Region of Waterloo

Stage 1 Light Rail Transit Project

Design and Construction Performance Output Specifications

Article 8

Train Control Systems

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ARTICLE 8 TRAIN CONTROL SYSTEMS

8.1 Introduction

(a) The purpose of this Article is to establish the guidelines, standards and design policies for the Train Control Systems for the Project. The Train Control Systems, also referred to as the Signal System, includes the functions of signal protection, grade crossing protection, and traffic signal coordination to allow vehicles, rail and rubber tired, to meet the operating goals for the Project, while providing a safe and operationally flexible system. Project Co shall prepare a Basis of Design Report – Train Control Systems, which explains Project Co's approach to Train Control Systems in greater detail and in a site specific manner as part of Project Co's Submission. The presentation of specific Train Control Systems requirements within this Article must not be construed to limit or modify in any way Project Co's responsibility to provide a holistic, comprehensive, and fully functional solutions to all Train Control conditions. The Basis of Design Report – Train Control Systems shall address every aspect of the Train Control Systems requirements cited in this Article. The rationale for all deviations or variances from any requirement cited in this Article must be fully described in the Basis of Design Report.

(b) The determination of a specific approach to train control and signaling is the responsibility of Project Co train signals designer. Project Co is responsible for the design, furnishing, installing and testing of all wayside, Central Control and train borne equipment and software, as well as interfacing this system with all of the other elements of the Project to produce a fully functional and well coordinated Train Control System.

(c) This Article provides guidelines on the Region's preferences and requirements on train signals and related or supporting systems to be considered by the designer during the overall approach to train signals and the details to be implemented. .

(d) Project Co's design of the Stage 1 LRT Project shall accommodate the forecasted ridership and to operate up to two-car trains at an operating headway of 5 minutes. The design must achieve a round trip time of 90 minutes or less including all necessary layover time at the terminal LRT Stops. The design of the Train Control Systems is a critical component to achieve these requirements and it is a critical component needed for computer model to be developed by Project Co as per Schedule 15-2 Article 1 Section 1.7(f). For additional clarity, the design requirement for a round trip time of 90 minutes or less is an ATP design requirement and not an operational requirement for scheduled train service. If Project Co's train control solution includes a combination of ATP sections and Line of Sight sections, the Line of Sight sections shall be treated in the roundtrip calculation (for the purposes of Train Control System simulation) as if full pre-emption (also referred to as free running time) is in effect.

(e) The Signal System will be designed to comply with the civil design and restrict speeds to comply with corridor conditions as follows:

(i) The maximum operating speed for the street running section between Conestoga Mall and the Waterloo Spur is 60 km/h.

(ii) The maximum operating speed on the Waterloo Spur section between Northfield Drive and Erb Street is 80 km/h.

(iii) The maximum operating speed on the street running section between Erb Street and Mill Street is 50 km/h.

(iv) The maximum operating speed on the Huron Spur section between Mill Street and Haywood Avenue is 80 km/h.

(v) The maximum operating speed for the side running alignment along Haywood Avenue is 50 km/h.

(vi) The maximum operating speed for the side running alignment along Courtland Avenue is 60 km/h.

(vii) The maximum operating speed for the Hydro One Corridor between Courtland Avenue and Fairview Mall is 80 km/h.

A train simulation will be performed to assure that the Signal System meets the operating goals. The Train Control System will employ track circuits in Automatic Train Protection (ATP) territory which will function with the railroad freight operations. A supplemental train detection technology may be employed for improved train detection of LRT vehicles, but track circuits for broken rail detection shall still be provided. Bi-directional signaling as per 8.5 (a) (viii) will be required on all areas of the LRT where ATP is provided.

(f) The Signal System shall be designed to address the distinct Right-of-Way characteristics for each alignment section. For the purposes of this Article, there are three basic types of Right-of-Way, exclusive, semi-exclusive, and shared Right-of-Way. Exclusive Right-of-Way is a dedicated Right-of-Way solely for the exclusive use of trains and does not permit rubber tired vehicles to cross the tracks at grade or occupy the tracks in any manner. This is typical of a subway system or an aerial system which does not have at-grade crossings. Based on this definition, there is no section of the Project alignment which meets the definition of Exclusive Right-of-Way. Semi-exclusive Right-of-Way permits rubber tired vehicles to cross the tracks at grade; however, it does not allow rubber tired vehicles to occupy the same travel lane as the train. This is typical of commuter rail and most light rail systems. Shared Right-of-Way permits rubber tired vehicles to cross the tracks at-grade and also permits rubber tired vehicles to occupy the same travel lane as the train. The Project alignment does not allow rubber tired vehicles to occupy the same travel lane as the train. Therefore, the design for all mainline alignment shall meet the needs of a Semi-exclusive Right-of-Way operating environment.

(g) Although the entire Project utilizes Semi-exclusive Right-of-Way, the Project alignment has four (4) different operating environments that shall be addressed in the design of the signal system. These environments are described below:

(i) Semi-Exclusive LRT Right-of-Way in which the light rail operation may use wayside signals (or equivalent) and relies upon grade crossing warning systems to separate rubber tired vehicles from LRT vehicles. Grade crossing warning indicators shall be provided to show the functional status of the grade crossing warning system.

(ii) Semi-Exclusive LRT Right-of-Way in which the LRV shares the same tracks with freight rail. LRT vehicle and freight rail trains will be time separated. Traffic and single tracking shall be incorporated into the signal system via wayside signals (or equivalent) and relies upon grade crossing warning systems to separate rubber tired vehicles from LRV and railroad vehicles. Grade crossing warning indicators shall be provided to show the functional status of the grade crossing warning system.

(iii) Semi-Exclusive Roadway Right-of-Way with a dedicated trackway located in the median of a road and is physically separated from vehicle lanes from adjacent traffic lane except at intersections. This operating environment may be signaled, depending upon site-specific conditions, such as distance, visibility, operating speed; however, in general, requires the modified traffic control signal system to separate rubber tired vehicle from LRVs. This operating environment may not have conventional train signals, however, may require some circuitry to influence the operation of traffic signals. There is no freight operation in this environment.

(iv) Semi-Exclusive Roadway Right-of-Way with a dedicated trackway located along the side of a road, either within the roadway Right-of-Way or parallel to the road Right-of-Way and is physically separated from vehicle lanes except at intersections and designated driveways. This operating environment may be signaled, depending upon site-specific conditions, such as distance, visibility, operating speed, however, in general, requires modified traffic control signal system, where traffic signals are present, or wayside warning strategies, to separate rubber tired vehicle from LRVs. This operating environment may not have conventional train signals, however, may require some circuitry to influence the operation of traffic signals and is more dependent upon the train operator's line of sight capabilities than other operating environments. There is no freight operation in this environment.

(h) In freight operation territory where there are LRT Stops, gauntlet tracks will be used through the platform area to provide additional clearance needed for the freight trains. Alternatives to the gauntlet track which address the safety of the LRT trains and passengers and freight railroad operations may be proposed as an innovation. Any alternative solution proposed shall be interconnected with the signal system and indicated to Central Control. Signal System Aspects will be provided to the freight trains, before they enter the joint track on the Spur, that the route has been lined for the designated railroad freight routing. Signal System Aspects shall also be provided the LRVs that the designated LRT routing has been lined for all the platform tracks.

(i) In semi-exclusive LRT Right-of-Way (where distance, increased operating speed, safety at interlockings, or other factors make the implementation of a full signaling system advantageous), it is preferred that LRV movements be controlled by the vehicle operator, governed by Automatic Train Protection (ATP).

(j) In semi-exclusive Roadway Rights-of-Way where the Right-of-Way is in the median of the roadway or in a side running configuration, the progression of the LRV through intersections shall be governed by LRT (bar) signals, controlled by street traffic control systems. Some train signaling may be desirable to enhance run time or required in those locations where operational and safety needs so dictate. Where train signaling is provided and vehicle operating speeds and street traffic conditions dictate the need for warning systems, road crossings may also be equipped with AHCW systems. Street traffic control systems with predictive priority are preferred to facilitate the movement of LRVs. Safety of operations shall be primarily the responsibility of Project Co and Project Co's adherence to operating procedures and polices. Where traffic signals are utilized signal enforcement is not required; however, it is preferred that all violations of traffic signals by an LRT vehicle be recorded.

(k) A Vehicle Supervision subsystem, also referred to as Automatic Train Supervision (ATS), is an integral component of the Supervisory Control and Data Acquisition (SCADA) subsystem. It shall be provided to monitor system status and provide the appropriate controls to direct the operation of vehicles in signaled territory. Control of the system shall be provided from the Central Control Facility (CCF) via SCADA, locally via the Train-to-Wayside Communication

(TWC) subsystem or via ITS systems as per Article 9. In addition there may be emergency local control via wayside local control panels or workstations. In non-signaled territory, vehicle tracking may be provided by the Communications Automatic Vehicle Location (AVL) subsystem or similar ITS system.

8.2 Codes and Standards

(a) The design, installation, and testing of the Signal System shall conform to the applicable requirements of the codes and standards or portions thereof listed herein, as well as all local codes and ordinances, unless specified otherwise. Where the requirements stipulated or referenced conflict, the more stringent shall apply. The governing version of the listed documents shall be the latest version adopted at the time of bid.

(i) Institute of Electrical and Electronics Engineers (IEEE):

A. IEEE 802.3 - LAN/MAN CSMA/CD (Ethernet) Access Method

B. IEEE 802.11 –Standard for Information Technology – Part II: Wireless LAN MAN & PHY Spec

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

D. IEEE Std. 1474.2 – IEEE Standard for User Interface Requirements in Communications-Based Train Control (CBTC) Systems

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

F. IEEE Std. 1474.4 – IEEE Recommended Practice for Functional Testing of a Communications-Based Train Control (CBTC) System

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

H. IEEE Std. 1478 – IEEE Standard for Environmental Conditions for Transit Rail Car Electronic Equipment

I. IEEE Std. 1483 – IEEE Standard for Verification of Vital Functions in Processor-Based Systems Used in Rail Transit Control

J. IEEE Std. 1698 – IEEE Guide for the Calculation of Braking Distances for Rail Transit Vehicles

(ii) Ontario Electrical Safety Code

(iii) European Committee for Electro technical Standardization (CENELEC):

A. EN 50121: Railway Applications – Electromagnetic compatibility

B. EN 50124: Railway Applications – Insulation coordination

C. EN 50126: Railway Applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

D. EN 50128: Railway Applications – Communication, signaling, and processing systems – Software for railway control and protection systems

E. EN 50129: Railway Applications – Communication, signaling and processing systems – Safety related electronic for signaling

F. EN 50155: Railway Applications – Electronic equipment used on rolling stock

G. EN 50159: Railway Applications – Communication, signaling and processing systems – Safety-related communication in transmission systems

H. EN 50238: Railway Applications – Compatibility between rolling stock and train detection systems

(iv) National Fire Protection Association

A. NFPA 130 –Standard for Fixed Guideway Transit and Passenger Rail System

(v) International Electrotechnical Commission (IEC)

A. IEC 60529 Degrees of protection provided by enclosures (IP Codes)

B. IEC 60812: Analysis technique for system reliability – Procedure for Failure Mode and Effect Analysis (FMEA)

C. IEC 61000: Electromagnetic Compatibility (EMC), Testing and measurement techniques – Electrostatic discharge immunity test

D. IEC 61000-5-2, Electromagnetic Compatibility (EMC) – Part 5 Instillation and mitigation guidelines – Section 2 Earthing and cabling

E. IEC 61373 - Railway applications – Rolling stock equipment – Shock and vibration tests

F. IEC 61508: Functional safety of electrical/electronic /programmable electronic safety-related systems

(vi) American Railway Engineering and Maintenance of Way Association (AREMA)

A. Communications and Signals Manual of Recommended Practices

(vii) International Organization for Standardization (ISO)

A. ISO 9001, Model for quality assurance in design, development, production, installing and servicing

(viii) American National Standards Institute (ANSI).

(ix) Electronic Industries Association (EIA).

(x) Insulated Cable Engineers Association (ICEA).

(xi) Ontario Traffic Manual (OTM)

(xii) Underwriters' Laboratories (UL).

(xiii) Canadian National Railway Design and Construction Standard (CN).

(xiv) Canadian Rail Operating Rules (CROR)

(xv) ASTM, Inc. (ASTM)

8.3 Functional Design Requirements

(a) It is preferred that the Signal System use service proven, state-of-the-art, off-the-shelf standard material and components to the greatest extent possible. The Signal System shall provide the highest levels of reliability, maintainability, and safety performance for LRV, pedestrian, and street traffic. Specific requirements for equipment shall be specified by the designer. Service proven systems are systems that have a documented operating history on other similar projects.

(b) The functional design requirements for the Train Signal Systems are listed below. Failure to comply with the requirements provided below may result in a major contract compliance issue. The applicability of these requirements depends upon whether the design is based on an ABS, Cab signals, or CBTC system.

(i) The Signal System shall provide broken rail detection in ATP territory, safe train separation, speed limit enforcement, absolute stop enforcement, route security through interlockings, and traffic direction.

(ii) The Signal System shall be compatible with the Communication System, with the Traction Electrification System, Trackwork, and LRV.

(iii) The Signal System shall be designed to be fail-safe (to the extent possible); that is, any single or multiple malfunctions affecting safety shall cause the Signal System to revert to a state known to be safe. All circuits and logic, or portions of, required for the safety of vehicle movements in order to protect life and property shall be considered vital. Those portions of the Signal System not considered fail-safe in signal terms (e.g., LRT bar signals where used) shall be designed using a compatible philosophy (e.g., inputs to and the operation of street traffic controllers shall revert to a stop condition if conflicting LRV and/or street traffic is detected, or if signal conditions (e.g., switch open,) are not met.

(iv) Wherever possible, malfunctions in the ATP apparatus shall be self-detecting. Circuits that affect safety shall be designed on the closed-circuit principle, such that any failure in the circuit results in the opening of the circuit, which in turn leaves the circuit in a safe condition and provides the capabilities for an alarm indication.

(v) Systems that provide the interface to accept requests for control or provide indications to a dispatcher may be non-vital. These non-vital systems shall interface with the vital systems. Following control requests by the non-vital systems, the vital systems shall provide the vital decisions that determine response and action.

(vi) Vital circuits shall be designed using standard North American rail signalling techniques. They shall be positive energy, single break within housings. All vital circuits leaving a housing or room shall be double break from where they first leave the housing or room to the power source.

(vii) Vital microprocessor-based systems shall be proven, fail-safe, fault-tolerant systems of high reliability, and a type proven to have a high Mean Time Between Failure (MTBF) in operation.

(viii) Non-vital circuits shall utilize non-vital relay or solid-state technology. Failure of non-vital equipment shall not affect the safety of the system.

(ix) Include provisions for the functional expansion of the signal system to be used in future extensions needed to complete the Stage 2 LRT. These provisions shall include, but not be limited to, facility allowances in the train signal equipment rooms, in Central Control, houses, cases and hardware allowances in apparatus affected by the projected expansions.

(x) Input to street traffic controllers may be provided by a combination of street traffic predictive priority detection loops (provided in the street traffic control system design), data radio, a type of Train-to-Wayside Communications (TWC) that has been used in a rail environment where TWC is used, and/or by track circuits, as applicable. Vehicle and traffic control systems for the LRT Project shall be designed and operated as a unified, integrated complete System.

(xi) The Signal System shall have automatic calibration of wheel size in order to obtain the maximum accuracy on speed determination and location. The System shall have the ability to compensate for wheel diameter and shall monitor and compensate for wheel slip/slide.

(xii) If a loss of train detection occurs, the ATP subsystem shall be designed to require the trains no longer detected to come to a complete stop.

(xiii) It is preferred, the Signal System employ two (2) over speed thresholds. The first threshold shall invoke a revocable service brake application. The second threshold shall invoke an irrevocable emergency brake application.

(xiv) If the Signal System detects a loss of train door closed and locked status, the train shall be allowed to proceed to the next station and dwell indefinitely with doors open unless door closed and locked status can be regained.

(xv) Traffic locking shall be provided to prevent the clearing of opposing signals or indicators into a section of track. Individual traffic circuits or logic shall be provided for each section of track between interlockings or crossovers in signalled territory. Signals or indicators will not clear until traffic relays or logic for the proper direction pick-up are energized. Traffic locking direction once established will remain locked until unlocked and call is made requesting entrance from the opposite end. The direction of traffic shall be locked on a section of track over which traffic locking is provided when any track circuit or track zone within that track section is occupied, or when traffic direction is requested into that track section or when the approach or time locking is in effect for a signal or indicator which has been cleared into that track section.

(xvi) Where communications-based signalling is provided, the ATP system shall adhere to the requirements of IEEE 1474.1 – IEEE Standard for Communications Based Train Control Performance and Functional Requirements.

(xvii) The designer shall determine the Safety Integrity Level (SIL) of the Signal Equipment and Signaling System based upon CENELEC industry standards to determine the level of system safety. SIL 4 shall be used in ATP territory, SIL3 shall used be in Non-ATP territory, and SIL 2 for Yard and “non-vital” purposes.

(xviii) Cyber Security design and implementation shall be provided throughout the Signal System

(xix) Hand operated switches for freight trains shall be indicated to CCF as part of the block occupied indication.

8.4 Automatic Train Supervision

(a) The ATS subsystem shall monitor and manage the overall operation of the Train Control System. ATS shall track vehicle movements against the selected schedule. Audio and visual displays shall allow the CCF to access conditions throughout the LRT System, and to take actions, as required. The ATS subsystem shall provide an interface for CCF controllers using workstations to select and transmit control commands to local equipment locations.

(b) The ATS subsystem shall include equipment necessary to perform the following functions:

(i) Train location with unique identification

(ii) Mode of operation

(iii) Direction of travel

(iv) Train's destination

(v) Alarms

(vi) Track switch position status

(vii) Routing information for the crossover or turnout

(viii) Highway and pedestrian crossing status

(ix) Status of traffic train control system

(x) Miscellaneous Controls and Indications

(xi) Local control functions and indications

(c) All equipment shall be furnished to support the functions and capabilities described herein.

8.5 Operational Design Requirements

(a) In the design and implementation of the Signal System, the following operational constraints and assumptions shall apply:

(i) Where signaled, the System shall support headways dictated by operational requirements as per Section 8.1(d) and supported by the traction power supply system design.

(ii) Interlockings at locations other than the ends of the lines shall enable trains to turn back or operate on a single track where permitted.

(iii) The Signal System shall provide a time separation of freight railroad and LRT trains by providing a signal aspect and a means of enforcing the route reservations that allows only a freight or LRT train to operate on that section of track. Switch point derails or other wayside elements may be required on the freight railroad tracks for enforcement of routes reserved for LRT trains. All wayside enforcement equipment shall be incorporated into the Train Control System and shall be monitored as well as controlled by the CCF.

(iv) The System shall provide for a lower level of service under certain anomalous scenarios, including utility power loss, and CCF malfunctions or loss of communications (e.g., backup power (as dictated by operational requirements), local operational control, etc.).

(v) Vehicle location and movements throughout the main line shall be displayed and supervised at CCF. Location of trains shall be continuous where track circuit detection is provided, and where not signaled, at station locations (at a minimum) via the Communications AVL subsystem.

(vi) Emergency local control shall be provided for all signaled crossovers from a local control panel or workstation in a house or room near the crossover or turnout. The panel or workstation shall allow an Operator to independently operate switches and request routes over the crossover, when either authorization from CCF has been provided, or when communications with CCF has been lost.

(vii) The LRV shall operate in the following modes:

A. Manual – In this mode the LRV is manually driven, with ATP supervision.

B. Restricted Manual – Manual operation with a speed restriction imposed by the car equipment

C. Rescue – This mode is used when pushing or pulling a disabled LRV. This mode shall be limited to speeds limited by ATP.

D. Wash/Coupling – In this mode the LRV is manually driven with a speed restriction imposed by the car equipment

E. Hold/Layover – In this mode the LRV is stationary with the pantograph up and power available to the vehicle.

F. Street – Restricted Manual operation with a speed restriction imposed by on board ATP equipment.

G. Yard – Restricted Manual operation with a speed restriction imposed.

(viii) The design for bi-directional running shall be coordinated with Schedule 15-2, Article 9, section 9.6 (b) (ii) 9 to ensure that the Train Control Systems and the Traffic Signal Control/Traffic Signal Priority Systems function as seamlessly as possible under reverse running train operations. On the Waterloo Spur, the design of the Train Control Systems shall support the Baseline Service Plan for the 30 minute revenue train service using a single track operation between 11:00 pm and 1:00 am.

8.6 Electromagnetic Interference (EMI)

(a) The Signal System shall be designed and installed to tolerate reasonable electromagnetic interference, without causing or being affected by such interference. The following considerations shall be taken into account in the design of the System:

(i) Track circuit design shall not permit EMI from any source, such as Traction Power, Power Supplies, Communications System, LRV Systems, utility power lines or equipment owned by HONI and local electrical utilities, or other wayside equipment, to interfere with its operation.

(ii) Audio frequencies for overlay track circuits, where utilized, shall be selected to minimize interference and crosstalk to a level that will not cause an unsafe condition.

(iii) Amplifiers shall be utilized to boost signal-to-noise ratios, and repeaters to regenerate signals, where applicable.

(iv) Shielded wire, twisted pair cables, and rigid steel conduit, if necessary, shall be utilized for EMI noise mitigation measures.

(v) Proper grounding and bonding of apparatus, conductor shields, and raceways, shall be provided to maximize shielding and minimize circulating currents.

(vi) Surge protection against lightning and other natural sources of EMI shall be provided.

b) All portions of the signal system and its components shall be designed to operate in the electromagnetic environment that will exist in the vicinity at the time of construction. Project Co shall perform a study to measure existing EMI/EMC conditions as input into the Train Control design. No portion of the signal system shall suffer from, or contribute to, harmful electromagnetic interference, whether conducted, radiated, or induced.

8.7 Growth and Expansion

(a) The Signal System design shall include the following provisions to allow for future growth and expansion of the System:

(i) At end-of line house locations, considerations shall be incorporated into the System design and hardware configurations to minimize the effort when subsequent extensions are designed. Twenty-five percent spare space shall be provided for the installation of a rack(s) for future equipment.

(ii) The design of individual racks and terminal boards shall include twenty-five percent spare space for the installation of future equipment and cable.

(iii) Provisions shall be incorporated into the design of control and indication circuits to Central Control for a logical expansion of the System, one hundred percent

(iv) Vital microprocessor-based systems shall support up to two (2) spare vital serial links for communications for future interfaces to additional microprocessor-based systems. The system shall have a additional fifty percent capacity, not including any redundancy requirements needed to meet the specified availability requirements for its site-specific configuration. Non-vital serial communications shall provide for transmission of data between the processor and SCADA, TWC, street traffic control systems, as well as an EIA-compatible modem for future remote communications. Where required, communications between vital microprocessor-based systems shall be provided via the Communications System Fiber Optic Cable Transmission System.

8.8 Signal Circuitry

(a) Vital signal control circuitry shall use vital relay logic, and/or vital microprocessor-based control systems, that incorporate fail-safe requirements to check and control all safety critical functions concerning track switch operation, vehicle occupancy status, wayside signal indications, and route security.

(b) Where provided, the Signal System shall perform the following functions:

(i) Continuous positive presence detection of all LRT and Freight Railroad vehicles (when track circuits are used).

(ii) Safe vehicle separation governed by the worse case safe stopping distance (in ABS and ATP territory).

(iii) Switch circuitry (route locking, detector locking, time locking, approach locking) to prevent the switch elements from unlocking or moving while a vehicle is approaching (time and approach locking in signaled territory only) or traveling through a switch section; and to prevent vehicles from approaching or entering a switch section unless the movable switch elements are verified as set and locked (electrically and/or mechanically, dependent on switch type).

(iv) Aligning and locking routes at all merging and diverging route locations, as operational needs mandate. Sectional release of route locking shall be provided as operational needs dictate.

(v) Control highway and pedestrian grade crossing functions, where utilized.

(vi) Gauntlet track mis-route protection, where utilized.

(vii) Special signalling and route locking shall be provided for freight railroad and LRT separation. Project Co shall provide, in locations determined by the CN, one dragging equipment detector and one wayside detectors on each of the freight tracks in approach to the LRT tracks. The wayside detector shall recognize locomotives and freight cars that that are higher than 16 feet above top of rail or exceed the width requirements consistent with CN standards for 8’-6” wayside clearance conditions. Freight equipment and locomotives outside these dimensions shall be prevented from being routed to the Waterloo LRT tracks and alarmed to the CCF.

8.9 Train-to-Wayside Communications (TWC)

(a) A TWC sub-system shall be provided to locally request and cancel normal operating routes, activate Automatic Highway Crossing Warning (AHCW) Systems (where applicable and not approach activated), and provide input to street traffic control systems, as operational requirements dictate. TWC shall be provided at:

(i) Terminal stations, to permit an LRV Operator to request a route out of the station platform without assistance from CCF under Project Co operating rules. TWC shall be provided at the station extremities to permit an LRV Operator to initiate the proper rubber-tired vehicle and LRT signal phasing into a tail track (if a signaled street intersection is located between the platform and the tail track) or other locations where required. In such instances, TWC shall also be provided to permit the LRV Operator to initiate the proper rubber-tired vehicle and LRT signal phasing.

(ii) All yard entrances and exits, to permit a vehicle operator to request a route into or out of the yard lead without assistance from CCF.

(iii) Pocket and siding track exit points, to permit a LRV Operator to provide an input to the street traffic control system to initiate the proper rubber-tired vehicle and LRT signal phasing (where a signaled intersection is located ahead).

(b) The TWC System shall include the firmware required to support error detection and corresponding re-transmissions in its data communication with CCF.

(c) The design of the car borne TWC equipment shall be fully coordinated with other Signal System equipment, vehicle propulsion and space limitations, and the Communications System.

8.10 Storage Yards

(a) Operation in the yard can be Restricted Manual, Wash, Unrestricted Manual and Layover. Normally, moves are made in restricted manual. A special mode for washing/coupling in the yard is also preferred.

(b) The control of vehicles in the main storage yards may be by line-of-sight rules and under the control of a Yardmaster or Dispatcher, via CCTV.

(c) Switches shall be hand-operated, power-operated with dual control, or a combination of both, as required, by operational requirements. All switches shall be trailable. Power-operated switches, where utilized, shall operate from a local control panel or workstation in the Yardmaster's office and shall include switch point indicators for facing point moves.

8.11 Switch Machines

(a) Track switches in signaled main line areas with ballasted track shall interface with the Train Signaling System. Powered switch layouts in signaled areas shall:

  (i) Mechanically couple the switch-operating layout to the switch points and, if required, to the moveable point frogs. Throw rods, locking rod and point detector rods shall be insulated in signaled areas.

  (ii) Provide a means for locking to prevent undesired switch point movement when points are in full normal or full reverse positions.

  (iii) Provide indication the switch points have been moved to, and are in the full normal or full reverse positions.

  (iv) Be equipped with a means to throw the points for manual operations.

  (v) Operate at voltages best suited for optimal performance.

(b) Track switches with throw rod and point detector rod in embedded track shall interface with the Train SignalingSystem.

8.12 Signals

(a) In semi-exclusive Roadway Right-of-Way, LRT bar signals controlled by the street traffic control systems (with input from the Signal System, where provided) shall be located at the limits of signaled crossovers to control entry to protected routes. To the extent possible, crossover limits shall be coordinated to jointly use OCS poles for installation of the LRT signals.

(b) In semi-exclusive LRT Right-of-Way, signals shall be the color light type, utilizing Light Emitting Diodes (LEDs), and shall be provided with lenses that provide for both close-up observation and long-range visibility to the LRV Operator.

(c) In semi-exclusive roadway Right-of-Way, illuminated switch position indicators shall be utilized at facing point switch locations. Indicators shall be embedded and mounted between the rails (25 mm (1”) above TOR, maximum).

(d) LRT (Bar) Train Signal System Aspects for turnouts and crossovers in street right of way

Aspect	Indication
No Aspect	Stop, Contact CCF
Horizontal Red Bar	Stop
Vertical Green Bar	Straight Route - Proceed on Primary route, prepared to stop short of any vehicle or obstruction.
Diagonal Green Bar	Diverging Route - Proceed on secondary route, prepared to stop short of any vehicle or obstruction.
Flashing Horizontal or Vertical Red or Green Bar	Route change in process.

(e) Color Light Train Signal Aspects

To be developed by Project Co as operational requirements are fully defined.

(f) LRT (Bar) Traffic Signal System Indications

Aspect	Indication
No Aspect	Stop, Contact CCF
Horizontal White Bar	Stop
Vertical White Bar	Proceed through traffic intersection prepared to stop short of any vehicle or obstruction.
Flashing Horizontal or Vertical White Bar	Traffic signal change in process.

(g) Train Signal Switch Position Indicator Aspects

Aspect	Indication
No Aspect	Stop, Contact CCF.
Green	Switch aligned Normal
Yellow	Switch aligned Reverse

8.13 Crossing Warning Systems

(a) Where traffic signals are not provided, and vehicle operating speeds, street traffic conditions, or requirements of this Article dictate the need for warning systems, road crossings shall be equipped with Automatic Highway Crossing Warning (AHCW) systems. It is preferred that a constant warning time approach circuits shall be utilized to provide a minimum of twenty (20) seconds warning time for both freight railroad and LRT trains along the Waterloo Spur and Huron Spur rights of way. The crossing gates and flashers shall remain activated if a second train is within 15 seconds of the activated crossing warning system. The ability to provide a constant warning time, given the different operating speeds of freight railroad and LRT trains, is a feature that needs to be identified by Project Co in their Submission. Project Co shall design the crossing warning systems along the Waterloo Spur for railroad freight train speed of 24 km/h (15 mph). Project Co shall design the crossing warning systems along the Huron Spur for railroad freight train speed of 40 km/h (25 mph). In general, crossings shall include the following, modified to site specific conditions based on traffic analysis:

(i) Gate mechanism operating voltage shall range from 10 to 16 Vdc, supplied with battery backup.

(ii) Fiberglass gate arms, including adapters with shear pins so that excessive side force against the gate arm shall cause the adapter's shear pins to shear allowing the arm to swing free and drop away, thus preventing major damage to the arm.

(iii) Flashers utilizing LED technology.

(iv) Vital solid state crossing controllers, including a means to adjust timer settings

(v) Off-quadrant flashers, and gates as applicable.

(vi) Cantilevers, including cantilevers for pedestrian travel ways.

(vii) Bells which operate between 100 and 325 strokes per minute. In noise sensitive areas, adjustable soft tone bells shall be provided.

(viii) Signage, gates and flashers as required by the Ontario Traffic Manual, Authorities having Jurisdiction and traffic analyses.

(ix) Grade Crossing warning indicator

(x) Wayside Event recorder with GPS time

(xi) Freight Railroad speeds

At the current time Transport Canada does not regulate the crossing warning system for Light Rail Transit systems however, Project Co shall complete their Safety Assessment activities for all railroad crossing warning systems, railroad/LRT shared crossing warning systems, and all LRT only crossing warning systems, including those crossing warning systems cited in 8.13 (c) in compliance with Transport Canada requirements for Safety Assessments and prepare the formal application documents for the Region. The safety assessments will treat LRT trains in the same manner as railroad trains. For all crossing warning systems involving freight railroad trains, the Region will make the formal submission to Transport Canada and Project Co shall support the Region in the approval process. The Region may seek Transport's Canada review of some or all of the LRT only crossings warning systems. Project Co shall comply with findings of Transport Canada review of all crossing warning systems involving freight railroad trains and Region direction on all LRT only crossings warning systems.

(b) Pedestrian crossing warning systems, if required, shall utilize the same equipment utilized at grade crossings, modified to site-specific conditions.

(c) As a minimum, Project Co shall provide flashers and gates including gates for pedestrian movements as indicated below:

(i) Northfield Drive with a special analysis to coordinate with traffic signals and railroad freight crossings

(ii) Old Albert Road

(iii) Bearinger Road

(iv) All new pedestrian crossing between Bearinger Road and Columbia Street

(v) Columbia Street

(vi) All existing and new roadways and pedestrian crossings between Columbia Street and University Ave.

(vii) University Avenue

(viii) Seagram Drive

(ix) All existing pedestrian crossings between Seagram Drive and Erb Street.

(x) Erb Street with a special analysis to coordinate with traffic signals and railroad freight crossings

(xi) King Street at Waterloo Spur with a special analysis to coordinate with traffic signals and railroad freight crossings

(xii) Mill Street/Ottawa with a special analysis to coordinate with traffic signals and railroad freight crossings

(xiii) Hayward Avenue and railroad freight crossings

(xiv) All local access points between Hayward Avenue and Block Line Road.

(xv) Block Line road with a special analysis to coordinate with traffic signals

(xvi) Siebert Avenue

(xvii) Balzer Road and Courtland Avenue with a special analysis to coordinate with traffic signals

(xviii) Wilson Avenue.

8.14 Traffic Signal Interface

(a) Where the LRT System operates at grade in non-signaled territory, with at-grade crossings of road traffic, LRV movements shall be controlled by the traffic signal system through the use of Predictive Priority, where agreed to by the local authority in the Inter-governmental Agreement. LRT bar signals shall be controlled and operated by the traffic signal controller and provided in the traffic design. Inputs to street traffic controllers shall be provided by advanced street traffic detector loops, data radio, and/or track circuit occupancy as applicable, sufficiently far in advance of a crossing to coordinate rubber-tired vehicle and LRV movements.

(b) Where the LRT System operates at grade in signaled territory where AHCW systems are utilized, LRV movements may be controlled by wayside signals, however, AHCW system shall provide an interface with the street traffic signal system to allow street traffic that is not impacted by the LRT movement to be given a priority.

8.15 Track Circuits

(a) Track circuits, which are capable of operating in dc electrified territory without interference from the LRV propulsion system or high power lines, shall be utilized in signaled areas for LRT and freight railroad vehicle detection. Track circuits shall be capable of operating in the vicinity of high voltage lines that are overhead or buried close to the LRT tracks. Track circuit types shall include:

(i) Audio frequency overlays for crossing warning systems, if applicable.

(ii) Double-rail power frequency circuits for all main line crossovers and turnouts.

(iii) Single-rail power frequency circuits in selected areas and within crossovers.

(iv) Microprocessor based digital track circuits

(b) Impedance bonds shall be utilized at insulated joint locations to maintain continuity of the dc negative return system. Impedance bonds shall have a minimum rating of 1500 amps.

(c) In signaled areas, the running rails shall be crossbonded through impedance bonds. Crossbond intervals shall be as determined by traction power simulations, however, no closer than every second track circuit. Negative return connections in signaled areas, shall be connected to impedance bonds. In non-signaled areas, crossbonding and negative return connections shall be based upon the traction power requirements for that specific area. The traction power system shall be design to reduce step and touch potential.

8.16 Signal Power

(a) General Power Requirements

(i) The Signal System shall be powered from either the nearest passenger station, traction power substation, or from a dedicated power drop from a local utility company. The local signal power system shall supply all local equipment required to operate the system.

(b) Redundant Power Requirements

(i) The signal power system shall be designed to incorporate the use of redundant power supply or inverters, or two dedicated power sources systems.

(ii) At a minimum, the following Train Control functions shall utilize redundant power or source supplies.

A. Line circuits

B. Vital logic

C. Non-vital logic

D. Switch machines

E. Signals

F. Track circuits

G. Highway or pedestrian crossing equipment

H. Any life safety equipment or circuits

(c) Ground Detection Requirements For Vital Circuits

(i) Ground detection shall be provided for the vital dc-supply system, at a minimum. The need for an ac ground detection system shall be considered on a case-by-case basis, as dictated by maintenance requirements.

8.17 Houses and Cases

(a) Signal System equipment shall be installed in houses, cases, or rooms in the general vicinity of crossovers, turnouts and highway and pedestrian crossings. Houses and cases shall:

(i) Be pre-fabricated, pre-wired, and sized to accommodate all equipment required to operate the System, including the necessary provisions for growth and expansion. Where aesthetics is a concern, facilities-provided concrete structures shall be provided which are integrated into the environment in which it is placed. Aesthetic enhancements to pre-fabricated structures may be provided in lieu of concrete structures as urban design guidelines dictate. Houses and cases shall be constructed of corrosion resistant materials. Aesthetics for cases and houses shall include color. Signal cases (cabinet) aesthetics for urban design includes type, size and color.

(ii) Provide sufficient space for the installation of Communications System equipment, where applicable.

(iii) Include heating, and air conditioning to protect equipment from the Project environment.

(iv) Be oriented logically from the maintenance and operations perspective.

(v) Include a local control panel or workstation to allow local control of switches and signals in signaled territory during emergencies and testing purposes.

(vi) Include fire and intrusion detection systems.

(vii) Insulation shall be provided to protect from the Project environment including temperatures normally experienced in Waterloo.

(viii) Use flame retardant materials.

(ix) Floor matting shall be provided.

(b) Rooms, where utilized, shall be equipped with stand alone, pre-wired 482.6 mm (19”) racks, and all associated location equipment, power supplies, relays, microprocessor, etc

8.18 Signal Equipment and Technologies

(a) All portions of the signal system shall use current and at least two years of service proven technologies in all respects, including all components used therein.

(b) The vital system logic shall be a proven, fault-tolerant system of high reliability, of a type proven to have a high Mean Time Between Failures (MTBF) in operation.

(c) All equipment used shall be standard products produced by a manufacturer regularly engaged in the production of such equipment or material, and shall conform to all applicable codes and standards.

(d) Assemblies and components used to perform identical functions within the system shall be mechanically and electrically interchangeable. Standard commercially available equipment and material available from multiple sources shall be used where practicable.

8.19 Maintainability Design Requirements

(a) All test points, indications and components requiring adjustment or replacement shall be visible and accessible while mounted in their normal position, without disassembly of other components.

(b) Test points for checking essential voltages and wave forms shall be clearly labeled, shall be provided wherever required for troubleshooting and routine maintenance, and shall be capable of accepting probes and connectors used with standard equipment, such as voltmeters and oscilloscopes. Accessible points shall also be provided where signals need to be injected for testing.

(c) Built-in indicators or meters shall be provided when frequent observations or adjustments are necessary. All electronic modules shall be equipped with LED or other approved indicators. They shall, at a minimum, demonstrate that each function of the module is performing correctly. All indicators shall be labeled. As an alternate, electronic modules may be equipped with a receptacle to permit observation of equipment with a portable plug-in diagnostic unit in place of LED indicators

8.20 Vehicle Train to Wayside Communications

(a) The wayside locations shall be provided with an inductive or data radio means for receiving data or transmitting from and to the LRT vehicles for non-vital logic processes. Data to be transmitted shall include vehicle identification data and train operator settable information (route, train ID, train consist, etc.)

(b) The data transmitted shall be determined by non-vital wayside logic processes and may be used for the following purposes:

(i) Automatic routing through an interlocking and TCS routing for normal movement.

(ii) Train operator-controlled alternate routing.

(iii) Monitoring of vehicle entry and exit to yard tracks.

(iv) Monitoring vehicle occupancy for grade crossing purposes in non-signaled track.

(v) Alteration of traffic signal cycles.

(vi) Passenger information system (PIS)

(vii) Monitoring of train performance and health

(c) The apparatus installed on the vehicles and the wayside shall be similar in function and method of operation. Project Co shall provide the data radio, inductive data interface, traffic priority and WLAN downloads.

8.21 Vehicle Provisions for Project Co ATP, ATS and TWC Equipment

(a) All LRVs shall have minimal provisions for Automatic Train Protection and Operation Equipment. See Schedule 35 for information on these provisions.