

Region of Waterloo  
Stage 1 Light Rail Transit Project

Schedule 15-2 Appendix A

System Description

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## **APPENDIX A      SYSTEM DESCRIPTION**

### **A.1      Project Description**

- (a) Project Co shall be responsible for the financing and for design, build, operations, maintenance and rehabilitation of the Region of Waterloo's Stage 1 Light Rail Transit Project. The LRT will provide fixed guideway transit service between Conestoga Mall and Fairview Park Mall. Major connections to an expanded bus service will be provided at the Stage 1 Light Rail Terminals and other stops along the alignment. In addition to the Stage 1 Terminals, other major destination points include downtown business areas in Waterloo and Kitchener, the planned Intermodal Facility at King Street and Victoria Street, as well as the University of Waterloo. The Region intends to procure the Intermodal Facility as a separate contract, although Project Co shall be required to coordinate interfacing with the facility. The Region will also be supplying the Light Rail Vehicles (LRVs). A set of alignment drawings has been included in Appendix I.
- (b) The Region of Waterloo LRT will consist of at-grade tracks constructed as ballasted track in semi exclusive Right-of-Way or embedded track within or adjacent to street Right-of-Way.
- (c) The Region is committed to meeting all of the requirements and commitments cited in the Environmental Project Report (EPR) and Project Co shall adhere to the EPR requirements and commitments. In particular, the Region is committed to minimizing or eliminating impacts, where possible, to businesses, institutions, and residents along the alignment and promoting ways that enhance the economic viability of these businesses during the construction of the Project.
- (d) This is an overview of the design, construction, operations, and maintenance and rehabilitation requirements of the Stage 1 LRT project. If there is a conflict with the requirements cited in the other Schedule 15-2 or 15-3 Articles, the requirements cited in the other Schedule 15-2 or 15-3 Articles shall take precedence.
- (e) Other key aspects of the Project are presented in the following paragraphs.

### **A.2      Project Co General Scope of Work**

- (a) Project Co shall provide all the Work required to design, deliver, furnish, install, procure, test, train, commission, etc.:
  - (i) wayside systems (which include Automatic Train Protection, communication subsystems).
  - (ii) traction power distribution systems installed along the tracks.
  - (iii) all civil works.
  - (iv) test, certify, commission, operate and maintain the LRT System.
- (b) In addition, Project Co shall develop approaches enhancing ridership on the LRT System.
- (c) The Region will provide the LRVs to Project Co for their use during systems integration testing, training of Project Co's staff, and performing pre-revenue and revenue service. Project Co shall include in its Project Schedule the number of LRVs and dates the LRVs are required to support their installation of on-board equipment as well as system

qualification and integration testing needs. Project Co shall be responsible for the operations and maintenance of the LRVs.

### **A.3 Project Co Responsibilities - Design & Construction Scope of Work**

- (a) The Design-Build Work in the Project Agreement will require Project Co to design, build, furnish, install, integrate, test, and certify the following:
- (i) Roadway and Structures including demolition of existing roadways and structures
  - (ii) Utility Relocation, Protection, and/or Removal
  - (iii) LRT Stops and LRT Stop equipment
  - (iv) Interface to wayside equipment for the LRT vehicles
  - (v) Ballasted and Embedded Trackwork
  - (vi) Special Trackwork
  - (vii) Train Control Systems including Automatic Train Protection (ATP)
  - (viii) Intelligent Transportation System (ITS) components and subsystem
    - A. Traffic Signal Control Systems and Transit Signal Priority
    - B. Transit Management System
    - C. Traveller Information System
    - D. Security Systems
  - (ix) Communications Systems
  - (x) Supervisory Control and Data Acquisition (SCADA) system
  - (xi) Traction Power Substations and Overhead Contact Systems (OCS)
  - (xii) Provisions for the Fare Collection system (Fare Collection Equipment will be furnished by the Region and installed, tested and commissioned by the supplier)
  - (xiii) Operations, Maintenance and Storage Facilities (OMSF), including:
    - A. Storage yard
    - B. Service and Inspection shops
    - C. Fixed and mobile workshop equipment
    - D. Standard and special tools
    - E. Test and diagnosing equipment
    - F. Wheel Truing
    - G. Transportation and Maintenance-of-Way facilities
    - H. LRV Car Wash
    - I. Central Control Facility (CCF), with Yard Control
- (b) Additional information on the above items is provided within the Design and Construction Performance Specifications and the Management, Operations, Maintenance

and Rehabilitation Specifications. Unless specifically and explicitly identified as an element of work that is not included in Project Co's Design & Construction Scope of Work, the presentation of specific Articles or listing of requirements within Articles of the Project Agreement shall not be construed to limit or modify in any aspect Project Co's primary responsibility to provide a holistic, comprehensive, and fully functional solutions needed to provide to the Region a fully functional and complete LRT System.

#### **A.4 Project Co Responsibilities – Operations, Maintenance, Rehabilitation and Replacement Scope of Work**

- (a) Project Co shall maintain all:
  - (i) Tracks and Trackway including civil works such as trackway drainage, roadways etc.
  - (ii) Special Trackwork
  - (iii) LRT Stops
  - (iv) OMSF and Traction Power Substation buildings
  - (v) LRT portions of the Traffic Control installations
  - (vi) Train Control Systems & Wayside Equipment
  - (vii) ITS Components and Systems
  - (viii) Communication and Security Systems
  - (ix) Traction Power Substations and OCS
  - (x) Light Rail Vehicles
  - (xi) Fixed and mobile rail borne workshop equipment and rubber-tire work vehicles.
- (b) The operations Work in the Project Agreement will require Project Co to perform the following functions:
  - (i) Operate Light Rail Vehicles
  - (ii) Operate Central Control
  - (iii) Provide Street Supervision in the field to supervise safe operations
- (c) Project Co shall be responsible for the Rehabilitation and Replacement of all systems and equipment required for the System. Unless specifically and explicitly identified as an element of work that is not included in Project Co's Operations, Maintenance, Rehabilitation and Replacement Scope of Work, the presentation of specific Articles or listing of requirements within Articles of the Project Agreement shall not be construed to limit or modify in any aspect Project Co's primary responsibility to provide a holistic, comprehensive, and fully functional services needed to provide to the Region a fully operational and well maintained LRT System.

#### **A.5 Passenger Service and System Operating Characteristics**

- (a) The LRT will provide a convenient, safe, and highly reliable service. The initial operating headway will be 7.5 minutes during peak hours and 15.0 minutes during off-peak hours. The design may require a minimum operating headway of 5.0 minutes with a

- non-interference headway which provides sufficient time for maintaining a reliable and stable operation. Revenue Service hours are shown in Schedule 15-3 Appendix D.
- (b) The design goal is a round trip time of 90.0 minutes or less. This time period is the time it takes for a train to depart from a Terminal Station, return back to the same terminal station and is ready to once again depart from that Terminal Station.
  - (c) The initial operations will be a one-car train. The ultimate train will be two-car train consist.

#### **A.6 Alignment Technical Overview**

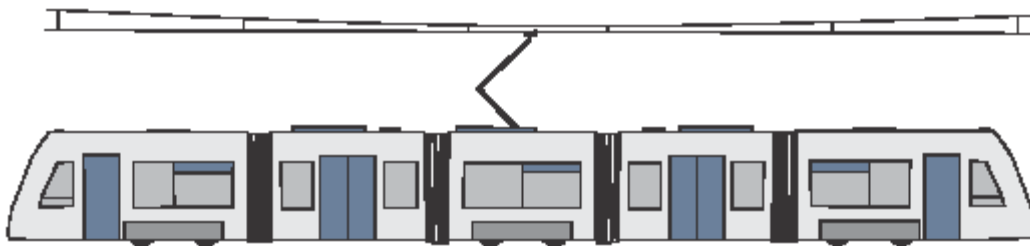
- (a) The LRT alignment has been developed based upon the following primary design parameters:
  - (i) Use of Existing Rights-of-Way: The alignment has been designed to make use of existing, publicly owned Rights-of-Way, to the maximum extent possible.
  - (ii) At-Grade Trackway: The alignment is based on constructing at-grade tracks using semi-exclusive Rights-of-Way and street Right-of-Way. The design for street Right-of-Way conditions will allow vehicular crossing of the LRT track at existing signalized cross streets only. When the LRT trackway is in a side running configuration it shall allow access to businesses and property owners along the LRT trackway. No longitudinal intrusion of vehicular traffic on the LRT trackway is permitted. The physical integration of the LRT trackway into the existing street environment shall be accomplished in a seamless manner. The trackway design shall address roadway geometry, sight distances, surface and subsurface drainage as well as mitigating access issues for utilities.
  - (iii) Intermodal: The LRT is being designed as part of an overall intermodal system including Grand River Transit buses, iXpress buses, GO Transit, VIA, and the aBRT. Access to these modes shall be incorporated and integrated into the design.
  - (iv) Alignment: The Systems and trackway elements shall be designed for an alignment that has a significant number of curves with a small curve radius in the street Right-of-Way. Avoiding intrusive Overhead Contact Systems (OCS) in these locations is important. Providing effective train warning systems for pedestrians is another key consideration; especially when the LRV is negotiating a curve with a small radius in the street Right-of-Way.
  - (v) Track: The vast majority of the alignment consists of at-grade track which will be a combination of embedded track and ballasted track. In some areas, the track design will have to incorporate noise and vibration mitigation.
- (b) A general description of the alignment sections are as follows:
  - (i) The alignment section from Conestoga Mall to the Waterloo Spur track will require embedded trackwork. The design for this section requires a structural analysis of the existing overpass at Highway 85 for LRV loading.
  - (ii) The alignment section between Northfield Drive and Erb Street will consist of ballasted track with road and pedestrian crossings of the LRT track. This section of the alignment will have to be designed to meet CN railroad requirements. The CN will continue to serve industries located north of the LRT trackage. All CN

operations along this section will use LRT tracks; however, will occur after LRT revenue service hours. Achieving adequate railroad clearances from the LRT platform may require the use of gantlet tracks in the station areas. Wayside conditions will also require attention to railroad clearance needs. This section of the alignment will have a minor new structure crossing Laurel Creek just north of Erb Street.

- (iii) The alignment section between Erb Street and Mill Street will consist of embedded track in a side running configuration or a median configuration. This section contains the most significant civil construction that Project Co will have to design and construct. The current at-grade road crossing of King Street and the CN Guelph Subdivision track between Breithaupt Street and Victoria Street shall be grade separated. Project Co will be required to design and construct this grade separation. Additionally, there are two structures required to cross over Schneider Creek. Also a section of the Northbound track from King Street to Erb Street will have to be designed to accommodate CN railroad operations. This section includes an LRT Northbound platform.
- (iv) The alignment section between Mill Street and Hayward Avenue will consist of ballasted track paralleling the CN Huron Spur track. Unlike the Waterloo Spur, CN operations, track sharing or track crossing will not occur on this section.
- (v) The alignment section between Hayward Avenue and Balzer Road may consist of ballasted track or embedded track paralleling either Hayward Avenue and Courtland Avenue with road and pedestrian crossings of the LRT track.
- (vi) The alignment section between Balzer Road to Wilson Avenue/Fairview Park Mall may consist of ballasted track within the Hydro-One Corridor with road and pedestrian crossings of the LRT track. The Hydro One overhead transmission power lines will be buried for most of this section. Local overhead power lines will not be buried.

## A.7 LRT Vehicles

- (a) As noted, the Region is currently negotiating with Metrolinx to use their existing contract with Bombardier for the delivery of Light Rail Vehicles and Region will provide these Light Rail Vehicles to Project Co. Detailed information on the design characteristics and Technical Specifications of the LRV are included in Appendix D and Schedule 15-2 Article 5.
- (b) Each LRV will consist of five car body modules with articulated sections between each module.



- (c) The interior of the LRV has a 100% low floor configuration. There will be 60 seats and the LRV has a total capacity of approximately 200 persons based on a standee capacity of 4 passengers per metre squared. The LRV has an overall car body length of 30.3 metres and two cars coupled together have an overall length of 62.2 metres. There will be four doors per side. The two doors in the end modules are about 800 mm wide and the two doors in the interior modules are about 1,300 mm wide.
- (d) The maximum operating height of the pantograph is 6.4 metres and the minimum height is 3.8 metres. Normal operating height is 5.5 metres.
- (e) The car is bi-directional and has a maximum operating speed of 80 KPH (50 MPH). The trucks in the end modules are powered trucks and the truck in the middle module is non-powered. The car accelerates at 1.2 m/sec<sup>2</sup> and brakes at 1.5 m/sec<sup>2</sup>. Emergency Braking is 2.44 m/sec<sup>2</sup> based on using track brakes.
- (f) The empty car weighs 48,670 kg (53.7 tons). A fully loaded car at a standee capacity of 4 passengers per meter squared would weigh 62,040 kg (68.4 tons).
- (g) The maximum sustained grade is 6%. The minimum curve radius is 25 metres; and the track is standard gauge.
- (h) The EPR was completed before the Region was able to finalize the concepts for the LRV. The selected Project Co will be required to review the noise and vibration analyses previously prepared by the Region and update that analysis using the selected LRV.

#### **A.8 OMSF and Central Control Center**

- (a) The OMSF complex, as shown in Appendix I, will be located along the Waterloo Spur Right-of-Way between the Northfield and R&T Park Station Stops. All train operations, vehicle and wayside maintenance, as well as the storage of rail cars not in service, will occur at the OMSF. Project Co will be responsible for the design and construction of the OMSF and Central Control Room as well as all ancillary equipment rooms in the OMSF associated with LRT operation and control. Project Co will design the layout of these rooms and install all of the equipment associated with the operation and control of the LRT. The storage yard will provide storage capacity for about 28 to 30 rail cars. The shop will include a wheel truing machine and other special equipment needed to maintain the LRVs. A car wash will be provided for the exterior cleaning of the LRVs. Train operators will report to the OMSF to assume their duties, and therefore, the OMSF will need support spaces for administration, lockers, restrooms, and training.

#### **A.9 LRT Stops**

- (a) LRT stops are designated at-grade transit loading/unloading points. There will be 16 northbound (NB) stops and 16 southbound (SB) stops. Although most of the NB and SB platforms are at the same location, there are 5 locations where the NB and SB platforms are not co-located. The design for the LRT stops shall respect the immediate environment and be appropriately sized for the expected level of passenger activity. The design for the LRT stops shall address the initial one car train operation as well as the provisions needed to accommodate the ultimate train length of two cars (62.2 metres).
- (b) In addition, the design for the LRT stops shall include:



- (i) Weather protection
  - (ii) Provisions for Ticket Vending Machines (TVMs), and Ticket Validators (TV) or Platform Fare Transaction Processors – Actual Machines will be provided by the Region.
  - (iii) Passenger and Pedestrian Flow
  - (iv) Passenger information displays and static signage
  - (v) Public address system
  - (vi) Passenger Security including Closed Circuit Television (CCTV) coverage
  - (vii) Passenger Assistance Intercoms
  - (viii) LRT Stop furniture, Advertisements and other stop amenities such as lighting.
- (c) Representative station design concepts have been provided in Appendix L for information purposes.

#### **A.10 Fare Collection**

- (a) The LRT system will use a Proof of Payment (POP) fare collection system. The Region will provide the equipment (i.e. ticket vending machines, and ticket validators or platform fare transaction processors). Project Co shall be responsible for the design and construction of supporting civil, power, and communication provisions for the fare collection system at each LRT Stop. The Ticket Vending Machines will be fully tested and commissioned by the equipment supplier chosen by the Region under a separate procurement. No fare collection activity is envisioned to occur on the LRV and enforcement of the POP as well as setting fares will be the responsibility of the Region. Project Co shall not be required to maintain fare vending equipment.

#### **A.11 Roadways and Utilities**

- (a) Project Co shall be responsible for the physical integration of the LRT system into the existing roadways and utilities. It is the Region's intention to relocate some of the impacted utilities prior to Project Co commencing construction work. A matrix of advanced utility relocations as well as Utility Drawings has been included in Appendix O.

#### **A.12 Right-of-Way**

- (a) It is the Region's intention to purchase all permanent property rights for the Project prior to Project Co commencing construction. If Project Co identifies additional permanent property rights, the Region will, to the extent the Region considers it appropriate, either purchase those rights or obtain a right of access.

#### **A.13 Automatic Train Protection and Related Systems**

- (a) An Automatic Train Protection (ATP) system for the semi-exclusive Right-of-Way will be used. The ATP system will include train separation, speed control, and interface with the crossing warning equipment in case of crossing warning equipment malfunction. The goal of the ATP section(s) is to improve train speed for a shorter round trip time and enhance the passenger's perception of a faster trip time. Project Co is responsible for the design, furnish and installation on specific on-board systems including on-board

components of the ATP system. It is anticipated that the vehicle supplier will assist Project Co with the integration of the onboard ATP and other on-board systems. Project Co is responsible for the design, furnish and installation needed to provide for the train operator with the ability to throw switches.

- (b) Project Co shall be responsible for providing pedestrian and vehicular protection at road crossings and pedestrian crossings.

#### **A.14 ITS**

- (a) Project Co shall be responsible for the design, deployment, and integration with existing systems, of all ITS components for the LRT Project, including but not limited to:
  - (i) Traffic Signal Control/Transit Signal Priority Systems
  - (ii) Transit Management System
    - A. Automatic Vehicle Location (AVL) System
    - B. Scheduling System
    - C. LRT Stop Variable Message Signs
    - D. Onboard Automated Passenger Counting System
    - E. Onboard Variable Message Signs and Automated Announcements
  - (iii) Advanced Traveler Information System Data Provisions
  - (iv) Transit Security
    - A. Onboard Closed Circuit Television (CCTV) Surveillance and Recording System
    - B. LRT Stop Closed Circuit Television (CCTV) Surveillance with Central Recording System
    - C. Access Control and Detection System
    - D. Passenger Assistance Intercoms
    - E. Public Address System
  - (v) Central control facility video wall, system servers/hardware, workstations, and supporting equipment and furnishings
- (b) Further details and requirements for the ITS systems are provided in Schedule 15-2 Article 9.

#### **A.15 Communication Systems**

- (a) Project Co shall be required to design, furnish, install, and test all communication systems needed for the LRT and ITS systems. This includes, but is not limited to:
  - (i) Communication backbone
  - (ii) SCADA
  - (iii) Telephones
  - (iv) Voice radio

- (vi) Communication provisions for fare collection equipment
- (vii) Communication links for ITS systems
- (viii) Control centre to train data communications
- (ix) Train-to-wayside field equipment communications
- (x) Field equipment to control centre communications
- (xi) Centre-to-Centre communications

#### **A.16 Trackwork, Special Trackwork, and Mitigation of Stray Current**

- (a) Project Co shall design, furnish, install, and test all trackwork and special trackwork needed for the LRT. Some trackway sections may require special treatment for addressing noise, vibration, or aesthetic issues. Refer to the EPR for additional information. The running rail shall be 115RE rail and would be both for ballasted track and embedded track sections. In addition to supporting and guiding the LRV, the completed Trackwork shall control noise and vibration to acceptable limits. It shall control stray current within limits to mitigate any corrosion control issues. It shall be Project Co's responsibility to monitor stray current and correct any defects in the track's isolation materials. It is assumed that Project Co will use a rubber boot to isolate the 115RE rail in the embedded track section. However, Project Co may propose other approaches especially at higher speed road crossing of the trackway, noise or vibration sensitive areas, and special trackwork locations.
- (b) Special trackwork will be required at terminals, interlockings, and in the OMSF. Wherever possible, Project Co shall be required to apply American Railway Engineering and Maintenance-of-Way (AREMA) standards for special trackwork. Switch heaters shall be provided at all special trackwork locations.
- (c) The trackwork design shall address the actual wheel profile to ensure a smooth transition at frog and switch areas and a proper rail/wheel interface with the running rail.
- (d) Particular attention is needed to design and construct embedded and ballasted track to avoid frost heaving. This issue is also important at the station stop platform edge to ensure the Accessibility for Ontarians with Disabilities Act (AODA) requirements are not compromised during cold weather conditions.

#### **A.17 Overhead Contact Systems (OCS)**

- (a) Project Co shall design, furnish, install, and test all Overhead Contact Systems. Where needed, the OCS may be required to be supplemented by a parallel underground traction power duct bank. The OCS shall be designed for receiving regenerative power from the braking LRV.

#### **A.18 Traction Power Substations**

- (a) The Traction Power Substations (TPSS) shall provide a source of electrical power that meets the electrical load requirements for train operations in a safe, reliable and efficient manner under normal as well as contingency conditions. It is estimated the LRT Project will require about 13 TPSSs. Twelve TPSSs are needed for mainline power and one TPSS is required for the OMSF. The TPSS will provide 750 volts of DC current to the OCS. Each substation will draw power from two independent but shared 13.8 kV feeders

and regenerative power will not be returned to the AC system. The design of the TPSS and OCS shall comply with industry valid norms and standards with respect to grounding and bonding and shall be coordinated in order to control the level of touch potential voltage within acceptable North American standards.

**A.19 Systems Integration, Systems Engineering, Testing, Certification, and Commissioning**

- (a) Of special note is the need for Project Co to provide personnel who are highly qualified and experienced in System Integration, Systems Engineering, Testing, Safety Certification and all pre-revenue activities needed to commission the System. The design shall address any electromagnetic interference or radio frequency interference issues and ensure the design for the System incorporates the principles of electromagnetic compatibility.