum	120mm
Truck clearance, minimum (except sand nozzles)	50mm
Truck to carbody clearance, minimum	15mm
Coupler cover in the closed position	No greater than 250mm TOR

3.8 Vehicle Weight Definition

(a) Project Co shall consider options for weight reduction during the Design phase to maximize the energy efficiency of the LRT System and shall determine the Vehicle weight for the Vehicle in accordance with the definitions outlined in Table 4-3.3.

Table 4-3.3

Description(1)	Definition
AW0	LRV empty weight (Tare) + dry sand
AW1	Fully seated Passenger load and one Driver + AW0
AW2	Standees at 4 Passengers/m^2 of

Description(1)	Definition
	suitable standing space + AW1
AW3	Standees at 6 Passengers/m^2 of suitable standing space + AW1
AW4	Standees at 8 Passengers/m^2 of suitable standing space + AW1 (Structural design load, not expected for Revenue Service)

(1) Note: 70 kg/passenger shall be utilized in all weight calculations.

(b) The Vehicles shall be designed to balance weight per powered axle.

(c) The maximum allowed lateral imbalance shall be 2700Nm:

(i) The maximum allowed weight deviation supported by each truck shall be 910kg.

(ii) For 30 metre Vehicles, the center truck shall support a minimum of ¼ of the total empty Vehicle weight. For longer Vehicles, each truck shall support no less than 12,000kg of empty Vehicle weight.

A. Centre Truck(s) loading requirements shall be maintained under all conditions of acceleration and deceleration.

3.9 Noise, Shock and Vibration Requirements

(a) Noise internal to the Vehicle shall be less than:

(i) 68dBA with the Vehicle stationary and all Equipment running in Revenue Service conditions;

(ii) 78dBA at Vehicle speeds up to 100km/hr; and

(iii) 80dBA in the Tunnel sections of the right of way, at Vehicle speeds up to 65km/hr.

(b) All measurements of exterior noise levels shall be made with the Train on or operating on level, tangent track in a free-field environment, such as outdoors, away from any reflecting surfaces. Noise external to the Vehicle, shall not exceed:

(i) 70dBA, when measured 20m from a stationary LRV; and

(ii) 80dBA, when measured 20m from a Train traveling at 100km/hr, and braking.

(c) Vibration shall not exceed:

(i) Levels required to successfully pass the Ride Quality Test conducted per ISO2631 in Vehicles traveling at speeds from 0km/hr to 100km/hr. Testing shall take into account Track conditions when determining ride quality.

(d) Carbody mounted Equipment shall resist shock loads of:

(i) 2g lateral, 3g vertical, and 5g longitudinal.

3.10 System Voltage

(a) All Equipment shall function at the nominal OCS voltage as per IEC 60850 and subsystems shall function throughout voltage ranges allowed by EN 50155.

3.11 Electrical Equipment Environmental Conditions

(a) All Vehicle electronic Equipment shall function reliably under power quality conditions detailed in EN 50155, unless otherwise specified. Where environmental conditions listed in this section are more severe, those conditions shall take precedence over EN 50155.

3.12 Performance Requirements

(a) Performance shall be in accordance with the requirements of Table 4-3.4.

Table 4-3.4

Parameter[(1)]	Specification
Maximum speed	≥100km/hr
Acceleration	
Initial Maximum Vehicle Acceleration, OCS voltage ≥ nominal OCS voltage, AW2 loading	≥1.34m/s^2 ± 5%
Speed for Initial Tractive Effort for OCS voltage ≥ nominal OCS voltage	≥32km/hr[(2)]
Electric Braking	
Electric brake type	Regenerative/rheostatic with line voltage control
Full service electric brake rate at AW3 loading	1.34m/s^2 from 64km/hr to 5km/hr with electric brake fade below 5km/hr and taper

Parameter(1)	Specification
	above 64km/hr
Blended Braking	
Full service blended electric + friction brake rate at AW3 loading	1.34m/s^2 from 80km/hr to standstill
Maximum service brake rate (electric/friction blended + Track brakes) at loads up to AW3	≥2m/s^2 from 88km/hr to standstill
Friction Brakes	
Friction brake type	Hydraulic Apply Disc Brakes with spring apply Parking Brake
Full service brake rate (friction only) at loads up to AW3	1.34m/s^2 +/- 10% from 80km/hr to standstill
Emergency Brakes	
Friction only at loads up to AW3 (with sanding as required)	1.78m/s^2 +20%/-10% starting from 80km/hr to standstill
Emergency Brake from irretrievable emergency brake switch	
Initiated by emergency pushbutton (friction + Track brakes) at loads up to AW3	≥2.5m/s^2 – 0.006m/s^2 per km/h, starting above 48 km/hr and > 2.24m/s^2 starting from less than 48 km/hr (standing to no motion)
Parking Brake	
Parking brake capacity	Shall hold an AW3 Vehicle on a 6% grade, indefinitely.
Jerk Rates and Transition Dead Time Limits	
Jerk rate limit	Adjustable 0.44m/s^3 to 1.34m/s^3

(1) Note: Acceleration and braking rates assume that adhesion is not the limiting factor.

(2) Note: Alternative knee points may be considered if an analysis of operational performance indicates that the proposed reduction in acceleration rate will have an insignificant impact on trip time.

(b) Propulsion Thermal Normal Duty Cycle Requirements

(i) With an AW3 loading, maximum ambient temperature, maximum variation in wheel diameters and a line voltage between nominal OCS voltage and nominal OCS voltage less 16.7%, an LRV Train shall be able to operate continuously over

the entire length of the OLRT. The Train shall accelerate at the maximum rate up to maximum CBTC controlled speeds and decelerate at 0.89m/s2 for Station stops. No part of the propulsion system shall exceed the manufacturer's recommended temperature limits for a 30 year life.

(c) Propulsion Thermal Degraded Continuous Duty Requirements

(i) With an AW2 average loading, maximum ambient temperature, maximum allowed variation in truck wheel diameters and a line voltage between nominal OCS voltage and nominal OCS voltage less 16.7%, an LRV Train shall be able to operate continuously over the entire length of the OLRT line with 25% of the propulsion systems cut-out. The Train shall accelerate with the maximum remaining tractive effort and decelerate at 0.89m/s2 for Station stops. No part of the propulsion system shall exceed the manufacturer's recommended temperature limits for a 30 year life.

(d) Towing Duty Requirements

(i) At AW3, maximum ambient temperature, maximum allowed variation in truck wheel diameters and a line voltage between nominal OCS voltage and nominal OCS voltage less 16.7%, any LRV Train shall be able to tow an equal length, equal weight, dead LRV Train between any two Stations. No over temperature shut down shall occur and no part of the propulsion system shall exceed the manufacturer's limits for a 30 year life.

(ii) At AW0, maximum ambient temperature, maximum allowed variation in truck wheel diameters and a line voltage between nominal OCS voltage and nominal OCS voltage less 16.7%, any LRV Train shall be able to tow an equal length dead LRV Train the entire length of the line. The speed through Stations shall be limited to 16km/h. No over temperature shut down shall occur and no part of the propulsion system shall exceed the manufacturer's limits for a 30 year life.

3.13 Maintenance Based Requirements

(a) Project Co shall provide, at a minimum, LRVs with the following:

(i) All major Vehicle systems shall be provided with diagnostic and fault logging capability with central fault data storage in each Vehicle. Faults shall be reported to a central maintenance computer. Fault and maintenance records shall be available to the City for inspection and review, at the City's request.

3.14 Safety

(a) FMECA

(i) Project Co shall perform a FMECA to identify weaknesses in system-wide hardware and software Design, and to analyze the modes and effects of failures whenever these details are not established by historical records of Equipment

operation. The FMECA shall provide input to system Designs and to the Safety analyses for theoretical circuit behaviour, random component failures, electrical interference, systematic component failures, and software errors in software-based logic. The FMECA shall be updated throughout the system design development and throughout the operational life of the OLRT system.

(b) Hazard Analysis

(i) A PHL, a SSHL and a SHL shall be prepared and submitted as part of the Works Submittals according to Schedule 10 – Review Procedure.

(ii) Project Co shall identify failure-induced and normal operating (non-failure condition) hazards falling into severity Categories I, II and III (as defined in MIL-STD-882) Hazards shall be compiled into a PHL, SSHL, and SHL. The following hazards shall be included in the listings and shall be considered hazards of Category I or II severity:

A. Emergency brakes fail to apply when requested;

B. Service brakes fail to apply when requested;

C. Propulsion fails to cease when requested;

D. Propulsion fails to cease when Emergency Brake is requested.

E. No-motion detection system indicates no-motion when Train is moving;

F. Door opens spontaneously when not commanded;

G. Door opens on wrong side of car;

H. Door closes on person's object and indicates door closed and locked to the control system;

I. Door interlocks erroneously indicate door is closed and locked;

J. Excessive currents or overheated equipment cause fire hazard;

K. Indication of uncoupled when not uncoupled;

L. Train moves in wrong direction;

M. Slide control does not reapply brakes after slide correction;

N. Cars in Train separate when not commanded; and

O. Train regenerates into dead section of catenary.

(c) Project Co shall perform a hazard analysis on all hazards identified above, in accordance with the requirements of Part 1 Article 10 – Safety and Security Certification.

3.15 Electromagnetic Compatibility

(a) All LRVs and related equipment shall comply with the EMC management plan described in Part 4 Article 9 – EMI/EMC.

(b) An analysis shall be provided showing that no Safety or signal Equipment shall be affected by Vehicle emissions.

3.16 Fire Safety

(a) Fire Safety shall be achieved through adherence to the following requirements or equivalent specifications:

(i) All non-metallic components used on the Vehicle shall be smoke, flame and toxicity tested to NFPA 130, 49 CFR part 238 and BSS 7239. Maximum smoke developed, flame spread indices and toxicity limits are outlined in Section 3.31 of this Article;

(ii) Project Co shall retain a list of materials (flammability matrix) used in the Vehicles showing location of material, weight (density and total weight), heat value per kg and per Vehicle, flame spread, flashpoint, smoke generation, and toxicity. Project Co shall retain and manage test results for each component for the operating life of the Vehicle.

(iii) All heat sources on the Vehicle shall be protected with redundant levels of protection so that circuits are open before unsafe temperatures exist;

(iv) Smoke detectors shall be located in fresh air intake section of each unit;

(v) Automatic dampers shall prevent the introduction of external smoke from entering the Vehicle;

(vi) Protection from smoke and fire originating under the Vehicle floor or through the roof shall be proven through test reports documenting successful completion of a 30 minute roof and floor fire test in accordance with ASTM E119, NFPA 130, and 49 CFR part 238;

(vii) Two fire extinguishers shall be located in each cab;

(viii) An interior manual door release shall be provided for each side door; and

(ix) An exterior manual door release shall be provided for each side door.

3.17 Carbody

(a) Carbody General Requirements

(i) The front and rear ends of the Vehicle shall meet the structural and crashworthiness requirements of all the related standard and requirements outlined in this Article.

(ii) The car shall be constructed of the following materials:

A. Stainless steel utilizing AISI type 301LN or approved equivalent (non-corrugated);

B. HSLA per ASTM A588 or approved equivalent;

C. Stainless steel, HSLA or FRP sidewalls; and

D. Aluminum, in the following alloys: 6061-T6, 5083-H111, 6082, 6005A, 6008, 6106 T6, 5454 H24 and 5754 H26. 2000 and 7000 series alloys shall not be used. Vehicles which offer aluminum carbodies shall include a full analysis of the effects of salt. Analyses shall prove compliance with the required life expectancy below.

(iii) The carbody shall have a 40 year expected life.

(b) Carshell Design features

(i) Equipment arranged for ease of service.

(ii) Roof fairings that provide aesthetically pleasing body lines.

(iii) Roof drainage through interior drain tubes terminating under the car.

A. The Design shall include features that prevent water from draining over the sides or ends of the Vehicle.

B. The structure shall be designed to eliminate all water traps.

(iv) An exterior that is smooth and free of corrugations and that will allow effective vinyl wrapping.

A. The body sides of Vehicle shall be flat or include a designed curve. Deviations shall not exceed 2.5mm over 1m.

(v) A carshell finish that is graffiti resistant, and does not promote snow and ice adhesion.

(c) Thermal and Acoustical Insulation

(i) Thermal insulation shall be installed throughout the Vehicle, such that all exterior walls, floor and ceiling to meet energy objectives.

(ii) Sweating shall not occur on any interior or exterior surface under any temperature or humidity level.

(iii) Acoustical insulation shall be utilized as required to meet the noise requirements outlined in this article.

(d) Articulation Section

(i) All aspects of the articulation shall be service proven.

(ii) Articulation sections shall be proven per ASME RT-1, or equivalent, by static compression test. Collision requirements of ASME RT-1 shall be proven by calculation.

(iii) Articulations shall include interior and exterior flexible bellows that provide a water-tight seal and prevent Passenger exposure to pinch points. Bellows shall be compliant to the smoke, flammability and toxicity limits of this article. Exterior bellows shall be flush with the exterior surface of the side walls.

(iv) Articulation sections shall be designed to allow a free flow of Passengers between body sections. Minimum aisle width through the articulation shall be 1.2m. Hand holds shall be provided throughout the articulation section.

(v) The floor panels shall be arranged to allow relative motion between body sections and allow easy access to the articulation joint. The Design shall not present a trip hazard under any conditions of movement, including rotation about the longitudinal axis (body roll).

(e) Carshell structural features shall include:

(i) A full width anticlimber on each end of the Vehicle;

(ii) A coupling speed up to 8km/hr with no resulting damage to coupler or anchorage. Replaceable energy absorption components of the coupler are excluded from this requirement;

(iii) Provisions for Vehicle towing;

(iv) The structural integrity shall be to ASME RT-1 or equivalent and protect the driver and passengers;

(v) Sufficient jacking pads to allow Vehicle jacking during maintenance and in the case of derailment. Jacking pad locations shall be coordinated with the

requirements of Part 6 – MSF and rerailing equipment. The position of the jacking pads shall be identified on the carshell;

(vi) Pilot beams, skirting and an energy absorbing front bumpers to prevent structural damage or entrapment of struck objects;

(f) Carshell Strength Requirements

(i) Strength requirements shall be in accordance with ASME RT-1 or equivalent.

(ii) If EN 12663 is proposed as an alternate specification for carshell strength, the Vehicle shall meet the requirements of category P-III.

(g) Carshell Collision Resistance Requirements

(i) Collision resistance requirements shall be in accordance with the requirements of ASME RT-1 or equivalent.

(ii) If EN 15227 is proposed as an alternate specification for collision resistance, crushable elements shall be tested in accordance with the requirements contained therein. The Vehicle shall meet the requirements of category C-III.

(h) Carshell Qualification Testing

(i) The first carshell shall be evaluated and certified to comply with the strength requirements and collision crashworthiness of ASME RT-1 or equivalent.

3.18 Coupler and Draft Gear

(a) General

(i) The couplers shall be fully optimized for the Vehicle Design, for both initial and future operation. Full Train consists shall be fully functional, including capability to pull or push another full Train consist.

(ii) The coupler shall be equipped with an energy absorption device and a shear off device that contains the coupler while allowing front end deformation under crash conditions.

(b) The coupler shall:

(i) Be foldable or retractable to allow concealment by front bumper/coupler cover;

(ii) The coupler cover shall be easily removable for cars that are configured to operate as a pair. The cover may be omitted from the design and a standard non-foldable coupler may be utilized for Vehicles that be permanently coupled (a married pair) during Revenue Service, as long as exposed ends of the consist are fitted with a folded coupler and coupler cover;

(iii) Lock in the folded and unfolded position. Easily accessible handles shall lock/unlock the coupler;

(iv) Be a service proven Design;

(v) Use an automatic centering device that is negatable for coupling on curve;

(vi) Contain (10%) spare pins on electrical heads;

(vii) Be able to transmit VMS data signals and communications network signals across the coupled interface;

(viii) Be equipped with a weather protective device to protect couplers from rain, ice and snow;

(ix) Include manual coupling/uncoupling lever(s);

(x) Be equipped with heaters for coupler faces. Additional heaters shall be provided if they are required to ensure reliable operation in Ottawa climatic conditions; and

(xi) The Vehicle shall be provided with redundant LVPS units or coupler pins for B+ and B- suitable for providing low voltage power to all low voltage loads of the adjacent Vehicle (not including battery charging).

(c) Safety

(i) Coupler control shall be interlocked with the no motion relay.

(ii) Couplers shall be provided with shear bolts or equivalent to allow anti-climbers to engage in the event of an accident.

(iii) Couplers shall be capable of retreating rearward in a crash to allow complete collapse of all 3 crash energy management zones, as required in ASME RT-1-2009 or equivalent.

(d) Coupler Type Tests

(i) The first coupler shall be evaluated or certified to meet the requirements of operation within the OLRT System. Manual force requirements shall not exceed the limits for 5th percentile females as detailed in MIL-STD-1472, latest edition:

A. Static design load test (a maximum length consist pushing or towing an equal length consist);

B. Shear pin/crushable Element test (shall not deform under test A or during compression tests);

C. Gathering range test (shall be sufficient to couple under all possible scenarios foreseeable in revenue or non revenue service on the mainline or in the MSF);

D. Lateral force test;

E. Manual lever force test;

F. Maximum coupler Swing (shall be sufficient to negotiate all mainline and yard track);

G. Centering device test;

H. Electric coupler Water test (car wash); and

I. Electric coupler ice and snow test (exposed in snow or ice storm).

(e) Coupler Routine Tests

(i) Each unit shall pass a routine test before shipment from the supplier factory.

3.19 Cab Equipment and Controls

(a) The cab shall be a spacious, ergonomic, Driver friendly environment. It shall be full width, separated from the Passenger area by a full partition and a lockable cab door. The cab shall provide the Vehicle with an aesthetically pleasing, modern look. Large windows on all four sides of the cab shall not only add to the style but shall also provide excellent visibility to the Driver, which shall contribute to the Safety of the System.

(b) All controls necessary to operate the Vehicle, including circuit breakers, cut-out and bypass switches, shall be located in the cab. The arrangement and location of the controls and seat, visibility and overall comfort provided to the Driver shall be reviewed and approved during the mock up review.

(c) Cab shall be as follows:

(i) A full width contoured front windshield;

A. Designed to minimize glare and interior reflection.

B. Laminated Safety glass, FRA Type 1, clear.

C. Electrically heated.

(ii) Cab side windows;

A. Horizontal sliding panel on both sides of cab.

B. Latch easily operated by Driver.

C. Glazing to be laminated Safety glass.

(iii) Side windows; and

A. Fixed horizontal panels on both sides.

B. Maximized in size to contribute to the modern feel of the vehicle.

C. Glazing to be laminated Safety glass.

(iv) Partition Wall Windows.

A. Large windows on door and both sides of partition, if practical.

B. Glazing to be laminated Safety glass.

(d) Driver's Console

(i) A full width, modern, wrap-around style console shall be located at the center line of the Vehicle. The console shall be sealed to IP55 or NEMA equivalent. The console shall include the following:

A. All device controls, switches and pushbuttons;

i. Controls shall be labelled with recessed, durable, contrasting coloured pictograms to avoid cluttering the appearance of the console.

B. Warning and status indicators (LED);

C. All speakers, buzzers or other audible warning devices;

D. Coupler controls;

E. Sanding pushbutton;

F. Silent alarm pushbutton;

G. A Master Controller, including:

i. A transfer switch which uses a dedicated cab control key;

ii. A spring loaded handle to activate the dead man circuit or alternative alertness system that reduces ergonomic impact on the driver; and

iii. A direction switch;

H. Alternative approaches to the Master Controller arrangement may be considered during the cab mock-up presentation.

I. A VMU and a VMU display screen;

J. A CBTC panel;

K. Central dimming control knob for all displays and LED indicators;

L. A Communication Control Panel which shall include interfaces to:

i. PEI;

ii. Crew Intercom (cab to cab);

iii. PA (separate interior/exterior);

iv. Train voice radio (Public Safety Service Radio) as provided by others; and

v. PIDS;

M. A center forward facing camera with a clear view of the Tracks;

N. Passenger door controls, which shall:

i. Be a momentary recessed push buttons that preclude accidental activation. (collar type pushbutton); and

ii. Illuminated when activated (Color coded as follows: open = green, close = red, enable = yellow);

O. Irretrievable Emergency brake switch;

P. A low voltage voltmeter with a range as applicable for battery voltage; and

Q. An odometer.

(e) Other Cab Controls

(i) Separate circuit breaker panels for each voltage.

(ii) A bypass / cutout switch panel.

(iii) A PTU interface panel for access to the Communications System and its attached systems.

(iv) Ventilation, cooling, and heating controls.

(v) Platform camera monitor display screen(s).

(f) Cab Interior Appointments

(i) Hinged cab door, arranged to allow quick emergency egress into the passenger compartment (panic bar).

(ii) Cab flooring, wall lining and ceiling consistent with passenger area.

(iii) A lockable storage cab cabinet or box to store personal items. Volume shall be no less than 7,000cc.

(iv) A fully adjustable, heated cab seat.

(v) Independent cab heater with manual controls.

(vi) Side window defrost (may be combined with cab heater).

(vii) An adjustable footrest.

(viii) Armrest(s).

(ix) A fully adjustable visor for side and forward usage.

(x) A recessed folding coat hook.

(xi) A lockable convenience outlet.

(xii) Two Fire extinguishers (10lb and 20lb, ABC).

(xiii) Flashlight.

(xiv) Flip down cab seat or alternative arrangement for training purposes.

(xv) Lighting fixtures including:

A. Directionally adjustable and dimmable overhead lights on both sides of cab which shall be tied to the emergency lighting circuit; and

B. Auxiliary lights for breaker and cutout switch panels.

(g) Cab Exterior Appointments

(i) Windshield wipers:

A. Electrically operated (operable in the Lead cab only);

B. Speed control which includes Off, Low, High and adjustable Intermittent; and

C. Blade shall park out of view and not be fouled by ice build-up.

(ii) Windshield washers with no less than 15 litres of washer fluid capacity.

(iii) 100dBA Horn with deflecting cone.

(iv) 85dBA Bell.

(v) Three headlights, marker lights, turn signals.

(h) Cab Mock up

(i) Project Co shall build a mock-up of the cab, including cab console, Driver ergonomics, seating, window locations, cab wall and all cab amenities shall be reviewed with the City. Project Co shall implement any agreed ergonomic or functionality changes into the vehicle cab design.

(i) Hostler Panel

(i) A hostler panel, if applicable, shall be provided to allow the Vehicle to be operated from the non-cab end of the LRV. The size and location of the hostler panel shall ensure that safe operation of the Vehicle can be performed while, at the same time, providing passenger seating/standee space to maximize Vehicle capacity.

3.20 Passenger Doors and Controls

(a) The passenger side door system shall be designed to afford minimum dwell time and shall be suitable for operations in the City of Ottawa environment in peak or non-peak times.

(b) The door system shall be the bi-parting sliding plug type using high reliability overhead electric operators. Doors shall be arranged to ensure that the Platform may not be fouled under any circumstances.

(c) Door Operator Design Features

(i) A single door operator shall control each pair of doors and ensure that the panels open and close simultaneously. The operator shall be a service proven Design with a history of reliability without the need for maintenance and adjustment. The door mechanism shall be suitable for operation in cold temperatures and snow and ice storms.

(ii) The door operator shall be a simple, safe Design employing interlocking relay logic to prevent unintended operation. The door operator shall be interlocked with the no-motion relay.

(iii) Door panels shall be closed and locked out of service with a mechanical lock which is independent from the motor and mechanically prevents panel movement. The lock shall cut out door motion, provide a close and locked indication to the door summary loop and energize a door out of service sign. Door operators shall operate from the low voltage battery power circuit.

(iv) Door control operation, should provide the ability to adjust open and close time intervals using the maintenance PTU.

(v) The door closing force shall not exceed the limits specified in APTA SS-M-18-10 or equivalent specification. Pressure sensitive obstruction detection or motor current monitoring shall automatically open the doors when an obstruction is encountered. The obstruction detection system shall stop the affected panel from closing when an obstruction is detected, fully reopen and recycle.

(d) Door Panel Design Features

(i) The door panels shall be designed to blend seamlessly with the Vehicle exterior. Panel Design shall meet the following requirements:

A. Be fitted with laminated Safety glass windows. Window to be aligned with passenger side windows and tinted to match; and

B. Be provided with interior and exterior passenger pushbuttons in compliance with AODA and ADA to allow individual door control when enabled.

(e) Door Controls

(i) Doors shall be operable via pushbuttons in the cab, trainline signals or local door open pushbuttons, depending on the mode set up within the consist.

(ii) A Door Enable feature shall release door control and illuminate a "Door Open" LED pushbutton at each active door, in the interior and exterior of the Vehicle allowing passengers to open individual doors by pressing the "Door Open" button. A pictogram shall indicate the function of the pushbutton switch. Pushbuttons out of service will not display energized LEDs.

(iii) Door open indicators shall audibly and visually indicate door open status.

(iv) Crew switches shall have the capability to cycle the doors. Interior and exterior crew switches shall be installed on each side of the car adjacent to the doors nearest each end of the car.

(v) The door shall have a control system that permits fault monitoring and recording and shall be networked with the VMU over the Train Control System (see Section 3.31 of this Article for VMU details).

(vi) The door control system shall comply with the fault plan requirements of Section 3.31 of this Article.

(f) Safety

(i) Door control on each car shall be interlocked with the no motion detection system on that car.

(ii) Door operator Design shall include a Safety device to ensure doors recycle after contact with a 19mm round object or 9.5mm thick by 75mm wide object.

(iii) Doors closed and locked status shall be interlocked with propulsion.

(iv) All doors shall have a mechanical emergency release mechanism inside and outside the Vehicle.

(v) Door operators shall have a cut-out that locks the door and completes the door closed summary loop.

(vi) Door system shall have an audio and visual warning while open and during closing. Provision for the ability to flash marker lights and brake lights shall flash whenever doors are open.

(vii) Vehicle evacuation through a vehicle on its side shall be conceptually demonstrated.

(g) Side Door System Type Testing

(i) Door Operator Type Test

A. The door system shall be proven to be reliable in service.

(ii) Door Panel Strength Tests

A. One of the first door panels shall be tested to ensure its strength is sufficient to withstand a load of 90kg applied over a $20cm^2$ area. The maximum deflection of the panel shall be no more than 10mm, without permanent deflection.

(iii) Side Door System Routine Testing

A. Each door operator shall pass a routine test before shipment from the supplier factory. All functions shall be verified to operate correctly, including passenger request pushbuttons.

3.21 Heating, Ventilation and Air Conditioning

(a) The HVAC Equipment shall provide safe, reliable climate control in accordance with the climatic and environmental conditions outlined in this Article. The system shall utilize microprocessor controls to automatically control interior temperatures (both in the cab and passenger area) and prevent snow or ice or water from accumulating on the Vehicle floor or at thresholds. The system shall incorporate a layover mode to maintain moderate interior temperatures when Vehicles are not in revenue service.

(b) System Description

(i) The system shall be roof-mounted, fully unitized packages (no less than 2) with a height that meets the roof Equipment height limits detailed in this Article.

(ii) Watertight and leak-proof seals shall be provided between carbody and HVAC unit return and supply air interfaces.

(iii) The refrigerant circuit shall be hermetically sealed system charged with non-ozone depleting refrigerant. Refrigerant shall comply with all applicable Canadian standards and laws.

(iv) Eight (8) m3/hr fresh air per passenger shall be provided (all seats occupied and 4 standees/square meter) to ensure compartment air quality. Fresh air dampers, or equivalent, shall allow a quicker warm-up or cool down during initial start-up by limiting fresh air.

(v) The HVAC heating system shall be arranged to operate in stages. The system shall use duct sensors to keep supply air within 8°C of return air temperature.

(vi) Over-temperature Safety protection shall be:

A. Self re-settable thermostats that disable control voltage to the heater contactors; and

B. Fusible link(s), or equivalent, to protect the system in the event of a failure of the over-temperature thermostat.

(c) System Capacity

(i) The system shall be designed to maintain interior conditions between 19°C and 22°C with 1% Design conditions for cooling and 99% Design conditions for heating as defined in ASHRAE fundamentals handbook. Load calculations shall be submitted as part of the Works Submittals according to Schedule 10 – Review Procedure.

A. Setpoints shall be easily adjustable. Project Co shall adjust the setpoint as directed by the City.

(ii) The relative humidity in the interior of the car shall be maintained between 30-60% during all operating conditions requiring cooling.

(iii) A positive interior pressure shall be maintained at all times and at all Vehicle speeds.

(iv) Vehicle interior temperature shall be within 1.5°C of setpoint, 2 minutes after a 30 second door opening cycle in worst case Design conditions.

(v) Temperature stratification shall be limited to 2°C within any vertical or horizontal plane.

(d) HVAC Controls

(i) The HVAC controller shall allow software adjustments and modification to settings, including a ±2°C setpoint adjustment for all switching points. Setpoint accuracy shall be ±0.2°C.

(ii) The HVAC controllers shall have fault monitoring and recording and shall be networked with the VMU over the Train Control System described in Section 3.31 of this Article. The HVAC system shall comply with the fault plan requirements of Section 3.31 of this Article.

(e) Additional HVAC Features

(i) Emergency shutdown switch for HVAC system (per car and consist control) shall be located in the cab.

(ii) Emergency fresh air damper close switch (per car and consist control) shall be located in the cab.

(iii) Smoke detectors shall be located in all fresh air intake ducts. Upon activation, the detector shall energize a signal that shall indicate a smoke alarm, including Vehicle number and location of alarm within the consist. Activation of either the damper closed or HVAC shutdown will silence the smoke alarm signal.

(iv) A layover thermostat to maintain interior temperatures between 4°C and 8°C. (Dampers shall be closed and windshield heaters de-energized during layover).

(f) Floor Heat

(i) The grilles/heater guards shall be designed to prevent passenger exposure to unsafe surface temperatures and electrical connections.

(ii) Threshold heaters shall also be provided as part of the floor heat system. These heaters shall be sized to keep snow or ice from accumulating at the doorway or affecting the operation of the door system. Thresholds shall be arranged to allow drainage of melted snow and ice.

(g) Cab

(i) The HVAC Equipment within the Driver's cab shall consist of:

A. An electrically heated windshield;

B. Overhead air diffusers with volume and directional adjustability; and

C. Thermostatically controlled cab heater(s) with the following features:

i. Infinitely adjustable temperature control;

ii. OFF-LOW-HIGH rotary switch for air speed/volume control of both cab heaters;

iii. Heater noise level in HIGH speed not to exceed 72dBA;

iv. Heater coil and blower powered by AC circuits;

v. Manual adjustment to direct airflow to floor, cab side windows, or both;

vi. Cab heater surface temperatures shall not exceed 52°C; and

vii. Over-temperature protection shall include:

1 An over-temperature thermostat which shall automatically cycle the heater contactors upon excessive temperatures; and

2 Failure of the over-temp thermostat shall cause a manually resettable shunt trip breaker to open power to the heaters. Manual reset switch shall be easily accessible to the Driver.

(h) HVAC Type Tests

(i) The first HVAC unit shall be evaluated or certified to comply with these test requirements outlined below before production Equipment manufacturing is commenced. Testing shall at a minimum include the following:

A. Cooling and heating capacity tests;

B. Condensate carry-over test;

C. Heater safety tests; and

D. Smoke detector test.

(i) Cab Heater Type Tests

(i) Cab heater safety tests

(ii) Windshield defrosting tests

(j) HVAC Routine Tests

(i) Each unit shall pass a routine test.

(k) HVAC Climate Room Test

(i) Unless already certified in environmental conditions similar to Ottawa, a vehicle shall be completely instrumented and fully tested in a climate chamber to ensure the requirements of the RFP are met or exceeded.

3.22 Lighting

(a) The lighting system consists of all interior lighting, exterior lighting, and indicators. The Design shall provide lighting with a minimal degradation of color or luminosity over time. Safe levels of lighting shall be provided in the event of emergency conditions.

(b) The Lighting system shall:

(i) Be primarily LED based, operating entirely from the Vehicle low voltage system;

(ii) Have two luminosity levels for the main interior lighting: normal and emergency;

(iii) Be configured so that lighting in a multicar Train can be controlled from the lead car;

(iv) Provide lighting levels in passenger compartments and at doors compatible with AODA/ADA requirements;

(v) Have headlights, tail lights, marker lights, and stoplights consistent with the requirements of Canadian laws and regulations;

(vi) Provide indications to passengers and crews of failed doors and doors out of service.

(c) Interior Lighting

(i) The main lighting fixtures shall use LED cluster modules operating from the low voltage distribution network.

(ii) The interior emergency lighting shall use LED modules operating from the Vehicle battery.

(iii) LLEPM shall be provided along the aisle and vestibules leading to the doorways, utilizing a HPPL material strip embedded into the floor.

(iv) An interior LED indicator light shall be provided over each door to indicate that the door is not closed and locked.

(v) A small LED backlit sign shall be provided over each side door to indicate when the door is locked out of service.

(d) Cab area:

(i) LED indicator and instrument lighting shall be provided.

(ii) Overhead lighting shall be provided using two dimmable and directionally adjustable lights.

(iii) LED cab Equipment compartment lighting shall be provided.

(iv) Overhead and Equipment compartment lighting shall be included in the emergency lighting system.

(e) Exterior Lighting

(i) The following exterior lighting shall be LED type, visible in all natural and artificial lighting conditions:

A. Dual color marker lights;

B. Provision for turn signals (for mixed traffic operation), tail lights;

C. Brake lights;

D. Propulsion fault light;

E. Door open LED indicator light at each door;

F. LED backlit sign over each door to indicate when the door is locked out of service;

G. ATP bypass light; and

H. Vehicle door summary status light, viewable from transverse and longitudinal directions.

(ii) Headlights shall be provided on each cab end.

(iii) A third, forward facing headlight shall be provided at the center line of the Vehicle, above the cab to distinguish the LRV from other types of vehicles

(iv) Headlights shall have high and low beam functionality.

(f) Lighting Controls

(i) All lighting controls switches and circuit breakers shall be located in the cab area.

(ii) Passenger compartment lighting control shall be a trainline control function from the control panel on the lead car.

(iii) Cab lighting shall be controlled through a switch with dimmer control.

(iv) Equipment locker lighting shall be controlled by a switch on the control panel and a limit switch actuated by the locker door.

(v) A dimmer switch shall be provided to control the intensity of indicator panel back lighting.

(vi) Control of headlights, tail lights, stop lights, and marker lights shall be interlocked with the direction Train lines and coupler loop switches so that head lights, tail lights, stop lights and marker lights shall only be active at ends of the Train in accordance with Train direction.

(g) Performance

(i) The cab and passenger area lighting intensity shall meet as a minimum, the requirements of EN 13272 or equivalent.

(ii) Emergency lighting shall be available for 90 minutes after loss of the low voltage power supply and shall meet or exceed the minimum illumination requirements of APTA SS-E-013-99, Rev. 1.

(iii) LLEPM shall meet APTA standard SS-PS-004-99 Rev. 2.

(iv) Headlights shall meet all requirements of Canadian Motor Vehicle Safety Regulations, Technical Standard 108.

(v) Amber marker lights shall be activated on the front of the lead car when the master controller is in the forward position.

(vi) Marker Lights, tail lights and brake lights shall operate as follows:

A. Red marker lights and tail lights shall be activated on the last car at all times;

B. Brake lights shall be active on the last car when the Train brakes are applied;

C. Red marker lights and red tail lights shall be active on the front of the Train when no direction is selected;

D. Tail light and stop light intensity shall meet the requirements all requirements of Canadian Motor Vehicle Safety Requirements, Technical Standard 108;

E. Marker lights and brake lights shall flash when the Train is stopped and the doors are open. Marker and brake lights shall also flash when the Master Controller is in the reverse position; and

F. Turn signals operated from the console shall be provided and shall operate in accordance with Canadian highway regulations.

(vii) Interior passenger and cab lighting shall time out in 20 minutes after the Vehicle is turned off.

(viii) Exterior Vehicle door summary status lights shall be visible from both the longitudinal and transverse directions.

(h) Type Testing

(i) Verification of Design luminosity.

3.23 High Voltage Distribution and Auxiliary Electrical Equipment

(a) High voltage power shall be collected from the pantograph, which shall:

(i) Be capable of operation in both directions;

(ii) Have tension characteristics compatible with overhead contact system Design;

(iii) Be provided with a lightning arrestor rated for outdoor operation;

(iv) Be equipped with an electrically controlled system for raising and lowering; and

(v) Be equipped with a means of raising and lowering manually from inside the vehicle.

(b) The high voltage power distribution network shall be protected by a HSCB.

(c) The HSCB shall:

(i) Be rated in excess of the worst case interrupt current and line voltage;

(ii) Have trip settings coordinated with the Traction Power system Design to prevent nuisance tripping of Traction Power breakers; and

(iii) Provide a remote trip and reset function to be controlled by the propulsion system and auxiliary power.

(d) Output from the HSCB shall be split into three separately protected main circuits: Traction Power A, Traction Power B and Auxiliary Power.

(i) Fuses for Auxiliary Power systems shall be roof mounted in a protective enclosure.

(ii) Circuitry shall allow the Auxiliary Power system, and only the Auxiliary Power system, to connect to a Shop Power Feed. When the shop power feed is connected, the pantograph feed shall be disconnected through an electrical and mechanical interlocking system.

(e) Return Currents and Safety Grounding

(i) The high voltage return circuit Design shall return power safely to the rails in a manner that protects bearings, prevents return currents from interfering with trainline circuits and minimizes harmonic interference with the wayside systems.

(ii) The grounding of the car body sections, trucks and Equipment shall be designed in a manner that provides maximally redundant paths to the return rail and that complies with the EMC management plan described in Part 4 Article 9 – EMI/EMC.

(iii) The voltage rise between rail and car body shall not exceed 50mv with the loss of a single ground brush.

(iv) Resilient wheels shall be provided with 2 or more shunt straps between the wheel hub and rim.

(f) Auxiliary Power

(i) Auxiliary power converters shall include:

A. 3 phase 60Hz AC power inverters to supply power for HVAC, blower motors, compressors, fans, etc.; and

B. LVPS to provide low voltage DC power for control systems, and battery charging, lighting, etc.

(ii) Redundant inverters and LVPS shall be provided with independent controls and control power supplies to provide maximum availability.

A. In the case of failure of one inverter all essential Vehicle loads and 50% of HVAC loads shall be maintained by the remaining unit.

B. In the case of failure of one LVPS all loads and limited battery charging shall be maintained.

i. If vehicles are provided as married pairs, LVPS redundancy may be achieved with a single LVPS on each car if all low voltage loads and limited battery charging can be provided from the single LVPS.

(iii) Line filters shall be provided to protect the LVPS and auxiliary inverters and to minimize conducted emissions back into the OCS.

A. Line filters shall protect against all positive and negative OCS transients in accordance with IEC 60850.

B. If inverters and LVPS on each end of the Vehicle are located in a common enclosure with a common line filter, circuit breakers or contactors shall be provided to isolate shorted or failed units from the line filter.

C. LVPS and auxiliary power inverters shall comply and the line filters shall comply with the EMC management plan described in Part 4 Article 9 – EMI/EMC.

(iv) Power IGBTs used for inverters and LVPS shall not be exposed to any circulating air, filtered or not. Cooling of IGBTs shall be through external heat sinks or sealed heat transfer tubes only.

(v) Auxiliary Inverter output waveform and the Design of the attached motors shall be coordinated to prevent motor insulation and motor bearing damage.

(vi) The LVPS output shall meet the power quality requirements of EN 50155 and the ripple requirements of IEC 60077-1.

(vii) The LVPS shall have an automatic dead battery start feature.

(viii) Monitoring and Diagnostics

A. The LVPS units and the auxiliary power inverters shall be provided with diagnostic and fault recording capability and shall report all faults to a VMU.

(g) Battery

(i) A battery charged by the LVPS units shall be provided on each Vehicle.

(ii) The battery shall be protected by a fuse and a positive and negative side disconnect switch and over voltage protection.

(iii) The battery compartment shall be ventilated sufficiently to prevent build-up of explosive levels of hydrogen gas.

(iv) The battery shall not be lead acid.

(v) The battery shall be sized to meet the following loads:

A. In case of LVPS failure, 50% of lighting and all loads necessary for operation of the Train,; and

B. In case of loss of primary power, emergency lighting and communications functions and door operators (a minimum of 12 door opening cycles) shall be maintained for 90 minutes while other functions shall be progressively shed.

(h) AC and Low Voltage Distribution

(i) All AC and low voltage DC circuits shall be circuit breaker protected.

(ii) Low Voltage DC and AC Circuit breakers shall be located in locked enclosures in the cab.

(iii) All AC and DC circuit breakers shall meet the requirements of IEEE Std C37-13 and IEEE Std C37-14 respectively.

(iv) The low voltage DC system shall be grounded in a manner which prevents differences in potential between cars caused by traction return currents from interfering with trainline signals.

(v) Galvanically isolated, ground fault protected single phase 120VAC 60Hz power shall be provided to cab and passenger compartment outlets as needed for cleaning and for Vehicle maintenance.

(i) Qualification Testing

(i) Auxiliary Inverter and LVPS components shall be type tested in accordance with the standards outlined.

(ii) Auxiliary Inverter and LVPS shall be tested in accordance with IEC 61287.

(iii) The converters shall be noise tested in accordance with IEC 61133.

(iv) The battery shall be capacity tested at the point of manufacture in accordance with APTA RP-E-007-98-1999 and to demonstrate that it meets the capacity and emergency lighting requirements of this Article. The Battery cells shall be tested in accordance with IEC 60623.

(v) The HSCB shall be tested to prove compliance with the requirements of this section and IEC 60077-3:2001.

3.24 Propulsion and Dynamic Braking

(a) General

(i) Propulsion shall be microprocessor controlled IGBT inverter drives with two AC motors for each motored truck.

(ii) The propulsion system and its components shall meet the performance and duty cycle requirements of this Article.

(iii) At least one inverter shall be provided for each power truck.

(b) Propulsion Control shall:

(i) Be based upon networked and trainlined tractive effort and braking effort commands with load weigh compensation to provide consistent acceleration and braking rates regardless of passenger loading;

(ii) Detect and correct spins and slides in coordination with the friction brake and traction control system;

(iii) Request sanding control to apply sand in front of both wheels of the leading axle when wheel spin or slide exceeds a preset level;

(iv) Monitor direction, propulsion and braking control and friction brake status trainlines and inhibit or shutdown propulsion in case of conflicts;

(v) Protect the inverter semiconductors by tripping the HSCB and or dropping the line contactor in event of a critical fault or out of tolerance voltage surge;

(vi) Provide fault protection from events that may result in motor, wiring, or inverter or line filter damage or cause violations of electromagnetic emissions limits;

(vii) Coordinate with the friction brake system to prevent roll back during start-up on the maximum grade;

(viii) Coordinate with the friction brake the blending of brakes to ensure smooth transitions from dynamic to friction braking;

(ix) Provide fault recording and diagnostics for system troubleshooting and report faults to the Vehicle monitoring unit described in of this Article;

(x) Report all faults to the VMU described in this Article; and

(xi) Meet all requirements for monitoring and diagnostic systems outlined in that section.

(c) Line Filter

(i) Each traction inverter shall be protected by a line filter which shall protect it against any surges or spikes that may occur on the Traction Power system. Line filter shall comply with IEC 60850.

(ii) The line filter and the inverter control Design shall meet the requirements of the EMC management plan of Part 4 Article 9 – EMI/EMC.

(iii) Line filter and inverter isolation shall be provided in case of an out of tolerance line voltage, an emergency brake request or a critical inverter, line filter or motor fault.

(iv) Protection against energizing a dead section of the OCS with the line filter or regenerative braking energy shall be provided.

(v) Filter capacitors shall be rated for 15 year life in the Design operating environment and selected in accordance with IEC 61071.

(d) Traction Inverters

(i) Traction inverter units shall be microprocessor controlled with modular keyed IGBT semiconductor switches rated for the application voltage and all transients.

(ii) Unless 4 quadrant Traction Power Supplies or a Traction Power energy storage system is provided, a brake chopper and resistors shall be provided to control DC link voltage and dissipate braking energy.

(iii) The inverter container IGBTs, capacitors and control electronics shall be sealed from outside air. Cooling shall be through external heat sinks or sealed gas filled heat tubes only. The convection or forced cooling of the external heat sinks or heat tubes and the line inductor shall be provided.

A. If forced cooling is utilized, diversification of blower motors shall be provided and the Design of intake screens shall permit easy removal and cleaning.

(e) Traction Motors and Gear Units

(i) Traction motors shall be of a self-ventilated or totally enclosed Design. If motors are self-ventilated, air intakes shall be designed to preclude the ingestion of airborne material.

(ii) Traction motor insulation shall be rated class H or better and be designed for the inverter output voltage and waveforms.

(iii) Motor bearings shall be protected from high frequency IGBT switching harmonics capacitively coupled to the rotor.

(iv) Traction motors shall tolerate a minimum of 6mm difference in wheel diameters for the axles on a truck without overheating or causing a reduction in system performance or life.

(v) Gears shall be rated for bi-directional service in accordance with the duty cycle requirements.

(vi) Motor and gear unit bearings shall have an ANSI/AFBMA L10 rating or approved equivalent standard.

(f) Efficiency

(i) The propulsion system shall provide an energy system of greater than or equal to 80% efficiency from the OCS to the wheel.

(ii) Regenerative braking into a receptive line shall return 80% of the mechanical energy to the OCS when braking from 70km/hr to 8km/hr.

(g) Propulsion and Dynamic Braking system Qualification Tests

(i) Project Co shall perform qualification tests of the first two traction motors in accordance with IEC Std 60349-2 and IEEE Std 11.

(ii) Brake resistors shall be qualification tested in accordance with IEC 60077, 60322 and IEEE Std 16-2004

(iii) Inverter and line filter components shall be type tested in accordance with the tests listed IEC 61287-1 Section 4.5.2.1 Test of converter components and subassemblies.

(iv) A combined systems laboratory test shall be conducted on one complete set of propulsion Equipment, including the motors, brake resistor(s), power conditioning Equipment, inverters, protection devices, logic and controls, etc. A dynamometer shall be used for this test which simulates Vehicle inertia by various methods. The dynamometer test shall simulate the OLRT route profile to prove compliance with the normal, degraded mode, and towing mode requirements. Motor and inverter and IGBT temperatures shall be recorded to prove compliance with the thermal performance requirements. Worst case environmental conditions and wheel diameter variation shall be simulated.

3.25 Trucks

(a) Each LRV shall be supported by 4 wheeled trucks.

(b) The leading and trailing trucks shall have freedom of rotation about a center pin.

(c) All axles shall be fitted with hydraulic brake systems. Track brakes shall be fitted on all trucks.

(d) Truck Components

(i) Shall be either cast steel or fabricated/welded steel construction.

(ii) The secondary suspension shall be controlled by a levelling valve to fulfill AODA/ADA level boarding requirements.

(iii) Secondary lateral and vertical dampers shall be used.

(iv) Wheels shall be of resilient type and the wheel profile shall be selected by the car builder in concert with the Track Designer to ensure that a compatible wheel/rail interface is selected. The wheel/rail interface and truck Design shall be subject to a dynamic analysis, including wheel unloading, Vehicle overturning and truck hunting as described in APTA RP-M-009-98.

(v) Axles shall be solid and designed in accordance with AAR M-101 and APTA RP-M-001-98, or equivalent.

(vi) Journal bearings shall be tapered roller or spherical, designed with an L-10 life rating of 1,600,000km.

(vii) Heated sand tubes and scatter units shall be provided to prevent clogging by snow, ice or wet sand.

(viii) Stone guards and splash guards shall be provided.

(ix) Hinged or easily removable skirts that blend with the exterior visual aesthetics of the Vehicle shall be provided.

(x) Shock and vibration environment criteria for axle mounted components shall be:

A. 10g vibration levels up to 100 Hz;

B. 80g shock loads laterally and vertically; and

C. 50g longitudinal shock loads.

(xi) Shock and vibration environment criteria for truck mounted components shall be:

A. 6g vibration levels up to 100Hz; and

B. 20g shock loads – all directions.

(e) Truck Motion Control

(i) The trucks shall control Vehicle motions such that the dynamic envelope defined in Section 3.36 of this Article is not violated.

(ii) Primary suspension strokes shall never be exhausted under any condition of dynamic operation, Vehicle weight, weight variation and suspension creep.

(iii) Primary and secondary vertical and lateral stops shall not be contacted under normal operating conditions. Stops shall be fabricated from replaceable elastomeric bumpers.

(iv) A means for Vehicle height adjustment shall be provided to account for wheel wear and/or rail wear.

(v) Equalization shall be such that with the car on level Track under an AW0 load, lifting or dropping any wheel up to 38mm shall not change the load on any other wheel of the car by more than 60%.

(vi) Raising or lowering any wheel up to 50mm shall not result in loss of contact between any of the other wheels on the car and the rail.

(f) Vehicle Modeling

(i) Vehicle modeling, including collision analysis, shall include the requirements of ASME RT-1 or equivalent.

(ii) The analysis shall consider the limits of environmental conditions, Track deterioration, suspension wear, Vehicle weight and speed variations.

(iii) Modeling of Vehicle performance shall be by NUCARS, Vampire or equivalent.

(g) Stress Analysis

(i) For a service proven Vehicle, stress analysis and FEA results from a previous contract shall be submitted as part of the Works Submittals according to Schedule 10 – Review Procedure.

(ii) For a new or modified Vehicle a complete stress analysis shall be submitted as part of the Works Submittals according to Schedule 10 – Review Procedure.

(h) Design Ride Quality

(i) The methodology used to evaluate ride quality shall be ISO 2631 (latest edition), in the frequency range of 0.5 to 80Hz. Limits are valid for 3 axes.

A. Passenger RMS acceleration values shall not exceed $0.32 m/s^2$.

B. The vibration total value (root sum of squares summation) for each measurement point shall not exceed $0.50 m/s^2$.

(i) Resonant Frequency

(i) To ensure Bridge/truck/Vehicle resonant frequency compatibility, Project Co shall determine truck primary suspension frequency that ensures dynamic stability under all conditions, with appropriate safety margins.

(j) Truck Qualification Testing

(i) The first truck unit shall be type tested before production Equipment is commenced. Testing shall include the following, at a minimum:

A. Project Co shall perform a fatigue and static load test to verify that the maximum allowable stresses are not exceeded when the truck is subjected to the static loads;

B. After completion of the static tests outlined in A above, all critical welds of the tested truck frame shall be radiographically inspected; and

C. Project Co shall perform a wheel load equalization test to verify that the maximum allowable unloading is not exceeded.

(k) Routine Testing

(i) QC inspection of all components shall be performed and included with the shipping documentation.

(ii) 100 % of the truck frames shall be tested via MPI.

3.26 Friction Brakes, Track Brakes

(a) General

(i) A disc brake friction brake system shall be provided for all trucks.

(ii) Friction brakes shall be of an electro-hydraulic, microprocessor controlled Design with a spring applied/hydraulic release parking brake and shall coordinate with propulsion control to provide blended braking, slide control and roll back prevention.

(iii) A Track brake system shall be supplied to provide the required emergency brake rate. A sanding system shall be provided to apply sand to the rails in front of the lead axles.

(iv) The friction disk brake and the Track brake system shall meet all requirements of this Article.

(b) Disc Brakes and Calipers

(i) Hydraulic actuated disc brakes shall be provided on all axles of all trucks.

(ii) The friction surfaces of the disc rotors shall be replaceable without removing wheels or any truck parts other than brake calipers.

(iii) Disc rotors shall have a wear limit indicator.

(iv) Disc brake calipers shall:

A. Have a spring apply/hydraulic release parking brake;

B. Be provided with a pump release from inside the car for towing purposes;

C. Have a manual release for the calipers in case of hydraulic failure. The release shall be either mechanical or from a hydraulic circuit separate from the service hydraulic line. Access to the release shall be available either from the side of the Vehicle or inside the car;

D. Reset manually released calipers to normal operation after a maximum of three service brake applications, once the brakes are cut back in;

E. Brake calipers shall include an automatic slack adjusting feature that functions during both service and parking brake operation; and

F. The slack adjuster shall compensate for brake pad wear and shall ensure drag free operation.

(c) Hydraulic Fluid

(i) The hydraulic fluid shall be fire-resistant and meet all requirements of the latest revision of MIL-H-83282.

(d) Electro Hydraulic Unit

(i) The friction brake actuators on each truck shall be powered by the electro hydraulic unit for that truck.

(ii) EHU shall be resiliently mounted above the secondary suspension and be capable of meeting the shock and vibration loads specified in this Article.

(iii) The EHU shall contain a hydraulic fluid reservoir, motor driven pump and all necessary control valves, pressure switches and pressure transducers.

(iv) External connections shall be made directly to the manifold plate using self-sealing, quick-connect couplers.

(v) The reservoir shall be provided with a drain plug, fluid level sight glass and a quick-connect coupler for filling.

(vi) The motor driven pump shall operate from the Vehicle low voltage power supply and shall function within specification over the range specified.

(vii) Designs in which the pump motor operates continuously (100% duty cycle) shall not be permitted.

(viii) The EHU shall report low fluid fault conditions through the Vehicle monitoring system.

(ix) Pressures in the brake cylinders shall be limited to 60% of the maximum system pressure.

(x) The EHU shall have sufficient hydraulic capacity to provide continuous normal service operation with friction brakes only.

(e) Accumulators

(i) Nitrogen charged accumulators shall be provided to store the hydraulic energy.

(ii) The pressure level shall be sufficient to meet the required response times for all operating conditions including emergency and system cut-out.

(iii) A manual cut-out valve shall be provided to hydraulically depressurize the accumulator for maintenance.

(iv) The accumulator shall be protected from corrosion.

(v) The accumulators shall be properly sized such that from EHU cut-in pressure, the accumulator has sufficient pressure to supply two AW3 full service and one AW3 emergency brake applications with 30 second applications and 2 minutes between applications.

(f) Friction Brake Control Unit

(i) The hydraulic disc brakes of each truck shall be controlled by a FBCU for that truck.

(ii) The FBCU shall be physically independent or integrated with propulsion logic provided that the level of Safety, reliability and availability is the same as with an independent unit.

(iii) The FBCU shall:

A. Read and interpret trainline requests and load weigh transducers;

B. Communicate over a direct link with the propulsion system for that truck;

C. Read the dynamic braking effort signal from the propulsion system and command the friction brakes to provide the difference between braking request and the braking effort supplied by propulsion;

D. Take over if the TCU cannot control a vehicle slide within a preset time;

E. Request the sanding system to apply sand during low adhesion;

F. Perform Safety self-checks of the brake system and default to a restrictive state in case of failure;

G. In coordination with the propulsion system, provide roll back protection when the Vehicle is starting from a dead stop;

i. The roll back prevention function of the FBCU shall be coordinated with propulsion to prevent any rollback greater than 10cm during start-up on the absolute maximum grade for the OLRT System (6%).

H. Provide fault recording and diagnostics for system troubleshooting;

I. Meet all the requirements for fault reporting, system integration and local access;

J. Provide a brake application and inhibit Train propulsion when any accumulator pressure falls below a level required to provide a friction only AW3 emergency brake stop;

K. Control braking to provide the total trainline braking request in case of failure of the propulsion system to provide electric braking or in case of communications failure with the propulsion system; and

L. Default to safe operating mode if a failure of the load weigh sensor occurs on the truck.

M. Distinguish between speed sensor failures and vehicle slides.

(g) Track Brakes

(i) Track brakes shall be provided on each truck.

(ii) Track brakes shall be powered from low voltage DC system and the car battery.

(iii) Track brakes shall be adjustable with hand tools to compensate for wheel and Track brake wear.

(iv) Brake shoe material shall be removable without removing the whole Track brake assembly.

(v) All Track brake magnetic coils shall be hermetically sealed and all electrical connections shall be waterproof to IP67 per IEC 60529 or NEMA equivalent.

(vi) Track brake electrical connections shall be of a waterproof quick disconnect type.

(h) Sanding System

(i) A sanding system shall be provided that shall deposit sand at the wheel rail interface of the lead axle of each Vehicle in the Train.

(ii) The air system powering the sander shall store sufficient compressed air that it is capable of 20 seconds of sand application without running the air compressor.

(iii) Sand boxes and nozzles shall be heated.

(iv) Sanders shall be activated during spinning or sliding events and continuously down to zero speed during any emergency brake application.

(v) A momentary switch shall be provided on the console to manually activate sanding.

(i) Qualification Testing

(i) The following minimum tests shall be performed:

A. Golden shoe force test of service brake and emergency brake application;

B. Golden shoe force test of parking brake application;

C. Emergency brake build up time;

D. Dynamometer test of brake pad wear rates;

E. Efficiency of the slide control system proven to be equal to or greater than 85% in braking over the entire speed range;

F. Dynamometer test for compliance with friction brake only operation performance requirements; and

G. Brake shoe and wheel noise test.

3.27 Communications and Passenger Information System

(a) Communications System Functional Requirements

(i) Provide synchronized audio and visual passenger information announcements and shall include, at a minimum destination, Station stops, time, emergency announcements.

(ii) Coordinate emergency announcements on the Vehicle with station announcements so that station and Vehicle announcements do not compete.

(iii) Provide a passenger emergency intercom system.

(iv) Provide reliable voice communications with the TSCC.

(v) Provide networked data communication with the wayside network in line with safety and security requirements and for downloading maintenance, data passenger count information and for updating passenger announcements.

(vi) Provide a CCTV video monitoring and recording system.

(vii) Provide a display that shall provide a view of all Train doors and any passenger compartments in which there is an Emergency.

(viii) Provide fault recording and diagnostics for system troubleshooting.

(ix) Include a silent alarm reporting function.

(b) Power Distribution and Supplies

(i) Each subsystem listed in this section shall be powered from the low voltage DC power system and shall have its own isolated power supply.

(ii) Communications and passenger information systems shall operate reliably from the low voltage DC power system within the ranges and power quality allowed by EN 50155.

(iii) Each communications subsystem shall be protected by a separate circuit breaker.

(c) System Requirements

(i) Train Voice Radio

A. The vehicle PA system shall provide, as required, power, analog and digital interfaces and connections to the radio system supplied by others. Project Co shall work with the Radio System Supplier to determine the type and functionality required.

B. Project Co shall work in partnership with the Radio System Supplier to ensure that the antenna and transceiver do not cause intermodulation or interference with the other OLRT radio systems and equipment. Operational compatibility testing shall be coordinated with the City and the Radio System Supplier and operation shall be demonstrated to the satisfaction of Industry Canada.

(ii) Hi-Speed Train-to-Wayside Data Radio

A. Project Co shall ensure that the high speed Train-to-Wayside data radio system is resilient and does not present a security risk to the OLRT Systems and Vehicles.

B. The high speed Train-to-Wayside data radio shall reliably support all required train wayside networked data communications loads required by Articles 3 and 6 of this Schedule 15-2 Part 4.

(iii) Public Address System

A. The PA system shall accept input from the Driver's cab microphone, patched through TSCC announcements, and the automatic announcement system.

i. TSCC and cab input shall take priority over automatic announcements.

B. Voice shall be transmitted digitally over the CTS.

C. The PA and speaker system shall meet the performance requirements of IEEE Std 1477-1998, for frequency response, ambient noise level adjustment range, speaker distribution and intelligibility.

D. The PA system shall automatically compensate for ambient noise up to a 95dBA without exceeding Station platform noise level limits.

E. The PA control shall emit an activation chime different from the door chime before any announcement.

F. The PA system shall have both internal and external speakers. External speakers will not be active unless selected.

G. Turning off or reducing external speaker volume at night at At Grade Stations shall be provided.

H. Automatic selection of the correct side for external speaker activation based on location of the Station Platform shall be provided.

I. The PA broadcasts shall be transmitted over the Train and Vehicle Communications Network as VoIP.

(iv) Cab to Cab and Passenger Emergency Intercoms

A. Voice shall be transmitted digitally over the Train communications network for all intercom systems.

B. PEI and cab-to-cab intercom systems shall have a session hold function with ability to transfer between PEI and cab-to-cab sessions.

C. Once activated, the PEI stations shall require no further intervention by the passenger to communicate with the Train. PEI stations shall meet ADA and AODA requirements.

D. Queuing of multiple PEI or cab-to-cab intercom calls shall be possible.

E. The PEI system shall permit a passenger speaking at a distance of 50cm from the PEI unit in a normal tone of voice with ambient noise levels up to 85dBA to be heard. Total harmonic distortion through the system from microphone to cab handset shall be less than 2%.

F. If passenger announcement displays in the vehicle are not visible from a seated wheelchair position during peak hour ridership, the PEI in the accessible areas shall include a localized message display panel that also provides PA and announcement information.

G. Activation of a PEI station shall be reported and identified on the Video display along with a video feeds from the car in which the PEI was activated. Video frame rate shall be increased to 30fps until cleared by security personnel.

H. The passenger emergency video feed shall only appear when the Train has stopped. The Driver shall not be able to select video feeds.

(v) Radio and Intercom Control Panel

A. The Communications System control panel radio handset shall by default connect to the Train voice radio.

B. LED pushbuttons shall be provided to connect the handset to the cab-to-cab intercom and PEI systems. An LED pushbutton shall also be provided to activate the session hold functions described in the intercom section

C. Controls shall be provided to adjust the volume of the radio, and intercom speakers and handset volume above a preset minimum level.

(vi) Automatic Announcement System

A. The automatic announcements shall provide pre-recorded simultaneous voice and visual announcements over the Train PA system and the transverse announcement signs located in each body section of each Vehicle.

B. Station and connection announcements shall be provided as the Train enters each Station.

C. Pre-recorded special announcements may be selected from the Communications Systems control panel at any time and override any other messages.

D. The cab system may make direct announcements at any time over the PA system using the gooseneck microphone and a control switch.

E. Special announcements, voice and visual may be relayed from the TSCC over the high speed Train-to-Wayside data radio. The list of pre-recorded messages may also be updated over the high speed Train-to-Wayside data radio along with message priorities, announcement frequency, and expiration dates.

F. Station announcements shall be triggered based on Vehicle location provided by the CBTC system or alternative arrangement.

G. All automatic announcements shall be made in English and French using the existing standards established by the City.

H. Project Co shall provide all necessary management software and hardware for the City to generate and or modify announcements and upload the announcements to the Vehicles over the high speed Train-to-Wayside data radio system provided.

I. Project Co shall provide training to City personnel in the use of the automatic announcement management systems.

(vii) Passenger Information Control panel

A. A driver's passenger information Control Panel shall be provided to allow the driver to select pre-recorded announcements over the PA and to select destinations in case of the automatic system's failure.

B. The Driver's Passenger Information Control Panel shall also display failure of PA sign or PEI equipment in any vehicle in a Train.

C. The Passenger Information Control Panel shall be either an independent unit or a sub-screen of the train Display Screen of the Vehicle monitoring system described in this Article.

(viii) Announcement Signs

A. Electronic passenger announcement signs shall be located throughout the passenger compartment so that passengers may read a sign from any location in that compartment.

B. The announcement signs shall be controlled by the automatic announcement system from the lead Vehicle in the Train over the Train communications network.

C. Signs shall display characters at least 5cm in height and shall be large enough to display up to 30 characters.

D. Signs shall display longer messages by sequencing rather than scrolling.

E. Signs shall display time of day (military time) when not displaying a message.

(ix) Destination Signs

A. One external electronic destination sign shall be provided and installed at the cab end of each Vehicle (only one end if a single cab is provided) and two electronic destination signs shall be provided and installed on each side of the Vehicle.

B. The destination signs for the whole Train shall be controlled over the Train Communications Network.

C. The destination sign control shall automatically display the correct destination of the Train based on Train travel direction and location.

D. When a Train enters a terminal location the destination signs shall reverse direction as soon as the Train comes to a stop unless this action is overridden. The "Out of Service" message shall also be able to be selected.

(x) Security Alarm System

A. A pushbutton switch shall be provided in the cab compartment to activate the silent alarm.

B. Pushbutton location shall be determined during review of the cab mock-up.

C. Activation of the silent alarm shall:

i. Cause an alarm message to be sent over the Train radio system to the TSCC and BCC. This alarm message shall include the Vehicle number where the alarm was activated; and

ii. Cause a tag message to be sent to the NVR of the Vehicle where the alarm was initiated to prevent overwriting of the video data.

(xi) CCTV and Non-Volatile Recorder System

A. Network video cameras shall record in color to a NVR.

B. The network cameras shall be directly networked to the NVR.

C. Cameras shall record an image that is admissible in a court of law.

D. Cameras views shall cover the entire passenger area such that there are no blind spots.

E. Additional cameras shall be mounted to record the view out the cab front window and rear window.

F. Cameras shall have an auto iris lens to compensate for variations in ambient light.

G. Cameras shall compensate for ambient light changes within 1 second when entering or leaving a Tunnel.

H. Cameras shall stream video adjustable up to 30 frames per second. Triggering the silent alarm shall set recording to 30 frames per second until reset by security personnel.

I. Cameras and NVR shall be powered from the low voltage DC power with necessary DC to DC isolation converters.

J. Data shall be transmitted from the cameras over shielded cabling with rugged transportation duty connectors.

(xii) NVR

A. The NVR shall be networked into the communications network to provide video feeds to the Driver.

B. Each NVR shall have storage capacity sufficient to store 30 days of video data from the attached cameras without overwriting. The storage device shall be shock and vibration hardened for rail transit duty.

C. The NVR shall have an industrially rated RJ45 Ethernet or USB Port with a secure cover for local downloading of video data.

D. The NVR system shall safeguard and maintain authenticity of the video images using security techniques such as digital image watermarking or encryption and shall be able to demonstrate a chain of custody for data that will be used as evidence in a court of law. When a tag is activated, the NVR shall prevent the video data from being overwritten for 60 days.

E. Activation of the silent alarm shall insert a tag in the files of all recording units in the Train.

F. Any activation of the PEI, or silent alarm, shall insert a tag on the data files of the recording unit for the corresponding Vehicle.

G. A means shall be provided to determine if the camera has been tampered with or vandalized, or if the camera has failed.

(xiii) Cab Video Display

A. The cab video display shall be energized only in the active cab.

B. The cab video display shall be blanked when the Train is moving.

C. The cab video display shall display views of Train doors while the Train is stopped in a Station. A method shall be provided to ensure that the view provided is from the correct platform.

D. During a PEI call camera views from the car in which the PEI is activated shall be transmitted to the cab display when the Train comes to a stop. No camera views of the passenger areas shall otherwise be provided to the cab.

E. Camera views from the Vehicle where a PEI request has been made shall take precedence over all other video feeds until cancelled by the cab.

(xiv) APC System

A. The APC system shall use an infrared or other non-mechanical system to detect passenger boarding or exiting.

B. The APC passenger detection system shall distinguish between passengers boarding and exiting and shall not count passengers standing in the doorway.

C. The APC system shall count passengers with 95% accuracy and provide data on ridership that can be compared on a trip, daily, monthly, or yearly basis at each Station.

D. Once installed the APC system shall not require calibration or adjustment for the life of the unit.

E. The APC system shall have non-volatile memory capacity to store passenger data for all doors for 8 days assuming 20 round trips per day.

F. The APC system shall have a diagnostic and fault recording system and shall report failures to the VMS.

G. Diagnostics shall be remotely available over the communications network.

H. The data collected by the APC shall be provided to the Performance Monitoring System at TSCC in real time.

I. Project Co shall supply all relevant passenger counting data to the City. Data shall be downloaded every 24 hours.

(xv) Monitoring and Diagnostics

A. Each networked communications, passenger information or security subsystem shall have its own diagnostics and fault recording system.

B. Each subsystem shall report its health to the VMS described in this Article.

C. Diagnostics of all networked communications and passenger information and security systems shall be accessible over the communications network using a laptop PC and a web browser.

(xvi) Qualification Testing

A. All communications Equipment and power supplies shall be tested for successful operation within the LVPS voltage supply ranges and power quality as described in this Article.

(xvii) Routine Testing

A. Each system shall be tested to prove the performance of all specified functions and to prove proper operation under network loading.

3.28 Interior and Exterior Appointments

(a) General Interior Design

(i) The Vehicle shall provide level boarding at Stations. The entire low floor section shall be ADA/AODA accessible and include longitudinal fixed seats as well as the appropriate number of flip up style seats, to provide accessibility for wheelchairs at all door vestibules.

A. In addtion to the above, the Vehicle shall be designed and constructed to satisfy Transport Canada rules and regulations including but not limited to the CTA Code of Practice, Passenger Rail Car Accessibility and Terms and Conditions of Carriage by Rail of Persons with Disabilities.

(ii) Project Co shall provide a method to convey the interior design to the riding public and associated stakeholders to elicit feedback and market the new vehicle and assist in finalizing the aesthetics and branding.

(iii) Project Co shall provide a full size mock-up of the cab with proposed material finishes, to facilitate operating staff review of the ergonomics and aesthetics of the design. The cab mock-up shall be of suitable quality and construction to allow an efficient mechanism of showing equipment positioning and driver field of view to support the ergonomic study. The Driver's seat shall be the prototype proposed for production with complete adjustment and functionality. Where required, the mock-up shall be designed to be recyclable and maximise the ability to re-use components and equipment or place these back into maintenance spares. The cab mock-up shall be non-portable and be located at the MSF. Project Co shall

dispose of the cab mock-up once all ergonomic and safety assessments have been completed.

(iv) Project Co shall provide a mock-up of half of the vehicle only to facilitate staff and public review of the functionality and aesthetics of the design (including 70% and 100% low floor sections). The passenger mock-up shall be of suitable quality and construction to allow an efficient mechanism of demonstrating passenger movements for boarding, alighting and passenger movement within the vehicle. The passenger mock-up shall be non-portable and be located at a location to be determined. Project Co may dispose of the mock-up once all staff and public assessments have been completed.

(v) The partition and door between the cab and the passenger area shall include large laminated Safety glass windows to allow visibility through the front of the LRV.

(vi) Seats

A. The passenger seating shall be:

i. Stainless steel or aluminum shell construction;

ii. Contoured seats with rail transit grade cushion and a vandal resistant material; and

iii. A minimum width of 457mm.

(vii) Stanchions, Handrails and Grab Bars

A. Stanchions shall be placed to not interfere with passenger flow during boarding / alighting, but one or more stanchion, handrail or grab bar shall be within reach from any standee areas, including the articulation section.

(viii) Flooring

A. The floor panel material shall be composite construction. Wood based, or wood containing products shall not be accepted.

B. The floor covering shall include the following:

i. High friction material in both wet and dry conditions; and

ii. Smooth surface (non-ribbed or dotted).

(ix) General Interior Design

A. FRP, gel coated sidewall lining panel/window masks.

(x) Interior Safety Equipment shall include:

A. PEI units located near every accessible area at a height in accordance with AODA requirements.

B. One (1) PEI unit located on each passenger compartment end wall.

C. Manual door release at each side door; and

D. First aid kits in the cab.

(xi) Miscellaneous interior appointments shall include:

A. Advertising card frames for ceiling corners, side walls, and end walls;

B. Locked convenience outlets for car maintenance (110 VAC);

C. Signage placed adjacent to the accessible space and denote priority seating for persons with disabilities;

D. Additional interior graphics/signs/instructions in Canadian English and French in consultation with the City; and

E. Emergency and car number information in Braille. General interior signage shall be submitted in accordance with Schedule 10 – Review Procedure.

(b) General Exterior Design

(i) The exterior Design of the Vehicle shall be sleek, modern and attractive. All electrical and mechanical Equipment shall be concealed behind easily replaceable roof shrouds, truck skirts, cab side skirts and the coupler cover. The pantograph and the ice scraper (when in use) shall be the only visible mechanical device on the Vehicle.

(ii) Articulation sections shall be covered with internal and external bellows. Intercar dampers and linkage shall be located undercar or on the roof.

(iii) All electrical connections, where feasible, shall be fitted with connectors between Vehicle wiring and components.

(iv) Exterior Equipment shall include:

A. Roof Equipment shall include no less than:

i. Two (2) unitized HVAC units;

ii. Two (2) propulsion inverters;

iii. Two (2) auxiliary inverters, or a single inverter with backup protection to allow unassisted return to maintenance shop after a failure;

iv. One (1) of each knife switch, HSCB, line filter, etc.;

v. Two (2) LVPS/battery chargers, or a single LVPS if married pairs are provided and all loads of the pair can be powered from the single LVPS;

vi. 1 battery box;

vii. Braking resistors;

viii. One (1) pantograph, equipped with protection (shear pin, or equivalent) that drives the arm to its lowest position in the event of excessive force applied to the head. Pantograph shall be heated, if required, to prevent build-up of snow on the head;

ix. One (1) ice scraper (electrically isolated pantograph without carbon strip or cabling) or alternate means of removing ice from the catenary shall be provided; and

x. All roof mounted equipment shall allow the use of cleaning agents that are reclaimed and controlled.

B. Undercar Equipment shall include no less than:

i. Two (2) automatic couplers;

ii. Three (3) hydraulic power units;

iii. Three (3) complete truck assemblies, that comply with the following:

1 All powered trucks shall be interchangeable; and

2 All non-powered trucks shall be interchangeable;

iv. One (1) Horn/Bell unit per vehicle end;

v. Vehicle Location System transponder reader antenna; and

vi. Sandboxes (if not underseat).

(v) Exterior Appointments shall include:

A. Passenger side windows;

i. Laminated Safety glass with a tint layer.

B. Exterior speakers next to each passenger side door;

C. Sand filling provisions;

D. Destination signs as follows:

i. LED type matrix displays shall be provided;

ii. One located at the front of each cab car;

iii. No less than two (2) located on each side of the car; and

iv. LED Exterior indicator lights;

E. At each passenger side doorway, the following crew access items shall be provided:

i. Exterior manual door release;

ii. Door indicator lights;

iii. Door audible chime;

iv. Door Open passenger pushbuttons; and

v. Door open/close crew switches at opposite corner doors of the LRV.

F. Exterior antennas for radio and high density wireless data communication to the station;

G. A method of viewing the entire consist length on both sides of the vehicle while the driver is seated;

H. Options for exterior painting, vinyl wrapping, decals and color scheme shall be submitted by Project Co for consideration by the City;

I. General exterior signage shall be submitted in accordance with Schedule 10 – Review Procedures;

J. Car number shall be prominently displayed on both ends of the LRV, both sides of the center section and on the roof;

K. Exterior RFID tags, or equivalent, shall be provided to allow car number communication; and

L. CBTC antennas.

(c) Qualification Testing

(i) Seats shall exhibit no permanent deflection when subjected to the following:

A. 1100N shall be evenly distributed across the front edge of the seat. Load shall be applied in a vertical downward configuration;

B. 1100N shall be evenly distributed across the top of the seat back. Load shall be applied in a horizontal direction, from front of seat to back; and

C. Fatigue loading of 15kg dropped from 300mm above the seat a total of 20,000 times.

(ii) Low Floor Panels (supported at maximum beam spacing per Vehicle Design) shall exhibit no delamination, deflect no more than 3.18mm or permanently deform no more than 0.25mm under the following tests:

A. A 1300N load uniformly distributed over a 15mm x 15mm surface area;

B. 2700N over a 150mm x 150mm surface area; and

C. An impact load resulting from a 3kg steel ball dropped from a height of 1.5m.

(iii) Heater guard tests to ensure surface temperatures do not exceed 52°C.

(iv) Stanchion mounting tests with 1.5kN applied to the midpoint of the span to ensure sturdy mounting. Cantilever mounted grab bars and hand-holds shall be tested with the load applied at the unsupported end.

3.29 Communication Based Train Control

(a) The onboard and wayside portions of the CBTC system are specified in Part 4 Article 5 – Train Control.

3.30 Event Recorder

(a) General Objectives

(i) Independent of the VMS, a separate event recorder shall be provided on each Vehicle.

(ii) The Event recorder shall be crashworthy, meeting the Construction requirements of IEEE 1482-1999.

(iii) The Event Recorder shall record all Safety critical data and allow retrieval after accidents or unsafe events.

(b) Data Recorded

(i) As a minimum, the following data and signals shall be recorded:

A. Mandatory channels from IEEE Std 1482.1-1999;

B. Car number;

C. Brake cylinder pressure from each truck;

D. Deadman control;

E. Dynamic brake application;

F. Propulsion effort request of the Master Controller and the CBTC systems ATO function;

G. Time and date;

H. Irretrievable Emergency Brake Switch activation;

I. Distance (shall be defined, preset wheel diameter);

J. Emergency brake application;

K. Catenary voltage;

L. Horn activation;

M. All Bypass or cutout switches;

N. Tractive effort level;

O. CBTC mode of operation;

P. All communications to and from the Zone Controller;

Q. All commands of the CBTC system to the trainlines and to the Emergency brake system;

R. CBTC cut in/cut out status;

S. Speed;

T. Current authorized speed; and

U. All cab initiated PA announcements.

(c) Diagnostics and Self-Test

(i) Event recorder shall have fault indication.

(ii) Event recorder shall perform automatic self-tests.

(iii) The Event recorder shall report its health to the VMS via a discrete output.

(d) Data Storage and Retrieval

(i) Data storage shall be FIFO, such that the latest information is retained.

(ii) The event recorder shall have sufficient storage to store 48 hours of continuous operation data before overwriting.

(iii) Data retrieval shall be retrievable by a laptop computer or similar portable device.

(iv) Downloaded raw data shall be converted into an easily readable format and visual display.

(v) Retrieval of data shall not delete data from the internal hardened memory module.

(vi) Event recorder Design shall prevent unauthorized access.

(e) The event recorder shall be powered from the battery backed up low voltage bus through a dedicated magnetic push to reset circuit breaker which cannot be turned off.

(f) Event Recorder Qualification Testing

(i) On the first car the Event Recorder shall be tested to ensure that all required data is accurately recorded.

3.31 Monitoring & Diagnostics System

(a) General

(i) The VMS shall be the central collection point for fault data on each Vehicle and shall provide access to diagnostic features of various subsystems. The VMS shall consist of:

A. A VMU in each Vehicle which shall collect fault and event data from all Vehicle subsystems in that car and transfer that data to all other VMUs.

B. TDS in each cab.

C. A connection to the high speed data radio for uploading fault data to the wayside maintenance database.

(b) System Description

(i) At a minimum, the VMU shall interface with the following subsystems:

A. LVPS;

B. Door control system;

C. HVAC system;

D. CBTC system;

E. Brake system;

F. Communications and Passenger information sub systems;

G. Propulsion system;

H. Auxiliary Inverters; and

I. Event Recorder system.

(ii) The VMU and the TDS shall operate from the Vehicle low voltage system and operate as a critical load from the Vehicle battery supply. The VMU shall use non-volatile solid state or battery backed memory to store recorded faults and events.

(iii) The real time clocks of all VMUs and subsystems shall be synchronized to the CBTC system time.

(c) Local Access for Subsystems

(i) Each subsystem reporting to the VMS over the network shall also have a local access port for access by a portable laptop computer.

A. The access port shall be of a type supported by the most current laptop computers and most likely to have continued support, for example USB 2.0 or higher or Ethernet, but not RS232.

B. The access port shall be industrial grade with a dust cover.

(d) Train Display Screen

(i) The TDS in the operating cab shall display a default screen showing a graphic of all cars in the Train.

(ii) The graphic shall highlight any doors open or brakes applied and indicate the malfunction.

(iii) Vehicles with any faults affecting Train operation shall be highlighted.

(iv) Clicking on the highlighted Vehicle shall list the current fault and recommended action.

(v) More detailed fault and diagnostic information shall be available to maintenance personnel in a key or password protected mode.

(vi) Fault logs of every subsystem on every car shall be selectable and viewable from the TDS without moving from car to car.

(e) Performance

(i) The VMU shall record and store not less than a rolling 60 days of faults in non-volatile solid state or battery backed memory in a circular first in first out file.

(ii) The VMU shall upload fault data and odometer reading to the MSF maintenance database upon request providing all new faults and flagged events since the last upload.

(iii) Transferring fault data to a PTU or to the wayside maintenance database shall not erase that data from VMU or subsystem memory.

(f) Project Co shall be responsible for systems integration of the monitoring and diagnostic system, including:

(i) Integration of the subsystems with the VMU; and

(ii) Train network integration of the VMUs with the TDS.

(g) Reliability

(i) Failure of the TDS or a VMU shall not disable the Train.

(ii) There shall be no loss of data due to memory degradation or failure.

(iii) If battery backed memory is used then batteries shall not require replacement more often than every 5 years.

(h) VMS Qualification Testing

(i) All subsystems reporting to the VMU shall be tested for ability to send and record data and faults in accordance with the Design fault plan.

3.32 Trainlines and Networks

(a) General

(i) The provided LRVs shall operate as a trainset through:

A. Discrete trainlines for critical functions;

B. An IEEE 1473 type T, or similar standard WTB/MVB Train Control System for Vehicle monitoring and Train Control functions;

C. An IEEE 1473 draft type E network or similar standard for communications and passenger information;

(b) Discrete Trainlines

(i) Safety critical functions such as door control, the all doors closed and locked interlock, emergency brake control, shall be transmitted either as double break trainlines or as two independent trainlines. Propulsion and braking control shall be implemented over the Train Control System with a discrete Train line check.

(ii) Power for trainline signals shall be provided from circuits off the LVPS/battery network of the lead car. Return power shall be through the battery negative trainline.

(iii) Cab control make up, and certain trainlines necessary for Train operation (but not necessarily Safety critical) and trainlines which may be cross checked may be implemented as single break trainlines.

(iv) Lighting control shall be provided by discrete trainlines.

(c) Train Control Network

(i) Vehicle monitoring communications within and between Vehicles shall take place over the Train Control network.

(ii) WTB Train sequencing data shall be available for other systems.

(iii) Train propulsion and brake control and other critical Train-wide functions as specified shall be implemented over the Train Control network or discrete trainlines.

(d) On Board Communications Network

(i) All Train-wide voice communications, control of destination signs and passenger information signs and transmission of video within the Train shall take place over the OBCN.

(ii) The VMU which is connected to the Train Control System shall also connect to the OBCN to:

A. Report Vehicle status to the wayside Maintenance database;

B. Provide Train sequencing information to the communications systems which need it; and

C. Receive health status from communications systems.

(e) CBTC System Network

(i) The CBTC system shall use the Train Control System or its own dedicated network for communications between its subsystems or between Vehicles. The OBCN shall not be used for this purpose.

(f) Performance

(i) Trainlines and networks shall be designed to allow operation of the Train, and control of doors from any active cab.

(ii) The networks shall have capability of increasing data loads by 50% without missing deadlines or losing data.

(iii) The OBCN transmission through the electrical coupler shall have the capability to simultaneously support four video streams plus a PEI session and PA and sign announcements with no visible or audible delays.

(g) Reliability and Availability

(i) Trainlines and networks shall be redundant across all coupler connections.

(ii) If any node fails, network communications shall be maintained between all unaffected nodes.

(iii) All networks shall be redundant through the Train.

(iv) All network Equipment and relays shall be located in the interior of the Vehicle.

(v) All network Equipment shall be compliant with EN 50155.

(h) Network Security

(i) Project Co shall provide an assessment of all network security threats in particular to the Communications System and the Train Control Systems and their potential impact as well as an analysis of the efficacy of all countermeasures designed to mitigate each threat.

(ii) The analysis provided shall be in accordance with the guidelines of the IEC/ISO 27000 series standards.

3.33 Materials and Workmanship

(a) Standards

(i) All materials shall conform to APTA, AISI, ANSI ASTM, ASME, IEEE, CEC, CAN/CSA and other specifications as stated herein or as otherwise applicable.

(b) Prohibited Materials

(i) The Vehicle shall comply with the Toxic Reductions Act of 2009, Ontario Regulation 455/09.

(ii) In addition, the following materials shall be prohibited from use on the Vehicles:

A. PVC;

B. Asbestos;

C. Cadmium (except for battery);

D. Lead (except in solder used for electrical purposes);

E. PCBs;

F. Carcinogenic materials as listed by current Publication of TLV and BEIs guidelines published by the ACGIH;

G. Materials that, in their normal installed state, emit products that are known to be toxic or irritants as per materials listed in 29 CFR 1910.19;

H. All CFC and HCFC compounds classified as ozone depleting substances per 40 CFR 82; and

I. Urethane Foam.

(c) Fasteners

(i) Fasteners – General

A. No protruding screws, rivets, mounting bolts, or similar items shall be permitted on the exterior of the Vehicle. Interior fasteners shall not protrude enough to become a tripping or snagging hazard.

B. Fasteners exposed to passengers shall be tamperproof.

C. All carbon steel fasteners shall be zinc plated.

(ii) Fasteners – Locking Requirements

A. All threaded fasteners shall be self-locking or provided with locking devices.

(d) Elastomers

(i) Elastomers – General

A. Elastomeric parts used for interior decorative trim shall be coloured to harmonize with adjacent surfaces. All colors shall be as approved by the City.

B. Elastomers shall meet the combustibility requirements of this Article.

(ii) Elastomers – Floor Covering

A. Project Co shall submit color and material samples and material friction tests in wet and dry conditions to demonstrate safety of Passengers as Part of the Works Submittals according to Schedule 10 – Review Procedure.

(e) Laminated Safety Glass

(i) Laminated Safety glass shall be used exclusively and shall conform to the following general, manufacturing, and finish requirements:

A. Float glass quality shall conform to ASTM C1036, Type 1, Class 1, quality Q3.

B. Tinted assemblies shall use a tinted PVB layer with clear glass laminate. Tinting shall be applied to the perimeter of the glass to mitigate UV damage of the elastomer surround or bonding agent.

C. Manufacturers stamp shall be positioned in lower right hand corner as viewed from inside the Vehicle.

(ii) Group I glass shall:

A. Be clear laminated Safety glass used for forward facing glazing;

B. Meet the requirements of 49 CFR 223, FRA Type I rating, having a minimum thickness of 14 mm; and

C. Be certified to comply with the requirements of ANSI Z26.1.

(f) Tempered Safety Glass

(i) Tempered Safety glass that may be used for internal glazing and partitions, shall be manufactured to ASTM C1048, Kind FT, Condition A, Type 1 clear, Class 1 clear, quality Q3 (or Class 3, tinted, light reducing).

(g) Piping and Fittings

(i) Piping and Fittings – General

A. Project Co shall perform a leak test on the final air and/or hydraulic piping system, with all components installed, on each Vehicle in accordance with IEC 61133. A copy of the test report for each Vehicle, including retest reports if appropriate, shall be included with each vehicle history book.

(ii) Piping and Tubing

A. Piping and tubing shall be fastened with insulated clamps.

B. After full installation on the Vehicle, and before connection or installation of system components, the piping system shall be completely flushed to remove and/or dissolve all contaminants from manufacture and installation. The piping systems shall be purged, following completion of component installation.

(h) Wire and Cable

(i) Wire and Cable – General

A. All wire and cable shall be in accordance with AAR RP-585 and the recommendations of APTA RP-E-009-98 section 6.0 (or latest version).

B. New wire and cable shall be soft annealed copper, tinned, stranded, and jacketed with radiation cross linked polyolefin (Exane), or City accepted equal, in accordance with ASTM B33 and AAR Standard S 501.

C. The use of aluminum wire and/or cable is prohibited.

D. The insulation system for all internal wires and cables shall be flame retardant and be specifically formulated to minimize smoke, noxious emissions or corrosive fumes in the event of severe overheating or fire. Materials used for the insulation shall be free of halogens.

E. All wires and cables shall be protected against movement, chafing and contact with other components that might cause damage to the insulation.

F. All wiring shall be printed with manufacturer's identification, conductor size, voltage rating and temperature rating.

(ii) Wire and Cable – High Temperature

A. High temperature wire and cable shall be used in locations where the operating temperatures shall exceed the limits of the other indicated insulations.

B. High temperature insulated wire shall not be used in conduit or raceways. This type of wire and cable shall not be bundled together or run with any other type of cable.

(i) Wiring

(i) Wiring – General

A. Wiring which operates at 120Vac and 208Vac shall not be placed in the same conduits or ducts with wires operating at battery voltage.

B. Wiring shall be in conduit, raceways or ducts.

C. Safety grounds shall utilize dedicated grounding bosses or grounding pads.

D. Power Train line cables shall be supported by insulated cable cleats with sufficient spacing between individual conductors to permit adequate ventilation.

E. For proper identification of phases, color coded shrink type markers shall be used on 208 volt cable ends.

F. Low and high voltage cables shall have separate individual raceways.

G. Splicing of conductors is prohibited.

(ii) Wiring – Terminals

A. All wiring shall be fitted with pre-insulated diamond grip terminals.

(iii) Wiring – Grounding

A. Battery (low voltage DC) circuits shall not be individually grounded.

B. All Equipment enclosures and frames of all resiliently mounted electrical apparatus, with the exception of the battery box, shall be suitably grounded to the car body.

C. The Vehicle grounding system shall meet all technical requirements of IEEE Std 16-2004 and APTA SS-E-005-98 (or latest version).

(iv) Wiring – Conduits and Fittings

A. Wires shall not occupy more than 50% of the free cross-sectional area of any conduit.

B. Where necessary to facilitate component removal and replacement, minimum lengths of flexible liquid tight conduit may be used.

C. Insulated bushings shall be used in all conduit and conduit fittings.

(j) Welding

(i) Welding – General

A. All welding practice shall be in accordance with the applicable requirements and recommendations of the AWS.

(k) General Corrosion Control

(i) All materials used shall be corrosion resistant. Equipment located in areas highly susceptible to corrosion shall be made from inherently corrosion resistant materials.

A. Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids.

(l) Dissimilar Metal Treatment

(i) Direct contact between electrically dissimilar metals is prohibited except for electrical connections between copper and aluminum where appropriate joint compounds are used. Isolating and moisture-proofing materials, appropriate to the materials being joined, shall be used at all times.

(ii) All metals used in the fabrication process shall be surface treated with corrosion-resistant materials prior to assembly.

(iii) All ferrous metal surfaces, other than stainless steel, shall be protected by painting or zinc plating.

(m) Flammability, Toxicity and Smoke Emission

(i) Materials shall comply with the flammability, smoke emission, toxic gas and fire retardation requirements specified herein.

(ii) Materials shall be low halogen in addition to meeting the low-smoke requirements specified herein.

(iii) As a minimum, all materials used in the Construction of the Vehicle shall meet the requirements of the 49 CFR 238.103, and Appendix B to Part 238 – Test Methods and Performance Criteria for the Flammability and Smoke Emission

Characteristics of Materials Used in Passenger Cars and Locomotive Cabs. Unless otherwise specified, all materials and Construction shall meet the requirements of NFPA 130-2010.

(iv) Should a conflict exist between the NFPA requirements, federal requirements and requirements listed elsewhere in these provisions, the more restrictive requirement shall govern.

(v) Project Co shall retain a list of materials (flammability matrix) used in the Vehicles showing location of material, weight (density and total weight), heat value per pound and per Vehicle, flame spread, flashpoint, smoke generation and toxicity.

(vi) Project Co shall retain laboratory test results for each test, including a technical data sheet.

(vii) Test report documentation shall specifically identify the tested material by the same description that appears on the technical data sheet and other related references. This documentation shall be directly traceable to the applicable carbuilder drawings.

(viii) Flammability and Smoke Generation Criteria, Flammability and Smoke Generation Criteria requirements are outlined in Table 4-3.8.

Table 4-3.8

Function of Material	Test Procedure	Performance Criteria
All Vehicle materials and components except as otherwise noted.	ASTM E162 ASTM E662	$I_s \leq 35$ D_s (1.5) $\leq$ 100, Ds (4.0) $\leq$ 165
HVAC Ducting	ASTM E162 ASTM E662	$I_s \leq 35$ D_s (4.0) $\leq$ 100
Lighting Diffusers / Plastic Glazing	ASTM E162 ASTM E662	$I_s \leq 100$ D_s (1.5) $\leq$ 100, D_s (4.0) $\leq$ 200
Thermal and Acoustical Insulation	ASTM E162 ASTM E662	Is $\leq$ 25 D_s (4.0) $\leq$ 100
Flexible Cellular Foams	ASTM D3675 ASTM E662	Is $\leq$ 25 D_s (1.5) $\leq$ 100, Ds (4.0) $\leq$ 175
Elastomers – Lock strip gaskets	ASTM C542 ASTM E662	D_s (1.5) $\leq$ 100, D_s (4.0) $\leq$ 200
Elastomers – Other gaskets or seals	ASTM C1166 ASTM E662	100mm (4.0in), maximum flame propagation (15) D_s (1.5) $\leq$ 100, D_s (4.0) $\leq$ 200

Function of Material	Test Procedure	Performance Criteria
Structural – Floor, Roof	ASTM E119	Pass (30 minutes minimum endurance at AW3 loading)
Floor Covering	ASTM E648 ASTM E662	CRF $\geq$ 0.5W/cm^2 D_s (1.5) $\leq$100, D_s (4.0) $\leq$ 200
Seat Cushion, Mattresses	ASTM D3675 ASTM E662	$I_s \leq 25$ D_s (1.5) $\leq$ 100, D_s (4.0) $\leq$ 175
Seat Frame, Seat Shroud	ASTM E162 ASTM E662	$I_s \leq 35$ D_s (1.5) $\leq$ 100, D_s (4.0) $\leq$ 200
Upholstery	14 CFR (FAR) 25.853 (Appendix F, vertical, textiles) ASTM E662	Flame Time $\leq$ 10s Burn Length $\leq$ 150mm (6in) D_s (4.0) $\leq$ 200
Wire Insulation	IEEE Std 383 – Flammability ASTM E662	Pass D_s (4.0) $\leq$ 50

(ix) Toxic Content Limits In Combustion Products

A. The maximum toxic gas concentration in the combustion products of any materials used in the Construction of the Vehicle shall not exceed the values outlined in Table 4-3.9:

Table 4-3.9

Toxic Gas – BSS-7239	Maximum Concentration
CO	3500ppm
Hydrogen Fluoride (HF)	200ppm
Nitrogen dioxide (NO2)	100ppm
Hydrogen Chloride (HCL)	500ppm
Hydrogen cyanide (HCN)	150ppm
Sulphur dioxide (SO2)	100ppm

(n) Panel Flatness

(i) The maximum allowable deviation of any point on the panel measured from a reference plane taken from any three corners shall be 3mm. The overall deviation of the panel thickness shall not exceed 1mm.

(o) Acoustic Insulation

(i) Sound damping material used in the fabrication of the Vehicle shall be resistant to diluted acids, greases, gasoline, fuel oils, aliphatic oils, and vermin. Material shall be resistant to fungus and shall not support combustion. The material shall not be affected by sunlight or ozone, and shall not become brittle with age.

(p) Thermal Insulation

(i) Thermal insulation materials shall be transportation grade of the rigid, non-rigid, or spray-on type. Insulation shall be installed with a vapour barrier as required to preclude moisture accumulation.

(ii) The type of thermal insulation to be used shall not be susceptible to mould or rot and shall not absorb water. Metals, which are attached to the insulation shall be corrosion resistant and not settle under Vehicle vibration.

(iii) Urethane foam insulation is prohibited.

(q) FRP

(i) FRP shall be polymeric-reinforced laminated material, composed of a gel-coated surface, fibreglass reinforcement, and polyester, acrylic, phenolic, or approved equal resin.

(r) Films and Graphics

(i) Films and Graphics – General

A. All graphic materials shall be transportation grade materials. Signage graphics shall have an opaque background with clear, vandal resistant overlayment. Printed signage graphics shall be either reverse printed on the back of the clear overlayment, or printed on opaque background and covered by the clear overlayment.

B. Films and graphics shall withstand effects of detergents and brushes used in washing procedures for removal of multiple applications of graffiti.

C. Films shall use a removable grade adhesive that upon removal does not require use of solvents, or secondary operations to remove adhesive or graphic residue.

(ii) Films and Graphics – Emergency Exit Signage

A. Emergency exit signage shall comply with APTA SS-PS-004-99, Standard for Low-Location Exit Path Marking and 49 CFR, Part 238.

B. LLEPM material shall be provided to illuminate the path to each emergency exit.

C. The LLEPM and emergency exit signage shall be passive and independent of the car's normal and emergency lighting systems.

i. HPPL material shall be used in the fabrication of the exit signage and the LLEPM.

(iii) Films and Graphics – Emergency Access Signage

A. Each door intended for use by Emergency responders for rescue access shall be identified with emergency access signs and instructions consisting of retro-reflective materials.

(s) Electrical Devices and Hardware

(i) Electrical Devices and Hardware – Contactors, Relays and Switches

A. All devices shall be readily identifiable by means of a permanent, durable marking strip giving the device circuit Designation.

B. Switches shall be provided with a "keying" feature that prevents the body of the switch from rotating.

(ii) Electrical Devices and Hardware – Circuit Breakers

A. The "on", "off" and "tripped" positions of all circuit breakers shall be permanently marked.

B. All circuit breakers shall be sized by current rating and tripping time to protect both the associated Equipment and the minimum size wire.

C. All circuit breakers shall be of a high shock-resistant Design.

(iii) Electrical Devices and Hardware – Fuses

A. Fuses shall be used only where the use of a circuit breaker is not technically feasible.

B. Each fuse shall be permanently identified and readily accessible.

i. The rating of each fuse shall be clearly and permanently marked on the fuse and holder.

C. The fuse holder shall have fuse retention devices at both ends.

D. Blown fuse indication shall be provided.

(iv) Electrical Devices and Hardware – Bus Bars

A. Bus bars shall conform to the requirements of IEEE Std 16-2004.

(v) Electrical Devices and Hardware – Switch, Circuit Breaker, and Fuse Panels

A. All live portions of the protected circuitry shall be completely concealed so that no danger of electrocution or shock exists from the touching of the panel or any appurtenances or devices mounted thereto.

B. All switches, circuit breakers, fuses, and indicating lights shall be provided with a nameplate clearly identifying the circuit which each controls and its circuit Designation.

(vi) Electrical Devices and Hardware – Illuminated Status Indicators and Annunciators

A. All illuminated status indicators, annunciators or similar devices shall be long-life LED type lamps.

(vii) Electrical Devices and Hardware – Rotating Equipment

A. Rotating machinery shall be suitable for continuous duty, and the continuous duty shall be confirmed in accordance with IEEE Std 11-2000.

3.34 Vehicle Testing

(a) General

(i) Qualification tests may be waived, at the sole discretion of the City.

(ii) Project Co shall notify the City of the planned test date no less than 30 calendar days prior to the planned start of the test.

(iii) Additional tests shall be performed by Project Co as required to ensure complete compliance to the specification, as well as all Applicable Laws, regulations and standards.

(iv) Production tests shall take place on all Vehicles.

(b) Test Documentation

(i) Test Plan

A. Project Co shall prepare a Master Test Plan. The Test Plan shall include all tests required to prove complete compliance to the Vehicle Article/specification.

B. The Master Test Plan shall be submitted as Part of the Works Submittals according to Schedule 10 – Review Procedure.

C. Test order shall be arranged, to the maximum extent possible, such that failures resulting in re-Design do not nullify the results of successfully completed tests.

D. Subsystem performance requirements may be addressed in one or more comprehensive tests, as elected by Project Co.

(c) Test Procedures

(i) All test procedures authored by Project Co or sub-supplier shall be submitted as Part of the Works Submittals according to Schedule 10 – Review Procedure.

(d) Test Reports

(i) Test reports shall be produced by Project Co and be available for review by the City, at the City's request.

(e) Test Protocol

(i) Labs shall be certified to perform tests, if required by applicable agency or administration.

(ii) All Equipment used in the performance of tests shall be calibrated by an independent test laboratory on an annual basis, or more often, if required by the specific test.

(f) Test Notification

(i) The City reserves the right to witness any test or portion of a test required on any Vehicle delivered under this contract. Project Co shall notify the City of any planned tests a minimum of 30 calendar days prior to the test taking place.

(g) Types of tests

(i) Component Qualification Tests

A. Components shall be Qualification tested before they are presented for review and approval at the FAI. FAI approval is required prior to sub-system installation on the first production car.

B. Component qualification testing is documented in the previous sections of this Article.

(ii) Component Production Tests

A. Components shall be production tested at the sub-suppliers factory before shipment to Project Co.

B. Test reports shall be shipped with each component. Copies of the test reports shall be included in each car history book.

(iii) Vehicle Production Tests

A. Vehicle Production Tests shall be completed before Project Co requests permission to ship each car.

B. Test reports shall be shipped with each Vehicle. Copies of the test report shall be included in the Car history Book.

C. Production Tests shall include:

i. All of the tests necessary to prove proper functionality of the Vehicle;

ii. Verification that water shall not enter the Vehicle during revenue service operation; and

iii. Vehicle weighing.

(iv) On-Site Commissioning Tests

A. Vehicles arriving on City property shall be commissioned to ensure they are ready to run in revenue service.

B. Testing shall include all tests required to ensure the Vehicle is safe to operate.

C. Testing shall also include all production tests required to verify complete functionality of all Equipment.

(v) Vehicle Qualification Testing

A. Qualification tests are one-time tests on the first production Vehicles produced by Project Co. The tests are required to prove that the Vehicle performs as required by the specification.

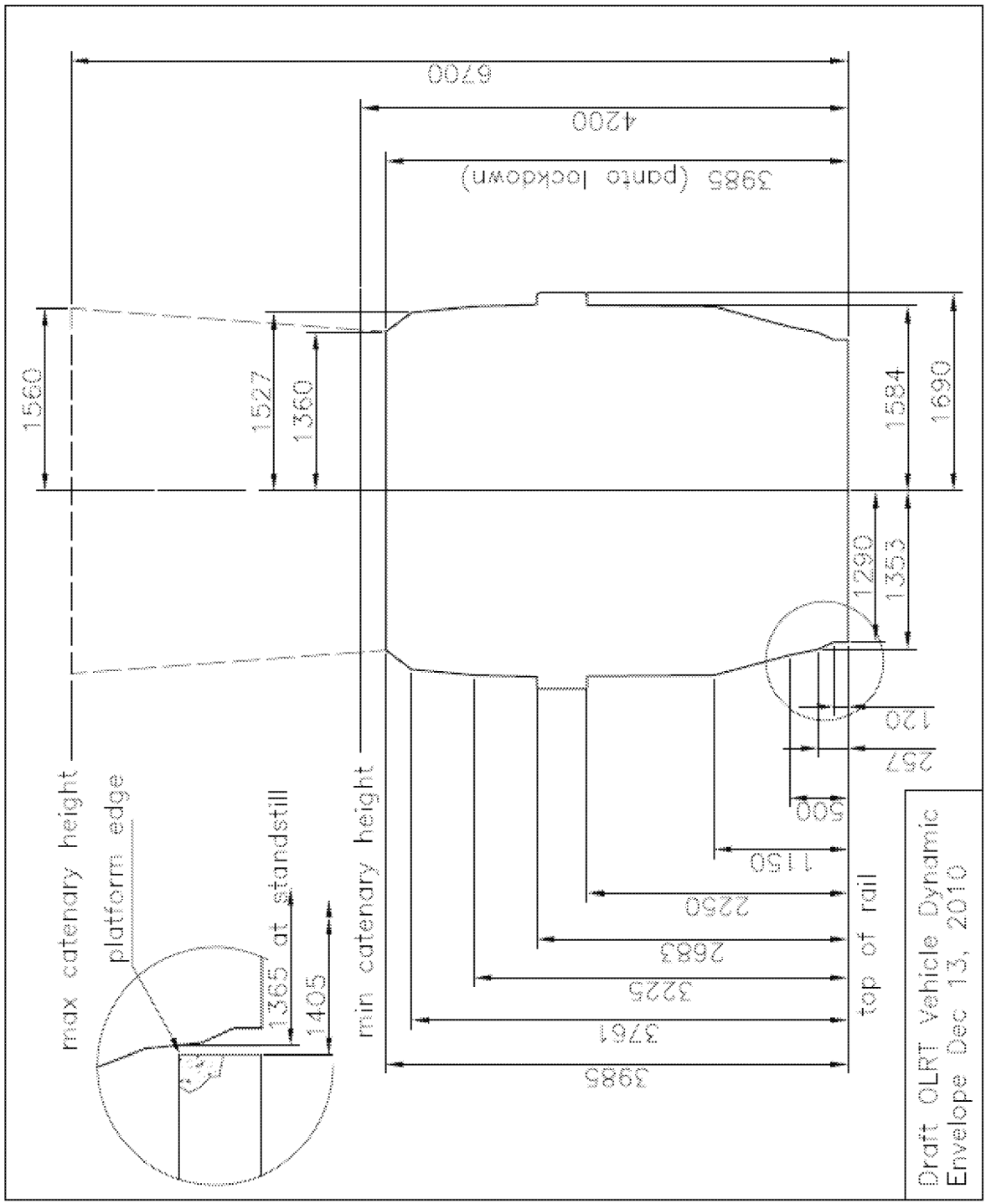
B. Vehicles other than the first production car may be used to complete tests, such as carbody compression and HVAC climate room, as deemed appropriate by the City.

C. Testing shall be performed on the completed Vehicles with production components.

3.35 Dynamic Envelope

(a) The dynamic envelope shown below represents the clearance envelope that has been utilized in the preparation of the Reference Documents. Project Co is responsible for definition of the dynamic envelope resulting from their design and the implications of the dynamic envelope on all aspects of the design, recognizing the constraints of this Schedule 15-2.

(b) Proponents shall size the structures based on the dynamic envelope of their selected Vehicle. If the envelope allows a reduction of the dimensions listed in Schedule 15-2 Part 2, Article 2.5 or in Schedule 15-2 Part 4 Article 8, the proponent may propose modified dimensions with appropriate supporting drawings detailing the resulting clearances and demonstrate that system safety is not compromised.


6700
4200
3985 (pantto lockdown)
1560
1527
1360
1584
1690
1280
1353
120
257
500
1150
2250
2683
3225
3761
3985
top of rail
max catenary height
platform edge
1365 at standstill
1405
min catenary height
Draft OLRT Vehicle Dynamic Envelope Dec 13, 2010

ARTICLE 4 NON-REVENUE VEHICLES

4.1 General

(a) Project Co's maintenance responsibilities related to the Non-Revenue Vehicles and the right of way are detailed in Schedule 15-3 – Maintenance and Rehabilitation Requirements. Project Co shall provide a sufficient number of Non-Revenue Vehicles to comply with these requirements, with consideration to availability, Mean Time to Repair, Response Time, etc.

(b) At the end of the Maintenance Term, all Non-Revenue Vehicles shall be provided to the City in a new or overhauled condition as per the Requirements of Schedule 15-3 – Maintenance and Rehabilitation Requirements. Non-Revenue Vehicles that are outsourced and not purchased or leased are not required to be provided to the City at the completion of the contract.

(c) Non-Revenue Vehicles shall be stored in a protective, sheltered environment when not in use.

(d) All non- revenue vehicles shall be detectable and protected by the Train Control System in the CBTC territory or on signalled MSF Track. When near the Alignment, protection shall be governed through mitigations developed from the safety and hazards analysis.

(e) Non-Revenue Vehicles shall be compatible to the physical and electrical Infrastructure of the LRV Train Control System.

(f) To promote service consistency and safety, Project Co shall work with the City to identify and select the non-revenue vehicles that shall be branded in accordance with Schedule 15-2 Part 1 Clause 2.9.

(g) Project Co shall ensure that civil Infrastructure, both new and existing, shall accommodate the worst case loading scenario for all Non-Revenue Vehicles.

4.2 Non-Revenue Vehicle Types and Maintenance Tasks

(a) Project Co shall submit a list of non-revenue vehicles required for OLRT and their respective task descriptions to support revenue operations and maintenance of LRT infrastructure.

ARTICLE 5 TRAIN CONTROL

5.1 Introduction

(a) Project Co shall provide for a CBTC system integrated with the wayside portion of the system.

(b) The CBTC system shall provide vital ATP with a moving or virtual block Design. The CBTC system's ATP function shall vitally enforce Train separation, switch and interlocking protection and direction of traffic interlocking. The ATP system shall vitally enforce all temporary and permanent speed restrictions as long as any portion of the Train is within the restriction zone.

(c) The CBTC system shall also provide a non-vital ATO overlay function operating within the limits established by the vital ATP system. The ATO function shall provide automatic speed regulation to keep the Train under the speed profile enforced by the vital ATP system. The ATO function shall also provide automatic station stopping and implement supervisory commands to adjust Headways and schedules.

(d) Trains shall normally operate in an ATO mode from Tunney's Pasture to Blair.

(e) Future extension of the System beyond these Stations into partially segregated rights-of-way with at grade crossings shall require Trains to operate with ATP only in those areas.

(f) The CBTC system shall also have a non-vital ATS function to non-vitally adjust the Train speed limits within the ATP speed profile and adjust Station dwell times to optimize Headway and Train spacing and to reduce energy usage. The ATS system shall also provide non-vital interlocking command and control and automated operation of the line.

(g) The Design of the wayside and onboard systems of the CBTC system shall provide minimum 80-90 second Headways.

(h) If the CBTC system cannot provide inherent redundancy of operation to locate the vehicle in the event of communications failures, Project Co shall provide a redundant or alternative method of train location independent of the CBTC system. The fall back signals at the interlocking shall provide additional safety against head on and conflicting route collisions and switch derailments. A means shall also be provided to detect broken rail and update the CBTC system of the areas of broken rail and necessary speed restrictions.

(i) Redundancy shall be built into all Train Control Systems to provide maximum availability.

5.2 Codes, Standards and Manuals

(a) The Design and Construction of the Works shall comply with the criteria contained in this Article, and all standards, regulations, policies, Applicable Law, guidelines or

practices applicable to the Project, including but not limited to each of the following Reference Documents. In the event of a conflict between criteria, commitments or requirements contained within one document when compared with another, the more stringent shall apply:

(i) AREMA Communications and Signal Manual – 2011.

(ii) EN 50126:1999, Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

(iii) EN 50128:2001, Railway Applications – Communication, Signalling, and Processing systems – Software for Railway Control and Protection Systems

(iv) EN 50121: 2000, Railway Applications – Electromagnetic Compatibility

(v) EN 50129:2003, Railway Applications – Communication, Signalling and Processing systems – Safety Related Electronics for Signalling

(vi) EN 50155:2001, Railway Applications – Electronic Equipment Used on Rolling Stock

(vii) EN 50159-2:2010 Railway applications – Communication, Signalling and Processing Systems -- Part 2: Safety Related Communication in Open Transmission Systems

(viii) IEC 61508, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems

(ix) IEEE Std. 1474.1 – 2004, IEEE Standard for Communications-Based Train Control (CBTC) Performance and Functional Requirements

(x) IEEE Std. 1474.2 – 2003, IEEE Standard for Functioning of and Interfaces Among Propulsion, Friction Brake and Train-borne Master Control on Rail Rapid Transit Vehicles

(xi) IEEE Std. 1474.3 – 2008, IEEE Recommended Practice for Communications-Based Train Control (CBTC) System Design and Functional Allocations

(xii) IEEE Std. 1483 – 2000, IEEE Standard for Verification of Vital Functions in Processor-Based Systems Used in Rail Transit Control

5.3 System Description

(a) General

(i) The CBTC system shall consist of Equipment located on the wayside, at the TSCC, at the MSF and onboard each LRV Train. The wayside, TSCC, and MSF Equipment shall be connected to each other by redundant fibre optic networks.

The onboard Equipment shall communicate to the wayside and TSCC and MSF Equipment through wireless APs connected into the CBTC Network. Systems providing the same functionality, Safety and level of redundancy as that described below are acceptable regardless of the assignment of functions among hardware or the terminology used.

(b) TSCC and MSF Equipment

(i) The TSCC shall serve as the command and control center for the OLRT. Work stations located in the TSCC shall communicate with redundant ATS and ATC servers located in the MSF. The TSCC workstations and the ATS servers located in the MSF shall allow the TSCC personnel to setup routes through interlockings using entrance/exit selection or direct switch control, and to clear, cancel or fleet signals. Using this system, TSCC personnel shall also be able to stop and release any Train or group of Trains. The TSCC personnel shall be able to put the ATS servers in an automatic mode to automatically set up routes through interlockings, send ATS commands to Trains to control dwell times, speeds, and acceleration or braking rates to manage Headways, and schedules and/or optimize energy usage. In the automatic mode, the ATS system shall also route Trains out of and into the MSF to build up and reduce service around the rush hours.

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

(iii) The ATS workstations at the TSCC shall have display screens that allow TSCC personnel to view the entire line and all the Trains (identified by lead car number), interlockings and switch positions as well as Equipment warnings, alarms, temporary speed restriction zones and work zones. GUI controls shall be provided to allow the TSCC personnel to control interlockings and switches, to clear, cancel and fleet signals, to turn switch point heaters on and off, to stop and release Trains and to transfer interlockings and the entire line between automatic and manual operation.

(iv) CBTC maintenance database servers shall be provided at the MSF to record all faults from wayside, TSCC, MSF and on board CBTC and network Equipment

A. Fault alerts and easy database access shall be provided for maintenance personnel.

(v) TSCC workstations and MSF servers shall be set up in a redundant configuration with redundant network interfaces.

(c) ATC Zone Controllers

(i) ATC Zone Controllers shall be distributed throughout the line to control the Train movements in the various zones. Redundant ATC Zone Controllers shall be provided in each zone. The number of zones shall be determined by the latency requirements of providing the required Headways, the requirements of maximum availability, as well as the requirements of the vital interface with the interlocking controllers provided.

(ii) Each ATC Zone Controller shall:

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

B. Synchronize Track Database versions with the MSF ATC server;

C. Receive signal status, switch position, and block occupancy status of the fixed block system either directly or from a VMIS;

D. Read input from the intrusion detection system installed at the OLRT Tunnel portals;

E. Read inputs from the smoke detector system;

F. Request and receive the Track Database version from each Train in its zone;

G. Deny Movement Authority to Trains without a valid Track Database version until the database is made current;

H. Send Movement Authorities to all Trains within its zone including overlap into adjacent zones;

I. Send a vital confirmation to Trains when they are fully berthed in a Station if required by system Design;

J. Provide Train location to the ATS system;

K. Inform adjacent ATC Zone Controllers of all switch, signal positions and Train location information within it zone; and

L. Receive the same information from adjacent controllers.

(iii) Redundant ATC Zone Controllers shall be provided for each zone.

(iv) Future expansion of OLRT may involve operation in partially separated rights-of-way with at-grade crossings. The ATC Zone Controllers shall have capability of interfacing with City traffic signals and with crossing barriers.

(d) Local ATS Processor

(i) Redundant local ATS processors shall provide a non-vital interface between the ATS servers and the VMIS to allow ATS control of interlockings. The local ATS processors shall also connect to the Local Control Panel to allow local control of the interlocking.

(ii) The local ATS processor shall direct ATS commands to Trains to adjust Train speeds and dwell times and shall obtain Train location information for the central ATS system. The processor shall also receive the Train locations from the ATC Zone Controller and report them to the MSF ATS servers.

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

A. Processor redundancy is provided.

B. Local control of the turn backs at terminal locations and of the interlocking controlling entrance to and exit from the MSF is not dependent on the health of the line CBTC Network.

(e) Interlocking Control

(i) Interlockings shall be controlled by redundant VMIS units using standard interlocking Safety logic including route locking, approach locking, detector locking, etc. A fixed block Train detection system shall be used in all interlockings to supplement CBTC location detection. Vital interlocking logic shall include control of traffic direction between interlockings. Traffic direction status shall be vitally maintained through power failures. Vital interlocking control may be integrated into the Zone Controller package provided that:

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

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

(ii) The VMIS units shall vitally read the states of all fixed blocks including those outside the interlocking.

(iii) The VMIS units shall provide the ATC Zone Controllers the status of all signals, switches, and fixed blocks within the zone as well as the allowed direction of traffic on each Track.

(iv) The local non-vital ATS processor shall allow the VMIS to process central ATS requests from the MSF ATS servers and provide indications to the ATS system.

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

B. The non-vital local ATS processor shall support local automatic operation of the interlocking based on approach triggering.

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

(v) In normal operation, approach locking shall utilize the ATC Zone Controller knowledge of Train speed and position and Movement Authority to minimize approach locking time.

(vi) Wayside signals with stop, diverging and normal aspects controlled by the VMIS shall be provided at the interlockings. In case of CBTC system failure, visual signal protection of interlockings shall supplement line of sight operation between interlockings.

(f) Central Instrument Houses

(i) All interlockings shall be controlled from a CIH.

(ii) Project Co shall locate the CIH within any building in close proximity to the interlocking as dictated by performance requirements of the signalling system. CIH's may be prefabricated units or part of the adjacent OLRT Infrastructure.

(iii) The CIH shall be secured in accordance with safety and security requirements.

(iv) The CIH shall be provided with doors with locks at each end. The doors shall also have an emergency bar on the inner side of the door which shall bypass the lock and open the door.

(v) The CIH shall house all microprocessor systems, relays, electronic switch controllers, etc necessary to control the interlocking from the central ATS servers or from the local control panel.

(vi) The CIH shall house, as necessary, CBTC Equipment such as ATC Zone Controllers, local ATS processors, CBTC networking Equipment, etc.

(vii) A Local Control Panel with switch controls, signal controls and Track and switch indications and switch heater status shall be provided. Controls to select local or ATS control, and local automatic or local manual control shall be provided.

(viii) The CIH shall be constructed with a white outer and be resistant to corrosion and weather damage. The Design shall minimize electromagnetic interference from the Traction Power fields.

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

(x) A 600 VAC single phase feed shall be provided with appropriate step down transformer(s) and distribution panels for signal power and for bungalow power outlets, lighting, HVAC etc.

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

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

(xiii) Four (4) hour battery backup shall be provided to power all signal and CBTC systems including fixed block detection and switch operation.

A. Batteries chargers shall be redundant.

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

C. Batteries provided shall be selected for the required capacity and minimal degradation of capacity with age and suitable for the environmental conditions outlined in the Output Specifications.

D. Batteries shall not be lead acid.

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

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

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

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

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

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

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

C. Provide cable identification; and

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

(g) Switch Machines

(i) Power switch machines provided shall:

A. Have heaters to prevent internal condensation;

B. Have a lockable hand throw lever and mode of operation; and

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

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

A. Be controlled by the TSCC/BCC or YCC with local manual control available for maintenance and troubleshooting; and

B. Have sufficient thermal rating and appropriate controls to operate successfully in the Ottawa climate.

C. The status of the switch heater (ON/OFF) for each switch shall be reported to the local control panel and to the TSCC, BCC or YCC.

D. Failure of switch heaters status to correspond to command status shall cause an alarm indication.

(iii) Switch heaters shall be powered from the OCS or from the same utility breaker that supplies power to move the switches.

(iv) If electric switch heaters are used:

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

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

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

(v) If gas heaters are used:

A. Flameout and ignition failure shall be provided; and

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

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

(h) Wayside Signals

(i) Wayside signals shall be provided only at MSF and mainline interlockings.

A. When the System is expanded into partially segregated territory, wayside signals shall be provided at interconnected highway traffic signals.

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

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

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

(i) Location Norming Transponders

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

(ii) The LRV's Onboard Computer shall detect missing of malfunctioning norming transponders and shall report this failure to the CBTC maintenance server.

(j) Fixed Block Train Detection System

(i) Subject to the results of the safety, risk and hazard analysis, in order to minimize disruption caused by communications failures, a fixed block Train detection system shall be provided. If a fixed block Train detection system is provided, the fixed block status shall be provided to the ATC Zone Controller through the VMIS.

A. In case of failure of CBTC with an individual Train for more than a pre-determined time, the ATC Zone Controller shall determine the location of that Train from fixed block occupancy;

B. In the case of a general communications crash and re-boot, the ATC Zone Controller shall utilize fixed block occupancy and vacancy to assist in verifying that all Trains are accounted for during recovery;

C. The length of fixed blocks shall be consistent with facilitating a quick recovery from a system crash; and

D. Fixed block Train detection electronics and power Equipment shall be consolidated in the CIHs located at interlockings.

E. Where track circuits are used, track circuit voltage selection shall take into account the track bed, stability, leaf contamination, wheel and rail profile and the potential for rail oxidization due to climatic conditions.

(k) Broken Rail Protection

(i) A broken rail detection system shall be provided.

A. The broken rail protection system shall provide direct input to the ATC Zone Controllers or use data collated by alternative rail condition monitoring methods to update the speed restriction table used by the Zone Controller and enforce speed restrictions.

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

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

i. Project Co shall monitor the environmental temperature of the track and associated track system and increase the frequency of rail monitoring /testing after experiencing >= 20 degree Celsius thermal swings in 12 hours or less;

ii. The frequency and type of monitoring shall be commensurate with the type of track used, its construction methods and the track bed;

iii. Project Co shall provide a method of interpreting track data such that the speed restriction tables in the Zone Controllers can impose the necessary speed restrictions;

iv. Project Co shall monitor Ottawa's seismic activity and increase the frequency of rail monitoring /testing after experiencing seismic activity that would exceed the design of the track and track bed or compromise structural integrity of the rail or stability of the track bed;

v. Project Co shall develop KPI's that will report the track condition to the City at a minimum of every month. This report shall detail temperature change and any seismic activity during that time period; and

vi. Project Co shall demonstrate that the alternative broken rail detection system has been assessed through the Safety and FMEA Analyses and any required mitigations or design changes shall have been implemented before trial running.

(l) The broken rail detection requirement applies to all mainline Tracks. It shall also apply to MSF Tracks if warranted by the Safety and FMEA analyses.

(m) CBTC Network

(i) The TSCC workstations, the MSF servers and all wayside CBTC controllers and interfaces, shall be connected to each other and to wayside APs over independent redundant fibre optic networks.

(ii) Networks Design and Equipment shall be based upon an open standard such that replacement Equipment may be procured from multiple sources.

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

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

C. Network switches shall be located in CIHs and in station communications rooms as needed.

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

(iii) The Network shall be designed to reliably meet the latency requirements determined by the Headway requirements outlined in Part 1 Article 2 – Operational Performance Requirements.

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

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

(n) CBTC Wireless Communication

(i) APs shall be provided along the right of way.

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

(iii) Leaky coaxial cable or waveguides may be used instead of antennas to guarantee reliable communication in Tunnels.

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

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

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

(vii) APs shall be spaced along the Alignment as needed to provide redundant radio coverage for each Train antenna at all times. Not only shall coverage be redundant but APs shall be redundant.

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

(ix) Project Co shall perform propagation studies and intermodulation studies to determine placement of APs and antennas on the wayside and the proper location of antennas on the Trains.

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

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

(o) Event Recording

(i) A TSCC and CIH event recording systems shall be provided to record changes in switch positions, and signal aspects, fixed block occupancy, Train location, and ATS commands to the interlockings and Trains.

(ii) All events shall be time stamped.

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

(iv) Onboard CBTC systems shall report all changes in Movement Authority, all Onboard Computer Train Control commands, all changes in speed limits, etc. to the Vehicle Event Recorder.

(p) Onboard CBTC Systems

(i) The onboard components of the CBTC system shall include redundant Onboard Computers, redundant VLS, a CBTC Panel in each cab, and redundant CBTC data radios and antennas. The onboard systems shall be powered any time battery power is available on the Vehicle.

(ii) The Onboard Computer shall:

A. Manage and verify communications with wayside CBTC systems;

B. Obtain Movement Authority from the ATC Zone Controller;

C. Vitally check the integrity and version of its Track Database;

D. Obtain an up to date Track Database as necessary;

E. Vitally determine the length of the Train and Train integrity;

F. Determine location of the Train and the maximum accumulated position error based upon data provided by the VLS;

G. Communicate Train location, length, speed and maximum position error to the ATC Zone Controller;

H. Calculate and enforce a penalty brake speed profile based upon Train location, Track grades, Movement Authority, civil and temporary speed restrictions and work zones;

I. Initiate an emergency brake application for any violation of the penalty brake speed profile or if a Train moves beyond the end of its Movement Authority;

J. Obtain a vital determination that the Train is within the Station and stopped before doors may be opened;

K. Vitally permit door opening on the Platform side of the Train only;

L. Provide zero velocity status to any Vehicle systems that need it;

M. Provide a vital roll back protection function; and

N. Have a non-vital processor to implement automatic speed regulation, automatic station stopping and other ATO functions and to implement ATS commands received from the wayside.

(iii) Vehicle Location System

A. The VLS shall determine Vehicle location based upon vital tachometer pulse counting with error correction based on vital interrogation of wayside norming transponders.

B. Vital checks shall be provided for speed sensor and pulse counter integrity.

C. The VLS shall also independently detect the direction of Train motion.

D. An algorithm shall be provided to account for distance travelled during spins and slides.

(iv) Vehicle CBTC Data Radios and Onboard CBTC Networks

A. Redundant data radios and antennas shall be provided to communicate with the wayside CBTC controllers through wayside APs.

B. Redundant communication paths and Equipment shall be provided both for Train to wayside and for all networked CBTC subsystems within the Vehicle and Train.

C. Any Train network used by the CBTC system to communicate between CBTC Onboard Computers on different Vehicles in a Train shall be redundant and have a proven record of reliable communication over electrical coupler heads that are frequently coupled and uncoupled. Reliance on Ethernet through standard electrical coupler heads for the operation of the CBTC system is not permitted.

(v) CBTC Panel

A. A CBTC Panel shall be mounted in each cab. The CBTC Panel shall be separate from the Train Display Screen.

B. The CBTC Panel shall be designed to minimize distraction from the task of operating the Train.

C. The displays on the CBTC Panel shall be designed for at least 100,000 hours MTBF.

i. Inputs shall be by pushbuttons rather than touch screen.

D. The CBTC Panel shall at minimum display:

i. Train CBTC operating mode;

ii. CBTC operational status as result of checks when entering CBTC territory, self-checks, etc.;

iii. Current CBTC determined Train speed;

iv. Currently authorized maximum CBTC Train speed;

v. Train speed alarm active;

vi. Side on which doors are enabled to open;

vii. ATS Station hold active indication;

viii. Bypass stop at next Station indication;

ix. Dwell over warning; and

x. Short messages indicating the reason for a temporary speed restriction or the approach to a work zone, faults, etc.

E. The CBTC Panel shall support at minimum the following system inputs:

i. Mode Selection – ATO, ATP Only, Coupling, or Non CBTC Territory.

(vi) CBTC Bypass

A. In order to allow movement of the Train under CBTC failure conditions, a CBTC bypass switch shall be provided in a locked cabinet to allow the Train Driver to bypass all CBTC control of the Train and its propulsion, braking and emergency brake systems.

B. When the CBTC bypass switch is activated:

i. An indicator that CBTC is bypassed shall flash on the CBTC Panel;

ii. Master Controller commands shall be passed directly to the propulsion and braking system;

iii. The propulsion system shall non-vitally limit Train speed to a reasonably safe speed; and

iv. Operation with CBTC bypassed shall be line of sight under TSCC supervision with observance of interlocking signals.

(q) Train Initiation

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

(ii) When the Onboard Computer determines it has entered CBTC territory it shall disable the Non-CBTC Territory mode of operation, come to a stop and attempt to initialize the Train with the wayside CBTC system.

(iii) During Train initiation the Onboard Computer shall:

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

B. Update and verify the Track Database; and

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

(iv) If initialization requires RFID tags on the Vehicle and wayside tag readers, tags shall be provided on all Vehicles and readers shall be provided at all entrances to CBTC Territory and as required to handle contingencies.

(r) Non-Revenue Vehicles

(i) Non-Revenue high rail Vehicles shall be detected and protected by the CBTC system.

5.4 Modes of Operation

(a) Modes of line operation and interlocking operation shall be selectable from the TSCC ATS workstation.

(b) Modes of CBTC Vehicle operation shall be selectable from the Control Panel. The mode of operation of each Vehicle shall be reported to the ATS system and displayed on the TSCC dispatcher's workstation display and recorded in the TSCC event recorder.

(c) ATP Only (Vehicle)

(i) ATP Only mode of operation may be used in any CBTC area.

(ii) In ATP Only mode all vital communications between the wayside and the Vehicle shall be processed.

(iii) In ATP Only operation, the Train speed shall be controlled within the limits of the penalty brake speed profile.

(iv) Door opening and closing shall be enabled.

A. The ATP system shall allow door opening only within the limits of the Station and only on the Platform side.

(v) When a Train exceeds a service brake speed profile 2 to 3km/hr below the penalty brake speed profile, the ATP system shall request a service brake application until the Train is below the service brake speed profile. An alarm shall sound until the Train is underspeed.

(vi) When the Train is 2 to 3 seconds from an automatic service brake application, an alarm shall sound.

A. Timing of the alarm and the service brake speed profile shall be designed so that a Driver will not exceed the penalty brake speed.

(vii) If the Train speed crosses the penalty brake speed profile, an emergency brake application and removal of all propulsion power shall be initiated.

(viii) ATS speed modification commands and station hold commands will not be enforced by the Onboard Computer ATO function. However, "station hold" and "next station bypass" indications shall be provided on the CBTC control panel.

(d) ATO Mode (Vehicle)

(i) ATO is a non-vital function overlaid on the vital ATP function and operating within the limits imposed by the ATP function. ATO mode shall be initiated from the CBTC Panel. In ATO mode, the Onboard Computer ATO function controls the propulsion and braking trainlines to:

A. Limit acceleration and braking rates in order to ensure a level of passenger comfort consistent with the required Headway and run times;

B. Allow the Train to operate as close as possible to the ATP penalty brake speed profile without exceeding it;

C. Accurately stop Trains in Stations;

D. Hold Trains at Stations based on ATS commands;

E. Skip Station stops based upon ATS commands;

F. Adjust allowed acceleration and braking rates and non-vital speed limits based on ATS commands received; and

G. Adjust maximum speeds within the ATP penalty brake profile to comply with ATS energy saving or schedule enforcement commands.

(ii) Automatic door opening and closing with override shall be a configurable feature of the ATO mode of operation.

(iii) A Driver may be required to take control of Train operation even during ATO operation. The interface with the Train Control system shall be such that a Driver

may assert control of the Train with the same Master Controller handle movement as would be used if the CBTC system were in ATP Only Mode. For example, it may be necessary for the ATO function to monitor the Master Controller output as well as its own propulsion and braking requests and output to the trainlines the more restrictive of the two.

(iv) The deadman function of the Master Controller handle shall be active during ATO.

(v) Automatic correction of station overruns shall not be provided.

(vi) With future expansion into partially segregated rights-of-way with at-grade crossings, the ATO mode shall be automatically cancelled when the Train enters the partially segregated territory. The Train shall drop back to ATP Only Mode.

(e) Coupling (Vehicle)

(i) A Train Control function shall be provided to allow a Train to close in on another Train at reduced speed for coupling purposes. This function shall not permit movement into an interlocking with a signal at stop.

(ii) When two Trains or Vehicles couple, the new Train that is formed shall register with the CBTC system before Movement Authority can be granted.

(iii) When a Train decouples into two Trains or Vehicles each section shall register with the CBTC system before Movement Authority can be granted.

(f) Non-CBTC Territory Mode (Vehicle)

(i) The Non-CBTC Territory Mode is provided for operation in areas where CBTC enforcement is not applied.

A. Movement Authority shall end at the beginning of Non-CBTC Territory. In order to move the Train into Non-CBTC Territory, a Driver shall select Non-CBTC Territory Mode.

B. In Non–CBTC Territory Mode, the Onboard Computer enforces a 20km/h speed limit.

C. Upon leaving Non-CBTC Territory, Non-CBTC Territory Mode is disabled and the Train will brake to a stop until it receives Movement Authority to proceed from with the wayside CBTC system.

(g) Manual Release Mode (Vehicle)

(i) A Manual Release mode shall be provided for each Vehicle to allow a latched manual operation at a restricted speed through areas where communications has failed. The restricted speed shall be enforced by the ATP function. When

communications is restored, the Onboard Computer shall automatically disable this mode and return to ATP Only mode.

(ii) Manual Release mode shall be initiated by activating a switch which is not accessible from the cab seat. This mode is a line of sight operating mode which requires TSCC permission.

(iii) During reverse movement in Manual Release, speed shall be limited to 5km/h.

(h) ATS Automatic Mode (Line Operation)

(i) The automatic mode of the ATS system shall control interlockings and switches, as well Train dwell times, Train speeds and acceleration rates within the parameters allowed by the ATP and vital interlocking systems.

(ii) In Automatic mode, the ATS system shall enforce schedules. When delays occur the ATS system shall automatically adjust Headways, departure times and speeds to optimize recovery and return to schedule. The ATS system shall also automatically control the interlocking interfacing with the yard to build up and reduce service around rush hours with minimal disruption of mainline traffic

(iii) Automatic mode shall also automatically set up routes and clear signals to bring Trains out of the MSF to the Mainline to build up service for rush hours and take Trains off the line to reduce service after rush hours.

(iv) Two optimization options for automatic operation shall be provided:

A. Headway and schedule optimization; and

B. Energy saving.

(i) ATS Manual Operation Mode (Interlockings)

(i) In the Manual Operation mode of the ATS system, the TSCC personnel shall control interlocking signals and switches through the TSCC workstation.

A. The TSCC personnel shall be able to set up routes by selecting entrances and exits or by selecting switch position for each switch.

B. The TSCC personnel shall be able to request switch positions and block and block and unblock switches

C. The TSCC personnel shall be able to call, cancel and fleet signals.

D. The TSCC personnel shall be able to set interlockings to an automatic turn back mode with approach triggering, scheduled departure ring offs and inbound Track preference. Automatic departure schedule adjustment to recover from delays shall not be available in this mode.

5.5 Interface with Passenger Information and City of Ottawa Systems

(a) The ATS servers or similar shall provide Train location information to the Train arrival announcement system.

(b) The ATS servers shall provide data to City of Ottawa applications.

(c) Data requests and transfers to outside systems shall take place over a network other than the CBTC network. The ATS interface to outside systems shall be provided with hardware and software security measures to block outside access to the CBTC network.

(d) The OBC shall provide a location and direction trigger to the Vehicle Automatic Announcement to trigger Station announcements.

5.6 Maintenance and Storage Facility Operation

(a) The MSF shall be either CBTC or non-CBTC territory.

(b) Project Co shall Design and implement a solution for Train Control in the MSF that provides:

(i) Control of power switches and interlockings from the YCC control panel.

(ii) A display on the YCC panel of all Trains on all Tracks and the order of the Vehicles in them.

A. The level of detail shall be selectable.

(iii) Standard signal system interlocking protection such as route locking, approach locking, detector locking, etc.

(iv) Signals at all interlockings to allow safe movement of Trains without functioning onboard CBTC systems.

(v) Yard speed limit enforcement for CBTC equipped Trains.

(vi) The Design of the yard Train Control System shall allow for coupling and uncoupling of Trains on any Tracks between interlockings.

(vii) The YCC shall not control the signals and switches in the interlockings entering or leaving the yard. These shall be controlled by the TSCC and the CBTC system.

A. CBTC transponders and wireless APs shall be installed on MSF yard lead Tracks approaching the interlockings interfacing with the mainline.

B. Trains which are not registered and initialized with the CBTC system shall not be permitted to leave the MSF yard without a manual override

5.7 Monitoring and Diagnostics

(a) The Vehicle borne CBTC systems shall be provided with fault monitoring and diagnostic capabilities in accordance with Part 4 Article 3 – Revenue Vehicles.

(b) All Vehicle borne CBTC systems shall report faults to the Vehicle monitoring system.

(c) The OBC shall provide time of day correction to the VMS.

(d) All microprocessor based Vehicle and wayside Train Control Systems shall monitor and report faults to a CBTC maintenance server.

5.8 Signal Cable, Signal Case and Junction Box Requirements

(a) Signal Cable

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

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

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

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

(b) Signal Cases and Junction boxes

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

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

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

5.9 Performance Requirements

(a) Latency and Response Times

(i) Communications latency and CBTC Equipment response times shall be optimized to facilitate the Operational Performance Requirements outlined in Part 1, Article 2.

(b) Maximum Position and Speed Errors

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

(ii) The Train shall stop reliably such that all doors are located on the Platform, with the required door setbacks from the Platform ends. The Train Control System shall be designed to allow precision stopping to support the future addition of Platform screen doors.

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

(iii) The ATP speed measurement error shall not exceed 1% at constant speed on level tangent track with scheduled wheel diameter checking.

5.10 System Safety

(a) Safe Braking

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

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

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

(b) Train Operation During Train/Wayside Communication Failure

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

(ii) If the ATC Zone Controller fails to receive a location update from a Train it shall maintain the previous location for Train separation purposes. If the communications failure continues for an approved length of time, the zone controller shall use fixed block occupancy for Train location. During communications failures fixed block occupancy shall also be used for approach locking and for route and detector locking release.

(c) Response to Intrusion

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

(d) Fire and Smoke

(i) The ATC Zone Controllers shall stop any Trains from entering the Tunnel or approaching an area where smoke is detected. In the Tunnel, but beyond the fire zone, trains shall not be prohibited from moving.

(e) Broken Rail Protection

(i) The ATC Zone Controller shall enforce a restricted speed or stop through any area indicating broken rail. A warning shall be presented on the CBTC Panel when the Onboard Computer is enforcing that restriction. If investigation proves that there is no broken rail, the restriction may be lifted from a TSCC workstation.

(f) Speed Restrictions and Work Zones

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

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

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

(g) Degraded Modes of Operation

(i) The CBTC system Design shall account for degraded modes of operation and shall develop a Safety analysis of fall back operation in accordance with the standards outlined in this article.

(ii) Project Co shall also work with the City to develop and implement solutions and operational policies for degraded modes of operation such as manual operation through interlockings with switch point detection problems, failed fixed block detection units, etc.

(h) Safety Design Standards Reference Documents

(i) The CBTC system shall meet the Safety requirements of IEEE STD 1474.1 and IEEE 1483-2000 and the formal verification methods referenced in IEEE 1483, Annex A, or IEC 61508, EN 50126, EN50128 and EN 50129. All required Safety

documentation of the generic products and the specific application and the operation the OLRT CBTC/signal system shall be provided.

5.11 Reliability and Availability

(a) Overall reliability of the CBTC Train Control System shall be such that with the provided redundancy, availability is 99.99% or greater. Availability calculations shall be based on the formula:

$$\text{Availability} = \frac{\text{Mean_Time_Between_CBTC_System_Functional_Failures}}{\text{Mean_Time_Between_CBTC_System_Functional_Failures} + \text{Mean_Time_To_Restore_CBTC_System}}$$

(i) Mean_Time_To_Restore_CBTC_System includes repair crew travel time and time to replace failed Trains on the line as well as mean time to repair the failure.

(b) CBTC availability does not include failures of fixed block or broken rail detection systems or switch machines. etc.

(c) The CBTC system shall be designed for a 30 year life.

(d) Onboard Equipment

(i) The CBTC Onboard Equipment shall meet an overall requirement of 480,000 km mean distance between chargeable failures

(e) Wayside Equipment

(i) Project Co shall provide calculations for the Mean Time Between Failures and Mean Time Between Functional Failures for all provided wayside networking Equipment, ATC Zone Controllers, VMIS, ATC and ATS Servers, local ATS processors, fixed block Train detection Equipment. Actual reliability data of similar installed systems may be provided as a substitute.

(ii) Particular attention shall be paid to the reliability of the wireless communication system.

5.12 Environmental Requirements

(a) Environmental requirements measures shall be included as part of the overall System Design considerations from the start of the Design to the final in-service testing. The wayside and onboard systems supplied shall meet the temperature and humidity conditions found in Ottawa.

(b) At a minimum, all wayside Equipment shall meet all of the environmental requirements as delineated in the AREMA Environmental Requirements. Project Co shall test Equipment and submit certified test results showing the dates, locations and testing agency that performed the verification, at the City's request, unless the Equipment has

been proven in service in an equivalent environment and test results are available which can support this.

(c) The onboard Equipment shall meet the requirements of EN 50155 and the environmental conditions outlined in Part 4 Article 3 – Revenue Vehicles.

5.13 Testing

(a) Onboard Equipment

(i) All onboard CBTC Equipment provided shall be type tested for compliance with the environmental and EMC requirements of this specification. Previous successful tests of identical Equipment may be substituted.

(ii) The onboard CBTC system shall undergo system integration tests to verify compliance with the VMS Fault Plan described in Monitoring and Diagnostics section of Part 4 Article 3 – Revenue Vehicles

(iii) The onboard CBTC system shall undergo integration testing before installation on the pilot car to verify compliance with the Network Interface Control Document described in Trainlines and Networks section of Part 4 Article 3 – Revenue Vehicles.

(b) Interlocking Testing

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

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

(c) CBTC System Tests

(i) Vital communications between VMIS and ATC Zone Controllers shall be fully tested for each bit or variable transferred.

(ii) CBTC software shall be subjected to the test cycles required during development by the Safety verification standards cited in Section 5.9 of this Article.

(iii) Before any wayside or Vehicle CBTC Equipment is installed, servers, workstations, ATC Zone Controllers, local ATS processors, VMIS, APs and simulated Vehicle Equipment shall be networked together to verify interface control documents and to perform functional simulations and load testing. During load testing, network errors and delays shall be simulated to verify the robustness of communications networks and that cycle times can be met under heavy traffic and less than optimal transmission and reception conditions.

(iv) CBTC equipped pilot cars shall be used to test communications quality along the entire right of way.

(v) Safe braking and Station stopping tests shall be performed under all weather and grade conditions to verify the validity of the speed profile algorithms.

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

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

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

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

ARTICLE 6 COMMUNICATIONS

6.1 General Requirements

(a) The communications systems for the OLRT will provide vital and non-vital support to daily operations and emergency services. The communications systems are designed to be integrated throughout the entire OLRT System, including Station, Tunnels, the MSF, the TSCC, the YCC, the BCC, ventilation systems, TPSS's, and CIHs. The communications system for the OLRT shall include the following:

(i) TSCC;

(ii) CTS;

(iii) PA;

(iv) PIDS;

(v) CCTV;

(vi) IAC;

(vii) Telephone and intercom system;

(viii) SCADA;

A. Traction Power SCADA

B. Train Control SCADA

C. Building Management System (BMS)

D. Building Automation System (BAS)

E. MSF BMS

(ix) Radio Communications as provided by others; and

(x) Train-to-Wayside Wireless system.

6.2 Operational Description

(a) TSCC – The TSCC for the OLRT shall be established by Project Co at the existing Bus City control center at, Ottawa, Ontario (referred to as herein). The TSCC shall include all of the systems and subsystems necessary to provide the command, control and monitoring necessary for the delivery of the OLRT services in a safe and efficient manner. The communications elements managing these functions shall be located either in the MSF communications room or in. TSCC.

(i) The TSCC, , shall consist of three new consoles constructed in a similar manner to the existing operations consoles. These consoles shall consist of workstation GUI, desktop telephones, and headsets required to access the Train Control, radio, PA/PIDS, SCADA, and security systems. The three new consoles shall be assigned as an OLRT console, superintendent console and Maintenance console. The location of the new consoles shall be coordinated with the City.

(ii) An overview display shall be installed in the TSCC which shall provide a graphical view of the OLRT Alignment as well as CCTV camera views to assist in operational monitoring of the Platform density. The location of the overview display shall be coordinated with the City. In addition, an ergonomic study shall be performed to determine the optimum location of the overview display and overall new console layouts. The overview shall display at a minimum the following pertinent information:

A. Real time location of every train,

B. Occupancy of signal blocks,

C. Position of interlocking switches,

D. Feeder breaker status for the OCS sections,

E. Vent plant status indicators, and

F. Station escalator/elevator status indicators

(iii) The workstation GUI required for operation of the OLRT PA and PIDS systems shall be integrated with the existing PA/PIDS console within the operating theatre to establish a seamless operation of the existing and new systems. TSCC personnel shall access the PA system through a desktop microphone.

(iv) The equipment room, , shall house all fibre optic and copper cabling, associated equipment, racks, video display servers, data servers, and all other equipment necessary to establish communication over the CTS with the MSF. Project Co shall assess space at to determine equipment arrangement for communication with MSF servers. Project Co shall use the existing raised floor to run cabling between the equipment room and the operating theatre. Project Co shall coordinate, assess and provide any HVAC upgrades necessary to establish sufficient operating temperatures for the new Equipment installed in the equipment room. Project Co shall coordinate and assess any electrical expansion for the equipment room.

(v) The BCC is an emergency control center facility providing a remote location complete with the basic functioning systems to dispatch, monitor, and control operations of the OLRT in case the TSCC at is unavailable.

(b) The CTS shall provide hi-speed fibre optic communications transmission for the various communications subsystems, including, CCTV, PA, PIDS, telephone, IAC system, fare

collection, train to wayside communications, fire life safety and SCADA systems, Train Control data communication shall be on a separate wireless network, see Article 5 – Train Control for details. The CTS shall be comprised of both fibre optic cabling and copper cabling with dual redundant hi-speed network nodes located at each Station, the main communications room at the MSF, and the TSCC data room.

(i) The CTS network shall include a WAN component and LAN component. The LAN shall provide local network traffic switching and aggregation of the network traffic at each OLRT Station, MSF, and TSCC for transport over the CTS WAN. The WAN shall be the core/backbone that connects all the local area networks and shall be able to interface with the Stations, MSF, TPSS, CIH and TSCC LANs.

(ii) The CTS shall include a NMS, which shall manage the network Equipment/device for fault, administration, configuration, performance, and security. The NMS shall be located in the main communications room located in the MSF. The NMS shall be accessed from an administration workstation located in the main communications room.

(iii) The CTS shall include a firewalled server which is configured to provide security for and access to non-vital components of the OLRT CTS system. The server shall allow external approved parties to retrieve operational performance and travel data (Open Data) for third party applications. This server shall produce Open Data in an XML format and will be designed to be interoperable with SIRI or other applicable standards.

(iv) In addition to the CTS, Project Co shall provide the ductwork for the City Highway Operations IT infrastructure optical fibre upgrade. Coordination of the ducts shall be undertaken with the City Highway Operations Department to ensure sufficient spare capacity, physical space and access are available for the installation of an additional 24 way optical fibre to the CTS requirement. The 24 way optical fibre shall be accessible at locations determined by the City Highway Operations Department through strategic breakout points located adjacent to the duct banks as detailed in Table 6.2.1 Each breakout point shall provide for a cabinet or housing and shall be supported on a concrete pad with duct or conduit. Any supporting trench work to link to the adjacent highways manholes to the breakout point on or near the Alignment will be accommodated by a separate contract undertaken by the City Highway Operations Department. The installation of cables will be undertaken by others.

(v) Project Co shall ensure that the ductwork alongside the Alignment (including the connection to the MSF) have the spare capacity for the insertion of this additional 24 way optical fibre cable by the City Highway Operations Department. The planning and installation of the ductbanks shall also be coordinated with the OTrain Expansion project and the ductwork terminated at the Bayview access point within the Lands to allow a separate contract to terminate or connect to the ductwork in the directions of Tunney's Pasture and Blair Stations.

(i) Table 6.2.1

(c) PA – Each OLRT Station shall be equipped with a PA system to broadcast audio announcements of arrivals, departures, general and Emergency/security information from a microphone or headset connected to the PA/PIDS console located in the TSCC. The PA system shall provide uniformly distributed audio throughout public areas of the Stations and shall be synchronized with the LRV announcements, see Part 4 Article 3 – Revenue Vehicles for details.

(d) PIDS – Each OLRT Station shall be equipped with PIDS signs to provide up-to-date, specific, location-based, visual operational and Safety-related messages for patron awareness. The PIDS shall be individually addressable and shall be accessed from the PA/PIDS console located in the TSCC. Under normal operating conditions, information presented on the PIDS shall include, but not be limited to: date, time, arrival time and destination of next Train, Safety messages, Train delays, holiday schedules, and other ad-hoc messaging. In an Emergency condition, the PIDS shall display both pre-programmed emergency announcements and simultaneous visual display of the PA system emergency announcements.

(e) CCTV System – The CCTV system shall serve both operational and security needs of the OLRT system. The CCTV system shall allow operations, security, and emergency personnel the ability to monitor elements of the system remotely from the TSCC. Operational views of the Platforms shall also be made accessible to LRV Drivers through a data connection over the Train to wayside wireless network to allow the operator the ability to safely operate and monitor the Vehicle doors. Vehicle side mounted cameras shall only be permissible when used solely for the purpose of secondary or supplementary video images to those images generated from the Platform camera views. Security related views, outside of the MSF, shall only be accessible by authorized

personnel within the TSCC. Project Co shall undertake a risk and safety assessment of the OLRT system and shall install CCTV's and / or any other security devices as an outcome of the assessment.

(i) CCTV Cameras shall meet the following requirements:

A. Provide CCTV in keeping with CPTED principles, including but not limited to CCTV coverage of entrances to washrooms, bicycles parking areas, platforms, train doors, corridors, and stairways;

B. CCTV cameras shall cover every door of the Train servicing the Station;

C. CCTV cameras shall cover all DWA. PTZ cameras shall not be used for the DWA; and

D. CCTV cameras shall monitor all Tunnel access and egress points.

(ii) The CCTV system shall be proactive in determining intrusion into the Alignment and private areas through the use of sensors and/or video analytics. The CCTV system shall be interfaced to the emergency intercoms and access control readers so that any events are automatically recorded at higher frame rates and resolution.

(iii) Where any justification is found in the safety and risk assessment, CCTV images shall be transmitted from the station area to the vehicle. Recorded video shall be downloaded from the on-board vehicle CCTV system at the MSF for long term storage of the video.

(iv) The CCTV system shall have video storage servers to store video for 31 days with sufficient resolution and frame rates required for evidence in a court of Law. Long term storage servers and system management servers shall be installed in the Data Room at. Backup system servers shall be installed in a Data Center and utilize the existing data connection between the Data Center and.

(f) IAC – This system shall control access and provide for detection of intrusion into non-public or otherwise restricted areas in Stations and along the OLRT Alignment. Project Co shall work closely with the City to ensure future compatibility with the City IAC system. Intrusion sensors shall sound an audible alarm locally and trigger an automatic alarm notification to the workstation GUI in TSCC for unauthorized entry or tampering to IAC Equipment.

(g) Access Cards – Access cards will provided as follows:

(i) Access cards shall be provided by Project Co to approved staff for entry into the MSF, CIHs, TPSS, and vent plants. This system shall be compatible with the existing IAC system.

(ii) Access cards shall be provided to Project Co staff for entry into private station areas and the TSCC.

(h) Telephone and Intercom System – The telephone and Intercom system shall provide emergency and non-emergency voice grade communications. All telephones shall use VoIP and route through the existing PBX. The emergency intercom systems (e phones and elevator help) shall provide a direct connection to the TSCC. Staff telephones shall be deployed in specific locations in the Stations and the TSCC to support OLRT operations. Emergency intercoms and staff telephones shall be VoIP and shall be routed through the City's existing PBX. Maintenance telephones shall be deployed in the MSF, TPSSs, CIHs, and vent plants and shall route through Project Co's own PBX installed in the MSF.

(i) SCADA – The SCADA system shall provide supervisory control of the OLRT and support systems. The SCADA system(s) provided shall be of the same manufacturer. The systems servers shall be located at the MSF and shall manage all system controls and indications for the OLRT. The SCADA system shall provide a GUI for operations in the TSCC, BCC, and YCC with the ability to filter out unnecessary indications and alarms according to user preference. There are a total of five (5) SCADA system functions required including:

(i) Traction Power – The Traction Power TPSS SCADA shall be an on-line, real-time, interactive system operated by TSCC personnel at the maintenance console to monitor and control power distribution and Equipment;

(ii) Train Control – The Train Control system shall have a separate Train Control SCADA monitoring system operating over the CBTC wireless network. Refer to Part 4 Article 5 – Train Control for details;

(iii) Building Management System – The BMS system shall monitor Station mechanical and electrical Equipment. Refer to Part 5 Article 4 – Mechanical Design Criteria for details;

(iv) Building Automation System – The BAS system shall monitor and control Tunnel ventilation systems and FLS systems. This system shall be compatible with the existing City systems and be interlocked with the fire management panel. Refer to Part 5 Article 5 – Electrical Design Criteria for details; and

(v) MSF BMS – The MSF BMS shall monitor and control MSF mechanical and electrical Equipment, pumps, levels, Shop TPSS, and maintenance equipment. This shall be a Project Co controlled system that is a separate system from the City BMS system and shall report to the YCC. See Part 6 Article 7 – Communications and PA System for details.

(j) Radio Communications – The OLRT shall utilize radio channels made available by the City of Ottawa Public Safety Service Radio System. The current Ottawa PSR is a trunked system with fourteen (14) voice and one (1) control channel in the UHF band (800 MHz). This system is presently used by the City of Ottawa Police Services, OC Transpo operations, Ottawa Fire Services, and the Ottawa Paramedic Service and will be upgraded as a separate contract by 2015. Project Co shall work in partnership with the

City and the Radio System Supplier to determine costs, maintenance and licensing fees for radio equipment necessary to meet the OLRT Project requirements. A radio dispatching workstation currently exists in the TSCC and will be upgraded as part of a separate contract with OC Transpo. Project Co shall install a dispatch workstation for installation in the YCC and BCC at the MSF or alternative position. Project Co shall be responsible for the procurement of the Radio Systems and shall work in partnership with the City and the Radio System Supplier to determine the radio requirements, mechanical and electrical interfaces, installation requirements, component type, quantity, costs, maintenance, testing arrangements and licencing fees for Radio equipment necessary to meet the OLRT Project requirements.

(i) Project Co shall allow the Radio System Supplier site access to manage the supply, installation and testing of the radio system within the OLRT alignment, and shall enter into a formal agreement to facilitate such access.

(k) Train-to-Wayside Wireless System – There are two separate wireless data systems required for supporting the transfer of data between the Trains and the Wayside.

(i) Project Co shall provide a wireless data system for the support of the OLRT CBTC system. This system shall have a separate fibre optic network that provides connectivity to APs along the Alignment. This system is only for CBTC, no other data systems shall be permitted on this network. See Part 4 Article 5 – Train Control for further description of this system.

(ii) Wireless APs shall be provided at each Station and within the MSF. These APs shall support the transfer of Revenue Vehicle diagnostics and, where justified by the safety and risk analyses, the transfer of live video between the Revenue Vehicles and the data servers located within the nearest communications room. Where also justified by the safety and risk analyses, the system shall also support the delivery of live video from the platform area to the vehicle.

6.3 Performance Requirements

(a) TSCC

(i) The TSCC shall contain three (3) new PC-based consoles/workstations whose functions will vary based upon the responsibility and access rights of the person who is logged on at that workstation at any given time. These consoles/workstations shall be provided for the LRT superintendent/supervisor, the LRT dispatcher, and maintenance console. Each console shall be capable of supporting any function within the OLRT systems. The system shall allow dispatchers to swap display views between the workstation GUIs and Overview displays.

(ii) A GUI on the console workstations shall provide a view of the LRT System in its entirety along with additional graphic details available by section or discipline within the transit line.

(iii) A graphical overview of the OLRT System as well as CCTV camera views to assist in operations monitoring of the Platform density, shall be provided on new video wall displays. The display shall exhibit the same level of detail as available on the dispatcher and supervisor/superintendent consoles and shall be easily visible throughout the operating theatre.

(iv) The TSCC shall provide a comfortable and ergonomic environment for operations and maintenance personnel. The consoles provided shall match the style and color and conform to the existing consoles to appear as one integrated control room.

(b) CTS

(i) The CTS shall include fibre optic and copper cable plant, network transmission Equipment, NMS, and other Equipment necessary for a complete communications network. Project Co shall provide a minimum of 50% spare fibre and network capacity for future expansion of the CTS.

(ii) The CTS shall be a high bandwidth and fault tolerant system. The CTS system shall be of a compatible design with that of the existing City system and shall have no single point of failure. Project Co shall be responsible for maintaining the existing OC Transpo optical fibre feeds to the BRT stations at all times and shall refer to the Utility article for the scope of the duct allocations. The CTS WAN shall be configured in a path-diverse topography in order to minimize disruption to the network in the event of a failure. WAN network Equipment shall support fast (sub-50 milliseconds) automatic network convergence (self-healing) in the event of a network link failure.

(iii) CTS Equipment shall include redundant power supplies. In the event of a power outage, CTS Equipment shall remain operational for a minimum of 24 hours through the use of uninterruptible power supplies, generators, and/or other backup power Equipment.

(iv) The NMS shall automatically discover network devices and network connections. In the event of a network failure, the NMS shall perform root cause analysis to pin-point location of failure. The NMS shall provide graphical reports and support export of reports.

(v) The CTS system shall be designed such that these component failures are minimized by redundancy. The availability of the system (i.e. availability of all system hardware, cabling) shall be greater than 99.9%, defined by more than 50% of circuits to any operational CTS.

(c) PA System

(i) Announcements shall be addressed to single and multiple zones within individual and/or groups of Stations. Separate zones with separate amplifying channels and

speaker systems shall be accessible individually or in combination. Stations shall have up to five (5) zones covering each Platform, mezzanine, and ancillary area.

(ii) PA system shall maintain a uniformly distributed sound level at least 10 dB above ambient Station operating noise level measured at 1.5 m above floor for indoor Stations. Outdoor Stations shall be not less than 60 dB plus or minus 30 degrees off axis, 1 meter above the floor, at Vehicle ambient noise level.

(iii) Automatic gain adjustment of the PA system shall be provided based upon ambient noise levels captured by ambient noise sensors. The system shall adjust volume and clarity in proportion to the increase in noise level from a preset quiet level.

(iv) The PA system shall be capable of playing pre-recorded messages in both English and French. All pre-programmed messages shall be provided in both languages.

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

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

(vii) The PA announcements from TSCC shall be delivered to the station PA controllers over the CTS using TCP/IP protocol.

(viii) In the event of a power outage, PA Equipment shall remain operational for a minimum of 4 hours through the use of uninterruptible power supplies, generators, and/or other backup power Equipment.

(ix) The PA system shall be designed to accept several competing inputs with successful transmission designated according to assigned priorities. Project Co shall coordinate with OC Transpo to determine priority levels. The system shall be prioritized for TSCC communications consoles, station microphone, fire alarm panel, and pre-recorded announcement devices.

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

(xi) The PA system shall be coordinated with in-Vehicle public address systems to prevent audible delays between the two systems while a Vehicle is at the Station.

(xii) The PA system announcements shall be recorded on the existing City voice recorder at.

(xiii) The local station PA systems shall accept an additional mixed input from a secondary audio channel. This secondary system shall be muted or attenuated on arrival and departure of the trains or when safety critical public announcements are made.

(d) PIDS

(i) Project Co shall design and furnish a PA/PIDS Customer Service Consoles which includes a desktop microphone, headset microphone, line audio speaker/monitor, and a PC workstation.

(ii) The Contractor shall design and furnish a GUI to serve as the means for operating the PA/PIDS System and for using the Administrative applications. No part of the PA system software shall be a command line based system.

(iii) This GUI shall have all the user selectable features and functionality of the existing PA System GUI, and shall include a provided geographical map of the entire rail system.

(iv) The PIDS shall provide a centralized message generator (that includes message creation, storage, and selection) and dispatch functions at the PA/PIDS workstation in the TSCC to address individual zones, Stations, groups of Stations, or System-wide announcements. Stations shall have zones covering each Platform, mezzanine, and ancillary area that roughly correspond with the PA system zones.

(v) At a minimum, the PIDS units shall be provided on the mezzanines of underground Stations and Platforms of all Stations as follows:

A. At mezzanine level of underground Stations, PIDS displays shall be provided near the fare collection areas. The PIDS display screen shall be in plain view of the patrons purchasing fare cards, patrons approaching the fare card machines, and for the patrons approaching the rail System's paid area; and

B. On each Platform, PIDS displays shall be provided such that at least one display is visible and legible from any location along the Platform edge. Separate displays shall be provided for each Platform edge on center Platforms. Displays shall be placed to maximize visibility throughout the Platform area.

(vi) PIDS shall have the capability of displaying messages in both English and French. All pre-programmed messages shall be provided in both languages.

(vii) The PIDS shall be designed to accept several competing inputs with successful transmission Designated according to assigned priorities. Project Co shall coordinate with OC Transpo to determine priority levels. The system shall be

prioritized for TSCC communications consoles, fire alarm panels, and pre-recorded announcement devices.

(viii) The PIDS shall work in conjunction with the PA system to provide synchronous broadcasting of audio and visual pre-recorded announcements and to enable near-synchronous transmission of live announcements. The PIDS head end may be a shared software platform as part of the PA system.

(ix) The PIDS shall be fully supervised with failure annunciation at the TSCC of all major system components such as PIDS displays, Station controllers, and power supplies.

(x) All PIDS announcements shall be recorded in database on the PIDS system servers.

(xi) All PIDS shall display station time, which will be synchronised with the central time server over the CTS.

(xii) In the event of a power outage, PIDS Equipment shall remain operational for a minimum of 4 hours through the use of uninterruptible power supplies, generators, and/or other backup power Equipment.

A. PIDS signs shall have a visual 'out of service' message when the sign is not operational.

(xiii) All PIDS signs shall be environmentally housed to prevent damage from moisture, dust, and vandalism. Outdoor signs shall be equipped to ensure readability in direct sunlight as well as protection from ultraviolet, rain, and atmospheric damage.

(e) CCTV

(i) Project Co shall provide a CCTV system based on Good Industry Practices, for example as described in the most recent edition APTA Standards Development Program Recommended Practice CCTV (APTA IT-CCTV-RP-001-11)

(ii) The CCTV system shall comply with Canada's Freedom of Information and Protection of Privacy Act.

(iii) The system shall include both fixed and PTZ cameras. Cameras shall be rated for the environment installed, including day/night capabilities, heater/blower, appropriate housing, etc.

(iv) Camera locations shall be strategically selected to ensure the views are clear, unobstructed, and not impaired by structures, signage, foliage, intense lights, or any other obstacles. Camera views of the fare collection area shall be arranged to provide images of the customer's frontal interface with the equipment.

(v) The CCTV system shall interface to the emergency telephone systems. Upon activation of passenger emergency telephones or elevator help telephones, the CCTV system at the TSCC shall automatically display the CCTV camera with the best view of the telephone area and, if necessary, automatically pan the nearest PTZ camera to monitor the area of the telephone.

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

(vii) The system shall automatically archive all alarm events automatically detected (e.g. IAC alarms, emergency telephone system activations, CCTV analytic alarms) to the TSCC head-end storage system.

(viii) The system shall have the capability to manually archive video at the TSCC for later review and retrieval. Recordings shall be digitally watermarked to prevent tampering. Access to recordings shall be restricted to Transit Law personnel only.

(ix) The system shall capture, record, store, download, view (playback), and allow monitoring of all CCTV cameras. The system shall be capable of providing simultaneous viewing, recording, and playback.

(x) The resolution and clarity of captured images shall be maintained under a range of lighting conditions from darkness through bright sunlight while ensuring optimal picture quality.

(xi) The system shall provide spare storage capacity to protect for the addition of up to 40% video inputs for future expansion.

(xii) The system shall allow an administrator to dynamically specify resolution and frame rate variation at a particular camera location for monitoring that location while not affecting the recording parameters.

(xiii) Cameras shall have de-icing and lens clearance protection. All cameras shall have a unique identity and provide a means of detecting image loss.

(xiv) The system shall store all recorded images in an accepted industry standard format.

(xv) In the event of a power outage, CCTV Equipment shall remain operational for a minimum of 4 hours through the use of uninterruptible power supplies, generators, batteries, and/or other backup power Equipment.

(f) Intrusion Access Control System (IAC)

(i) Access authorization shall be verified based on data submitted from any credential and retained in the system controller database, granting access by releasing electronic door locks once all correspondence is deemed accurate.

(ii) All access decisions/credential transactions shall be processed locally at the card reader interface board as it receives data from the system controller, minimizing network traffic while also providing real-time access determinations.

(iii) All cardholders shall have access based on facility, card reader, time, and day. The system shall allow the administrator to define access levels and apply them to any or all cardholders. Access authorization shall be denied by credential holder, time of day, group of staff, shift, and any additional characteristics that are identified by the system controller database.

(iv) The system shall provide controlled access and detect intrusion of the following:

A. Public to non-public doorways;

B. TPSS;

C. CIH;

D. Communication rooms;

E. Elevator machine rooms;

F. Escalator machine rooms;

G. Electrical equipment rooms

H. Vent Plants.

(v) The system shall also detect intrusion at Tunnel entrance/exit portals and Tunnel Station portals for any large object (i.e. human, large animal) intruding into the vicinity of the Tunnel portals. Intrusion detections shall provide an alarm at both the TSCC and the Driver panel of the approaching LRVs.

(vi) Provisions shall be made for remote signalling of the door opening to an IAC Panel.

(vii) The system shall provide a means to bypass zones for facilities/locations where certain alarm zones are not 24 hour zones and be capable of being armed and disarmed from the TSCC.

(viii) The system shall incorporate an interface to the fire alarm panel to allow override of door locks in an emergency situation.

(ix) The IAC system shall be interfaced with the CCTV system to allow the display of video of the nearest CCTV camera upon activation of an IAC alarm or use of an access control device at the TSCC.

(x) Safety and security warnings and signage shall be provided.

(xi) In the event of a power outage, IAC Equipment shall remain operational for a minimum of 4 hours through the use of uninterruptible power supplies, generators, batteries, and/or other backup power Equipment.

(g) Telephone and Intercom System

(i) The Telephone and Intercom system shall provide emergency and non-emergency voice-grade communications for the OLRT Project. The system shall include the following subsystems:

A. E phone emergency telephones;

B. Elevator help telephones;

C. Staff telephones; and

D. Maintenance telephones.

(ii) Emergency telephones shall be well marked. Emergency telephones shall be of similar construction to existing phones and shall be installed every 30m along the platform and in the DWA.

(iii) E phone emergency telephones and elevator help telephones shall interface with the CCTV system to automatically provide video of the area at the TSCC receiving a call from these phones. A minimum of two cameras shall view the areas so that cameras cannot be purposely panned away from possible incidents.

(h) SCADA System

(i) The SCADA head-end equipment consists of master terminal equipment, including servers and workstation GUIs, to control, monitor, gather data and communicate with OLRT field equipment. The SCADA system shall be a continuous, dynamic scanning type for gathering information and status indication of all points. Each point will be sequentially scanned point by point under normal conditions and the status of all points shall be continuously transmitted to the SCADA head-end.

(ii) The SCADA head-end ascribed functions shall be accomplished via the Remote Terminal Units (RTUs).

(iii) The SCADA system shall facilitate the transmission of indications and alarms from the RTUs to the TSCC and the transmission of controls from the TSCC to the RTUs via the CTS.

(iv) Signals transmitted from the RTUs to the processors at the TSCC shall be processed to provide monitoring information to all required subsystems, generate commands to be transmitted back to the RTUs, provide information for displays and alarm processing at the control consoles, and store information and historical data for future processing.

(v) For each remote location, the SCADA system shall display the following items on the SCADA monitoring workstations in the TSCC:

A. Current system and subsystem status;

B. Control panel status;

C. Remote control RTU functions;

D. Alarm handling and fault resets; and

E. Historical event logging.

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

(vii) Each RTU shall be designed to interface to the CTS. The RTU shall have electrical isolation between the system inputs/outputs and the CTS units.

(viii) Redundant server processors shall be provided and configured in a primary/backup mode to support automatic failover to the backup processor upon failure of the primary processor.

(ix) Each remote, monitored location shall provide a local HMI for local alarm annunciation and system control.

(x) Emergency conditions shall immediately be displayed within 3 seconds on the workstation GUI operating displays to permit the monitoring of device actions by the TSCC .

(xi) SCADA servers and related processing Equipment shall be located at the main communications room in the MSF and connected to a redundant or dual LAN.

(xii) High availability application servers shall perform real-time data acquisition and processing, generation of supervisor control commands, database queries, overview display, alarm management, executing of diagnostic, administrative and maintenance programs. The computer system shall produce, at a minimum, alarm and related logs, summaries, and other user defined reports.

(xiii) Schematic, one-line, pictorial, and alphanumeric displays of the SCADA system shall have the capability to be generated, altered, or deleted online by a GUI.

(xiv) As a part of initial system sizing, the SCADA system shall be provided with the processing capability and memory required for the OLRT Project. The SCADA system shall be designed for ease of expansion and alteration in an economical and efficient manner to protect for future OLRT expansion.

(i) Radio Communications Systems

(i) The train voice radio system, provided by others, shall cover the entire length of OLRT within the right-of-way, both above and underground Stations, yard, and MSF. Project Co shall work with the Radio System Supplier to determine quantities of radio equipment required to efficiently operate and maintain the LRT System.

(ii) Project Co will be part of a larger user group for the City of Ottawa Corporate Radio System and are identified as follows:

A. For the OLRT normal day-to-day operations:

i. LRV

ii. TSCC staff

iii. Project Co staff

iv. Transit Law

v. OC Transpo bus operation staff

(iii) The train voice radio system shall support fixed, mobile, and portable radio units. Project Co shall establish a separate contract for the provision of radios and maintenance with the Radio Supplier who will provide Project Co with the necessary radios for OLRT operations and the associated installation and testing. Project Co shall provide specifications of performance and quantities of equipment required to efficiently operate and maintain the LRT System.

(iv) The radio supplier shall implement a diagnostic and monitoring system for monitoring the active components used in the radio system. Any failures shall be immediately reported to Project Co and appropriate maintenance carried out by the radio installer. Project Co shall provide operational procedures in the event of loss of radio communication.

(v) Should Project Co require the use of the existing City of Ottawa Corporate Radio System during the OLRT construction period, Project Co shall negotiate terms and conditions with the City and radio supplier. In the event that the radio

specification and performance is insufficient for Project Co's requirements, Project Co shall make alternative provisions.

(j) Train-to-Wayside Wireless System

(i) Project Co shall provide a Train-to-Wayside wireless system that shall provide all LRVs with a high speed data connection at each Station and at the MSF for the data transfer of Train diagnostics, passenger count provision and CCTV video from the VCU.

(ii) The Train-to-Wayside wireless system shall be an extension of the CTS. A LAN connection shall be provided between the wireless APs and the nearest communications room in order to connect to the CTS WAN.

(iii) The system shall provide the latest wireless technology standards with backwards compatibility of established standards as needed.

(k) Systems Infrastructure Interface

(i) Each communications system element has a requirement for both power supply and data transmission.

(ii) Project Co shall supply and connect the power systems necessary for each communications device to operate properly to each device location.

(iii) Project Co shall supply and connect the data transmission systems necessary for each communications device to operate properly to each device location.

(iv) Project Co shall provide the power provisions and data provisions necessary for each fare collection device to operate properly to all communication rooms.

ARTICLE 7 FARE COLLECTION

7.1 General Requirements

(a) Power source provisions shall be provided within the communications room electrical service for all fare collection equipment needs.

(b) Data communication channels shall be provided within the communications room via the CTS so that fare vending Equipment may communicate with fare collection head end Equipment and accounting personnel located within the TSCC.

(c) All fare collection Equipment (Ticket Vending Machines, validators and servers) to be provided by others.

(d) Refer to Part 5 Article 5 – Electrical Design Criteria for Project Co responsibilities related to conduit for fare collection Equipment.

7.2 Equipment Description and Features

(a) Ticket Vending Machine

(i) Power, data requirements and Equipment size

A. Power for the TVM shall be provided by a single circuit breaker protected line delivered by underground conduit to the base of each TVM.

B. Data lines shall be provided to the base of the TVM from underground conduit using CAT 6 cable.

(b) Validators

(i) Power, data requirements and Equipment size

A. Power for the validator shall be provided by a single circuit breaker protected line delivered by underground conduit to the base of the validator.

B. Data lines shall be provided to the base or mounting devise of the validator from underground conduit using CAT 6 cable.

ARTICLE 8 OVERHEAD CATENARY SYSTEM

8.1 General Requirements

(a) This section provides the criteria for the OCS, including technical, operational, maintenance, local climatic and economic considerations.

(b) The OCS consists of the catenary system and their physical supporting structures. The OCS distributes DC power from substation to the LRVs operating on the mainline Tracks, yards and within the MSF through the pantograph interface.

(c) On mainline, the catenary shall be designed to include a wire tensioning system to maintain constant tension throughout its tension length. Where a simple catenary system is implemented, the wire tensioning system shall consist of balance weight assemblies with pulleys mounted out of running, one span away from the overlap transition span and supported with standard anchorage assemblies. The balance weight operating range shall accommodate the designed tension length.

(d) Project Co shall blend the appearance and style of the overhead catenary system into the adjacent communities and at visually sensitive areas including, but not limited to the following elements:

(i) Pole size, shape and color;

(ii) Location of the pole; and

(iii) Special attention shall be paid to the design of the catenary system and supporting system in visually sensitive areas of the alignment corridor as follows:

A. Within all Station Platform areas extending 15m to either side of Platform end;

B. From the West Portal to west of Bayview Station where the Tracks enter the existing BRT trench;

C. From the East Portal to Tremblay Road east of the VIA "D" loop road;

i. Excluding where the elements of the catenary system are located within the existing BRT trench in the vicinity of Lees Station.

D. In visually sensitive areas of the alignment corridor, closed or tapered sections shall be used.

(e) Design shall include components that:

(i) Are standard and off-the-shelf, available from multiple suppliers;

(ii) Have a proven maintenance performance; and

(iii) Maintain functionality even during extreme weather conditions and temperature changes as defined in the Output Specifications.

(f) In addition, the Design shall take into consideration existing overhead obstructions such as Bridges, overpasses, buildings and aerial Utilities that may impact the final layout.

8.2 Operational Requirements

(a) The OCS shall be comprised of the following major items:

(i)	Catenary Wires	Messenger and Contact/Trolley;
(ii)	Feeder Cables	Feeders from Substation to Catenary;
(iii)	Supports	Cantilever or Cross-Span;
(iv)	In-Span Materials	Hangers, Jumpers, Splices, etc.;
(v)	Midpoint Anchors	Tie Wire and Downguy Assemblies;
(vi)	Poles	Poles both Center and Wayside;
(vii)	Foundations	Drilled Shaft and Ground Connections;
(viii)	Lightning Arresters	Surge Protection;
(ix)	Structure Guying	Termination, Anchors;
(x)	Tensioning Systems	Balance Weight Assembly with Weights and Pulley Systems;
(xi)	Insulated Overlaps	Sectionalization;
(xii)	Section Insulators	Isolation; and
(xiii)	Disconnect Switches	Isolation.

(b) OCS Configuration and Tension Systems

(i) The OCS system shall be designed to meet:

A. Line speed;

B. Clearance;

C. Mandatory national standards;

D. Climatic and environmental constraints;

E. Vehicle power consumption and amipacity determined by the operational performance requirements; and

F. Traction Power load flow simulation.

(ii) Where there is a requirement for the transition between the two types of catenary, it shall be accomplished by a full catenary parallel wire overlap. The fixed termination overlap catenary shall be supported by an intermediate cantilever structure on the catenary at midspan.

8.3 Design Parameters

(a) The design parameters are outlined in Table 4-8.1.

Table 4-8.1

Ambient Temperature Range	In accordance with environmental conditions referenced in Section 15-2, Part 1 and Part 4
Auto Tension Temperature Range	In accordance with environmental conditions referenced in Section 15-2, Part 1 and Part 4
Heavy Ice Loading	In accordance with environmental conditions referenced in Section 15-2, Part 1 and Part 4
Maximum Design Train Speed	100km/hr, mainline 30km/hr, yard lead Tracks 15km/hr, MSF
Elevation Above Sea Level	60m

8.4 Electrical Clearances

(a) Clearances shall be maintained between live conductors, including pantographs and any grounded structures, in accordance with Table 4-8.2.

Table 4-8.2

Clearances	Static	Passing
Normal Minimum	155mm	130mm
Absolute Minimum	130mm	80mm

Where:

(i) Static clearance is the clearance between the catenary system and any grounded structure when not subject to pantograph pressure.

(ii) Passing clearance is the clearance between the catenary system or pantograph and an overhead structure under actual operating conditions during the time it takes the Train to pass.

(b) Mechanical clearance from the pantograph to any fixed item, excluding the steady arm or registration arm of a cantilever, shall not be less than 130mm. Pantograph clearance to steady arm shall not be less than 38mm.

(c) For Vehicle related clearance, full allowances shall be included for dynamic displacement of the Vehicle under operating conditions, including tolerances for installation and maintenance of the Track.

8.5 Height, Depth and Gradient Requirements

(a) The nominal contact wire height above top of the rail at Track centerline shall be in accordance with the requirements outlined in CAN/CSA C22.3 No. 1 & No. 8 as detailed in Table 4-8.3.

Table 4-8.3

Route Description	Track Type	Type of OCS	Contact Wire Height (mm)
Tunnel	Direct Fixation	Fixed Simple Catenary	4200 minimum
Open Route Alignments	Ballast	Auto –Tension Simple Catenary	5500 normal 4880 exclusive way
Yard Tracks	Ballast	Fixed Trolley Fixed Simple Catenary	6500 maximum 5700 minimum
Road Crossing	Embedded	Auto-Tension Simple Catenary	5700 minimum
Overhead Bridges	Ballast	Auto-Tension Simple Catenary	4800 desirable 4280 absolute minimum

(i) The contact wire height at supports shall take into consideration the effect of wire sag, due either to temperature rise or to ice loading, and installation tolerance, including Track Construction and maintenance tolerances.

(b) The system depth is defined as the height or distance between the messenger and trolley wires at the point of support. The nominal system depth is outlined in Table 4-8.4.

Table 4-8.4

Locations	System Depth, Nominal

Open Route Alignments	1220mm
Tunnel or Underneath Overhead Bridges	152mm
Yard Loop Tracks	1220mm

(i) These heights may vary at specific locations for the profile through Tunnel structures or under overhead structures.

(c) The contact wire gradient is defined as the rate of change in elevation of the contact wire with respect to TOR. Where possible, the contact wire grade shall match the grade of the Track for a contact wire gradient of zero.

(i) Table 4-8.5 presents the maximum gradient as per CAN/CSA C22.3 No. 8-M91:

Table 4-8.5

Train Speed	Maximum Contact Wire Gradient
Yard (15 km/hr) Yard (30 km/hr)	2.3% (1:43), Storage and Maintenance Tracks 2.0% (1:50), Yard Lead and Loop Tracks
50 km/hr	1.3% (1:77)
75 km/hr	0.8% (1:125)
100 km/hr	0.6% (1:167)

(ii) Except for MSF conditions, the change of grade from one span to the next shall not exceed one half the values shown above.

8.6 Horizontal and Vertical Clearances

(a) Side clearance shall be measured from the centerline of tangent Track. Minimum side clearances shall be as outlined in Table 4-8.6.

Table 4-8.6

Location	Horizontal Clearances
Tangent Track	1890mm to face of pole
Outside of Curved Track	Increase 12.5mm per degree of curve to the clearance for tangent Track
Inside of Curved Track	Increase 12.5mm per degree of curve and 2 times the actual super-elevation to the clearance for tangent Track

(b) The minimum vertical clearance above top of the rail at Track centerline is governed by the overhead catenary clearance requirements as outlined in Table 4-8.7.

Table 4-8.7

Route Description	Type of OCS	Minimum Vertical Clearance
Tunnel	Fixed Simple Catenary	4700mm
Overhead Bridges	Auto-Tension Simple Catenary	4800mm (note i) 4500mm (note ii)
Station Areas	Surface Alignment Underground	5500mm 4800mm

Notes:

(i) This represents the minimum for Construction of any new overhead Bridges.

(ii) This represents the acceptable minimum for existing structures, provided that the Track is tangent and a direct fixation type and the catenary can be suspended between poles spacing 18 meters maximum or supported from the existing overhead Bridges and structures.

8.7 Loading and Overload Factors

(a) Loadings and overload factors shall be based on the most current NESC requirements.

8.8 Strength Requirements

(a) The OCS shall be designed in accordance with the strength requirements specified in NESC Section 26.

8.9 OCS Wire Tensions and Tension Lengths

(a) The following shall be the base wire tensions for the stated tensioned system with a base temperature of eight (8) degrees Celsius:

(i)	Surface Alignment (Auto-Tension):	Messenger	2700 kg
		Trolley	1350 kg
(ii)	Tunnel and MSF Lead (Fixed Termination):	Messenger	2200 kg
		Trolley	1100 kg
(iii)	MSF Tracks (Fixed Termination):	Trolley	1100 kg

8.10 Sectionalizing Requirements

(a) The overhead catenary system shall be electrically sectionalized by means of insulated overlaps near each substation. The OCS Design shall adopt a combination of both insulated wire overlaps and section insulators (sleds). The OCS shall require sectionalization at crossovers, the MSF, and other special Trackwork. Section insulators

shall be used at crossovers, pocket Tracks, turnout, and siding locations. Overlaps shall not be placed on sharp curves.

(b) Additional sectioning may be required at specific sensitive areas of the Alignment where EMI considerations are required to be mitigated.

(c) Sectionalizing at Interlocking

(i) The sectioning of the standard two Track crossover arrangement, facing or trailing, shall be the standard arrangement of three (3) switched mainline insulated overlaps, and two (2) section insulators in the crossover wires. Diamond crossovers shall have insulated, and switched overlaps on both Tracks and on both ends of the interlocking and section insulators in the crossovers. The positioning shall be capable of allowing a single Train (5 cars) to pass the Track switch and signal.

(d) Sectionalizing in the MSF

(i) The Tracks in the MSF area shall be divided into working groups of four (4) Tracks or less. Exceptions may be granted for more Tracks of shorter lengths. Each group shall have a manually operated switch and section insulators to accomplish the section isolation. The catenary for the entrance to and exit from the MSF shall not be fed from the same DC breaker.

(e) Sectioning at the Maintenance and Storage Buildings

(i) Each Track inside the MSF buildings including the paint shop shall have the capability of individual sectionalization. A door mechanism shall be installed with insulation, which allows continuous pantograph passage when the door is in the "open" position. A switch shall be installed for de-energizing the trolley wire. Insulated joints shall be installed at the apron of all MSF Tracks.

(ii) Isolation Requirements

A. The OCS shall be designed with manual disconnects for isolating sections of wire at interlockings, at the MSF for isolating the MSF from the mainline, throughout the MSF for isolating sections of Track, and in the shop for isolating each section of wire.

8.11 System Safety and System Assurance Requirements

(a) As a minimum, the following items shall be provided by Project Co in the Design, specification, Construction, and functionality of the overhead catenary system:

(i) Double insulation from any type of grounded pole, structure, building, etc. shall be provided to eliminate the possibility of bridging or spanning from neutral or grounded parts to live wires.

(ii) Warning signs shall be attached to OCS or the supporting structures to warn personnel of the proximity of high voltage wires. Signs shall be attached to the OCS to denote the end of the electrified wires over the Tracks. The signs comprise of "High Voltage", "Danger", "Danger Live Wire" and "Electric Train Stop" in red and black with white background.

8.12 Pole Deflection

(a) Pole deflection plus foundation rotation during Train operation shall not exceed 50 mm at contact wire height. Pole deflection at the top of the pole under OESC heavy loading condition shall not exceed 3% of pole length. Overload factors shall not be applied in the calculation of pole deflection.

8.13 Pole Grounding and Bonding

(a) Each pole or structure shall be grounded by a 4/0 AWG copper stranded wire by exothermic weld connections to two reinforcing bars in the foundation and to a ground rod adjacent to the foundation if necessary. All OCS support structures shall be grounded to a total ground resistance not exceeding 25 ohms.

(b) Touch potential overvoltage at each pole or structure shall be limited to 50 V under normal operation and 70 V under outage conditions.

8.14 Bridge, Overhead and Roof Structure Attachments

(a) Attachment to overhead Bridges and overhead structures shall be prohibited unless other methods are not available. In instances with clearance limitations or where Bridge spans are greater than the allowable OCS span, attachments may be required. Underneath roof structures, a soft suspension assembly shall be used to minimize pantograph bounce and loss of contact between the pantograph and contact wire.

(b) Overhead Bridge and Tunnel Portal Protection

(i) At locations where the catenary passes underneath overhead structures that are equipped with sidewalks or walkways without guard and there is less than three (3) meters of clearance to the nearest wire, appropriate fencing is to be provided.

(c) Overgrade Bridges

(i) Where the catenary and Track are supported by overgrade Bridges, all metal materials attached to the Bridge shall also be attached to the electrical grounding system. Where poles are to be mounted, the pole ground shall be attached to the electrical grounding system.

8.15 Cathodic Protection

(a) Each structure shall be designed with a passive protection system. For specific requirements, refer to Part 1 Article 14 – Corrosion Control.

8.16 Construction Tolerances

(a) The following are System-wide allowable Construction tolerances:

(i)	Contact wire height:	-13 mm to +25 mm, open route 0 mm to +13 mm, Tunnel
(ii)	Messenger and contact wire stagger: (Relative to centerline of pantograph)	+/- 25 mm
(iii)	System Depth:	+/- 50 mm, open route +/- 25 mm, Tunnel

8.17 Lightning Protection

(a) A connection from the OCS to a lightning arrestor and to ground shall be provided at each feeder point, at approximately 300 meters each side of the DC feeders and at all mid-point anchor assemblies. The lightning arrestors shall have a minimum energy discharge capability of 2.6 kJ at 1000 kV.

8.18 Performance Requirements

(a) The system minimum functional life expectancy shall be 40 years.

(b) The LRVs shall be equipped with ice removal device(s) for operations during snow and ice conditions. All OCS Equipment shall undergo all complete factory and on-site inspections and testing. On-site inspection and testing include the following:

(i) Acceptance Measurements: Stagger, Trolley Wire Heights, Pole Horizontal Offset and Wire Stringing Tensions;

(ii) Visual Inspection;

(iii) Clearance Envelope Tests: Pantograph Clearance Envelope and Vehicle Clearance Envelope; and

(iv) Electrical Tests: Megger Test, Circuit Continuity (or Loop) Test, Hi-Pot Tests and Ground Resistance Measurement at Lightning Arrestors.

ARTICLE 9 EMI / EMC

9.1 General Requirements

(a) The Equipment shall be designed to be compatible with the surrounding electromagnetic environment expected in Ottawa. The OLRT System shall be designed and constructed such that the System does not electrically or magnetically interfere with the safe and proper operation of the Vehicle or any wayside Equipment, including Equipment or systems external to the OLRT System.

(b) The whole System shall also be designed and constructed to limit electromagnetic emission levels in order to protect against adverse effects in humans from exposure to electric and magnetic fields.

(c) All wayside electronic Equipment shall meet the immunity requirements of EN 50121 -4

(d) All onboard Equipment shall meet the immunity requirements of EN 50121-3.2

(e) If Track circuits or wheel counter systems are used, they shall be selected for minimum susceptibility to the conductive and inductive emissions of AC traction LRVs.

(f) Inductive and conductive emission limits for LRVs shall be coordinated with any Track circuit and wheel counter susceptibility levels if such Equipment is used.

(g) An EMC management plan, based on EN50121-1, for the entire System shall be submitted as part of the Works Submittals according to Schedule 10 – Review Procedure.

(h) As part of the EMC management plan, Project Co shall undertake an EMC risk assessment of the Design in order to detail the potential risks for electromagnetic compatibility and determine the necessary mitigations to reduce or eliminate those risks.

9.2 Reference Documents

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

(i) EN 50121-1: Railway Applications – Electromagnetic Compatibility – Part 1: General

(ii) EN 50121-2: Railway Applications – Electromagnetic Compatibility – Part 2: Emissions Of The Whole Railway System To The Outside World

(iii) EN 50121-3-1: Railway Applications, EMC – Rolling Stock – Train and complete vehicle;

(iv) EN 50121-3-2: Railway Applications, EMC – Rolling stock – Apparatus;

(v) EN 50121-4: Railway Applications, EMC – Emission and immunity of the signalling and telecommunications apparatus and

(vi) EN 50121-5: Railway Applications, EMC – Emissions and immunity of fixed power supply installations and apparatus

(vii) IEEE C95.1-2005: IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 3 to 300 GHz

(viii) IEEE C95.6-2002: IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0 to 3 kHz

(ix) IEC 61000-2008: Electromagnetic compatibility (EMC), Testing and measurement techniques

(x) IEC 1000-5-2: EMC Cabling guidelines

(xi) EMI / RF Baseline Study and Report by ViaTech Engineering during Preliminary Engineering

9.3 Emission Limits

(a) Except as otherwise indicated, limits for emissions shall be based on those given in EN50121-2. The most restrictive limit shall apply.

(b) All Equipment used on the OLRT shall be designed to be within FCC guidelines for emitted radiation.

(c) Project Co shall determine the location and sensitivity of Equipment, located in Third Party Facilities or privately owned, in the vicinity of the OLRT Alignment that might be affected by emissions from the OLRT System. The emissions from the OLRT System shall be limited to ensure that operation of any sensitive Equipment identified shall not be interfered with by the OLRT. Where such emission limitation is not feasible Project Co shall engage with the affected third-party facilities to mutually investigate possible EMI remediation and Project Co shall supply the required mitigation.

(d) The emissions from the OLRT System shall be kept within the maximum exposure levels identified in IEEE standards C95.1 and C95.6.

9.4 Susceptibility Limits

(a) All Equipment used on the OLRT shall be designed to have immunity to the expected ambient electro-magnetic environment. The presence of any EMI shall not cause any system or subsystem, either connected or indirectly connected, to malfunction outside of the expected designed performance or enter into an operating condition that would be unsafe.

(b) Except as otherwise indicated, limits for immunity to EMI shall be based on those given in the appropriate sections of EN50121.

(c) It is the responsibility of Project Co to conduct an EMI Site Survey along the Alignment prior to the completion of the OLRT System in order to identify existing sensitive receptors and emitters and engage with them to ensure that mutual EMC concerns are appropriately addressed and mitigated.

9.5 Grandfather Rights

(a) Project Co shall use, where feasible, Equipment that can demonstrate prior EMC performance testing and in-service proven ability. Use of these components or Equipment shall be assessed on prior records; if this is demonstrable their inclusion into the Design shall be justified using an EMC risk assessment.

9.6 Sensitive Receptors and Emitters

(a) The following locations have been identified where there is a potential EMC concern. It is the responsibility of Project Co to ensure that all existing sensitive receptors and emitters are identified, and that their EMC concerns are appropriately addressed.

(i) CBC

A. The CBC – Ottawa Broadcast Centre houses both transmitters and sensitive receivers.

(ii) NRCan

A. NRCan has a Magnetic Observatory in the Ottawa area. The Magnetic Observatory houses instrumentation that is used to measure fluctuations in the ambient magnetic field. Project Co shall ensure that any distortion to the ambient magnetic field potentially caused by the OLRT System is below the level that will be detected as excessive noise at the observatory. Excessive noise is defined as a disturbance that exceeds 100 picoTeslas (0.1nT) at the NRCan observatory.

(iii) University of Ottawa

A. The OLRT passes very close to the campus of the University of Ottawa. Some buildings within the campus house research instruments that are susceptible to fluctuations in the ambient magnetic fields and to electrical interference.