Region of Waterloo

Stage 1 Light Rail Transit Project

Performance Output Specifications

Article 10

Communications

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ARTICLE 10 COMMUNICATIONS

10.1 General

(a) The purpose of this Article is to provide design guidelines for the communication subsystems to be provided for the Project. Project Co's solution to communication subsystems shall expand on these guidelines. Project Co shall prepare a Basis of Design Report – Communications with equipment specifications and concept level drawings and block diagrams, which explain Project Co's approach to Communications design work in greater detail and in a site specific manner. The presentation of specific communication subsystems design 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 for all the communications subsystems. The Basis of Design Report – Communications shall address every aspect of the communications design requirements cited in this Article. The rationale for all deviations or variances from any requirement cited this Article must be fully described in the Basis of Design Report – Communications, which is referred to within this Article as the Basis of Design Report.

(b) The communications system supports the electronic communications, data processing, and human interface systems to enable the monitoring and supervision of Stage 1 LRT operations, security, maintenance and administrative functions. Also included are voice and data communication systems in support of operation, security, maintenance, customer service and administrative functions.

(c) The communications system may be provided through various media to enable the interconnection of subsystems, wayside/field devices, onboard vehicle subsystem/ devices, etc. associated with the Stage 1 LRT Project.

(d) Drawing # I-SA-001, "Stage 1 LRT ITS Architecture Communication Links" summarizes the overall design concept of the LRT communication system.

10.2 References, Standards, Regulations, Codes, and Guidelines

(a) The communications system shall be designed and implemented in accordance with codes and standards specified by the following organizations. Project Co shall comply with the latest revisions of the codes and standards identified below wherever applicable to the systems at the time of award of the Project Agreement.

(i) Canadian Standards Association

(ii) Ontario Electrical Safety Code - 2012

(iii) Electrical and Electronic Manufacturers' Association of Canada

(iv) Industry Canada

(v) Internet Engineering Task Force (IETF)

(vi) International Organization for Standardization (ISO)

(vii) National Electrical Manufacturers Association (NEMA)

(viii) National Fire Protection Association (NFPA)

(ix) Building Industry Consulting Services International (BICSI)

(x) Institute of Electrical and Electronics Engineers (IEEE)

A. IEEE 802.1b - LAN Management

B. IEEE 802 1d – MAC

C. IEEE 802.1g –Remote MAC Bridging

D. IEEE 802.1q –Virtual Bridged LAN

E. IEEE 802 1p –Quality of Service for Traffic Prioritization

F. IEEE 802.3 – CSMA/CD Access Method and Physical Layer Specification

G. IEEE 802.3ae – 10 Gigabit Ethernet

H. IEEE 802.3u – Fast Ethernet

I. IEEE 802.11a/b/g/n – Wireless Local Area Networks

(xi) Metro Ethernet Forum (MEF)

A. MEF 2 Requirements and Framework for Ethernet Service Protection

B. MEF 3 Circuit Emulation Service Definitions, Framework and Requirements in Metro Ethernet Networks

C. MEF 4 Metro Ethernet Network Architecture Framework Part 1: Generic Framework

D. MEF 6.1 Metro Ethernet Services Definitions Phase 2

E. MEF 7 EMS-NMS Information Model

F. MEF 8 Implementation Agreement for the Emulation of PDH Circuits over Metro Ethernet Networks

G. MEF 9 Abstract Test Suite for Ethernet Services at the UNI

H. MEF 10.1 Ethernet Services Attributes Phase 2

I. MEF 11 User Network Interface (UNI) Requirements and Framework

J. MEF 12 Metro Ethernet Network Architecture Framework Part 2: Ethernet Services Layer

K. MEF 13 User Network Interface (UNI) Type 1 Implementation Agreement

L. MEF 14 Abstract Test Suite for Traffic Management Phase 1

M. MEF 15 Requirements for Management of Metro Ethernet Phase 1 Network Elements

N. MEF 16 Ethernet Local Management Interface

O. MEF 17 Service OAM Framework and Requirements

P. MEF 18 Abstract Test Suite for Circuit Emulation Services

Q. MEF 19 Abstract Test Suite for UNI Type 1

R. MEF 20 UNI Type 2 Implementation Agreement

S. MEF 21 Abstract Test Suite for UNI Type 2 Part 1 Link OAM

(xii) Electronic Industries Association (EIA)

A. EIA 603 – Radio Transmitters

B. EIA 204-D – Radio Receivers

C. EIA 329-A, 1 – Radio Antennas

D. EIA RS-316 – Radio Electrical Performance

E. EIA-310-D - Cabinets, Racks, Panels, and Associated Equipment

(xiii) European Committee for Electro-technical Standardization (CENELEC)

A. EN 50121: 2000, Railway Applications- Electromagnetic Compatibility

B. EN 50126: 1999, Railway Applications:- The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

C. EN 50128: 2001, Railway Applications: - Communication, Signalling and Processing systems – software for railway control and protection system

D. EN 50155: 2001, Railway Applications:- Electronic equipment used on rolling stock

E. EN 60571: Electronic Equipment used on rail vehicles

(xiv) IEC 61373:- Revision 1999-01, Railway application –Rolling Stock equipment – 'Shock and Vibration Test'

(xv) IEC 60529 (consolidated edition 2.1 –February 2001) – Degree of Protection provided by enclosures (IP codes)

10.3 Light Rail Communication Systems

(a) The communications system for the LRT will encompass and/or support the following major functional elements:

(i) Communications Power Systems: These are the power requirements for communications equipment. The power configuration depends on the application and location.

(ii) Communications Fiber Plant: A fiber optic cable plant is required along the Right-of-Way and at other locations to interconnect each communications equipment location. The system may also be used to connect other Region of Waterloo control centres.

(iii) Communications Transmission System (CTS): Consists of fiber optic, radio microwave, and specialized point-to-point systems for the transmission of voice and data for other systems.

(iv) Supervisory Control and Data Acquisition System (SCADA): Provides data transmission capabilities between the Central Control Facility (CCF) located in the Operations, Maintenance, and Storage Facility (OMSF) and each LRT stop, signal equipment bungalow and wayside case, communication room and case, traction power substation, and various facilities.

(v) Telephone/Intercom System: Internal telephone/intercom system provides telephone communications between all light rail platforms, systems rooms, and facilities. Passenger Assistance Intercoms are discussed in more detail in Schedule 15-2 Article 9.

(vi) Closed Circuit Television System (CCTV): Permits visual monitoring of rail, administrative, and maintenance facilities to satisfy operations and security requirements. Video is recorded at a central location, and is available via the network to authorized users.

(vii) Two-Way Voice Radio Systems: Radio systems will generally be used for two-way voice communications between the CCF and field personnel, and among field personnel.

(viii) Data Radio Systems: Short-range wireless networking is used for several applications including transit management systems, automatic passenger counters, train control systems, shop maintenance data networks and for general communications to the CCF.

(ix) Transit Management System: Several systems are to be provided for train arrival and service exception information directly to passengers at light rail platforms. All fall under the umbrella of passenger information systems for the Transit Management function under ITS, which consists of several hardware arrangements to provide visual and audible announcements at platforms. Passenger information system on light rail transit vehicles will be supplied by the vehicle manufacturer. Variable message sign displays use real-time train location information to determine arrival time information for each sign at LRT platforms.

(x) ITS Based Security Systems: Several LRT facilities require security systems to detect intruders and to limit access into sensitive areas to authorized individuals. Examples of facilities with intrusion detection and access control include shop buildings, operator break rooms, traction power substations and the OMSF complex. This system will also include CCTV security functions and systems located on LRVs, and at LRT platforms.

(xi) Transit Security: Transit Security staff works in many areas of the system and generally require two-way radio, and CCTV network access. The LRT security office/centre also has a CCTV workstation that downloads and packages video for investigation of incidents on the LRT system.

(xii) Traffic Signal System: Traffic signals at signalized intersections are controlled, monitored and managed from a central location and system. Each traffic signal controller within the LRT corridor will be interconnected to a centralized traffic signal control system via the main fibre optic communications system.

(xiii) Fare Collection System: The communication system will provide secured communications for electronic fare collection systems located at LRT platforms along the corridor.

(xiv) Central Control Facility (CCF): Enables LRT Operations to remotely monitor and control LRT train control, security, power, facilities and related LRT systems. Also provides extensive rail management features and provides information to other LRT control centre systems. This is the location where full time supervision of LRT operations occurs.

(xv) Fire Alarm System: A Fire Alarm Control Panel (FACP) will monitor fire detection devices placed in each zone of coverage (e.g. building). The communication systems will allow operators at the CCF to monitor each FACP, receiving alerts when a detection device has been triggered. To attain redundancy in accordance with the applicable fire codes, a primary and secondary communication link will be required.

(b) Functional Requirements

(i) Communications related functional requirements for the various subsystems are provide within the designated system Article and/or subsections. Provided within this Article are specific communications requirements for the main communications backbone(s), as well as general communications requirements not related to, or addressed within, the various Articles.

(ii) Operations: Operation staff works in many areas of the LRT system and generally require two-way radio and telephone/intercom service for voice communications, and access to the LRT communications network.

(iii) Maintenance: Maintenance-of-Way staff works in many areas of the system and generally require two-way radio and telephone/intercom service for voice communications and access to the LRT communications network.

(iv) Field Locating Services: Project Co is responsible for the provision of field locating services for rapid transit buried communication, traction power and storm sewer infrastructures and any other systems as deemed necessary by the Region.

(v) Communications System Grounding

A. All communications equipment must be properly grounded to provide a safe installation and minimize spurious interference both to and from the communications system. The system design must include a grounding plan covering all equipment and parameters for pass/fail testing of the grounding system.

B. Each communications node requires a signal ground with a maximum earth-to-ground resistance of five ohms. This ground should be distributed to bus bars on the backboard and each equipment rack. Each equipment rack shall be electrically isolated from each other and from accidental grounds through mounting hardware. All equipment shall receive a chassis ground from the rack bus bar.

(vi) Communications Power Systems

A. In general, communications systems should operate in the event of utility power failure. Most communications equipment is now configured for 120 VAC, 60 Hz power, so Uninterruptable Power Supplies (UPS) are appropriate to maintain operation in the event of utility power failure. UPS units and batteries must be industrially rated to withstand temperature extremes and deep discharge cycles. Rated lifetime shall be a minimum of ten years. UPS systems must be tested at regular intervals agreed upon with the Region.

B. In ballasted territories, minimum field equipment and systems to be supplied by UPS units for a minimum of four (4) hours: CTS network equipment, CCTV, SCADA, telephone sets, and train control.

C. In line of sight territories and at platforms, minimum field equipment and systems to be supplied by UPS for a minimum of 90 minutes: CTS network equipment, CCTV, SCADA, telephone sets, passenger intercoms, and public address.

(vii) Communication and Power Duct Bank

A. All cables shall be installed in concrete encased ducts with a minimum of 10 ducts of a minimum 50 mm diameter. The duct bank allocation are as follows:

1	Fibre optic communication cable backbone
1	Train control signal cables
1	Train control signal power cables
1	Catenary electrical power cables
1	Fibre optic communication cable for traffic signals
1	Spare communications duct
1	Spare train control signal cable duct
1	Spare duct for others
2	Spare for Region of Waterloo

Project Co may propose alternate duct bank compositions and allocations from those noted above, if Project Co's design approach does not required a particular subsystem and its associated cables. In all design alternatives, spare ducts designated for the Region of Waterloo's use shall be provided.

B. The duct bank shall be located within the Stage 1 LRT Right-of-Way.

C. In ballasted track territory, concrete cable troughs may be used in lieu of the duct bank. The cable troughs shall be rated for occasional vehicle loadings and trough covers shall be securely bolted down. At at-grade crossings along the alignment, cable troughs shall not be used to cross the roadway.

(viii) Fiber Optic Cable Plant and Testing

A. A fiber optic cable plant is required to serve each major node, additional communications node (minor node), and facility requiring communications along the Right-of-Way. A separate fibre optic cable shall be provided to support the LRT systems and the traffic signal control system.

1. A fiber backbone consist of loose-tube single-mode fibers and interconnects each major communications node. These cables are installed in conduit within a duct bank. A minimum of 100% spare fibers is required.

2. Trunk and branch cables shall consist of all required single-mode fibers divided into buffer tubes and housed within a protective cable structure suitable for installation in outdoor underground ducts.

3. The mean optical attenuation of 1310 nm shall not be greater than 0.4 dB/km with a standard deviation not greater than 0.05 dB/km. The maximum attenuation of any continuous length at 1310 nm shall not exceed 0.45 dB/km.
4. The single-mode fibers shall have a step refractive index profile.
5. The single-mode fibers shall have attenuation and bandwidth specified at two wavelength windows: first wavelength window shall be around 1310 nm and second wavelength window shall be around 1550 nm.
6. The fiber optical bandwidth at 1310 nm and/or 1550 nm shall be equal to or greater than 1000 MHzkm.
7. The zero dispersion wavelength shall be at a wavelength of 1310 ± 10 nm. The maximum dispersion at 1550 nm shall not exceed 18 ps/nmkm.
8. All cables shall be rated for operational temperatures of -30°C to +60°C.
9. All cables shall provide mechanical support and protection for specified number of fibers.
10. Minimum static bending radius for cables under no tension shall be 200 mm whereas the minimum bending radius during installation shall be 300 mm
11. Materials used in cables shall not produce hydrogen in a concentration so large to cause any degradation in the transmission performance of the optical fibers.
12. The quantity of fiber terminations required at each major communications node is a minimum of 100% of the active fibers dropping off at the node. ST-type is standard for fiber patch panels.
13. Minor communications nodes, such as signal rooms/houses/cases, traction power substations, communication cabinets, depending on distance from main communications nodes and equipment requirements, shall be served with single-mode fiber cable between the minor node and the nearest major node. A minimum of 100% spare fibers is required or a minimum fiber count of 12. All fibers shall be terminated at each end on an ST-type patch panel.
14. Drop cable shall consist of all required optical single-mode fibers to be housed in a protective armoured jacket rated for outdoor installation in underground conduits. The cabinet end of the fiber shall be connectorized where the other end shall be spliced into a Trunk or Branch cable. The attenuation drop cable shall not exceed 0.35 dB/km measured at 1310 nm and 0.25 dB/km measured at 1550 nm.
15. Individual communication devices, such as CCTV cameras and other ITS equipment/field devices may be served with tight buffered, single-mode cables. A minimum of 6 fibers per cable is required, and no more than one third of the fibers in the cable may be assigned at time of construction.

16. All major node patch panels shall have capacity for all terminations plus 100% at a minimum. The attenuation of a fibre optic patch cord cable after installation shall not exceed 0.1 dB measured at 1300 nm and 1500 nm, not including connector loss.
17. At end nodes, all fibers shall be terminated.
18. At intermediate nodes, all un-terminated fibers shall be spliced through.
19. All train control network fibers shall be spliced through in communications rooms/cabinet/enclosures, without terminations.
20. Cable passing through electrical chambers shall be installed in split duct and shall have sufficient slack for expansion and contraction. The split duct shall clearly identify the contents to the fibre optic cable.
21. All splices in the Central Control Facility shall be housed in indoor splice enclosures.
22. Maximum loss introduced by any single-mode splice shall not exceed 0.25 dB at 1310 nm and 1550 nm. Average splice loss shall not exceed 0.1 dB for any given span, with a standard deviation not greater than 0.07 dB.
23. Each splice shall be tested for tensile strength by applying a force of not less than 200 grams.
24. Project Co shall be responsible for ensuring the cable length is sufficient to allow for connection between communication equipment and the splice enclosures, including provision for slack, vertical runs, cable necessary for splicing, wastage and cable to allow for removal of splice enclosure for future splicing.
25. Project Co shall be responsible for all testing and documentation required to establish approval and acceptance of installation and operation of the communication backbone and associated fibre optic equipment.

(ix) Supervisory Control and Data Acquisition

A. Supervisory Control and Data Acquisition (SCADA), provides an interface between systems such as train control, traction power, and facilities; and the communications network. Locate a microprocessor based Remote Terminal Unit (RTU) at each user node. Each RTU has input and output (I/O) capability as needed to interface to the users, and programming as required to transport indications from the RTU to a host computer located at the CCF and to actuate commands received from the host computer. RTUs are networked on the SCADA network LAN.

1. Train control and traction power systems typically are equipped with microprocessor based controllers at the train control wayside cases/houses and traction power substations.

(x) Point-to-Point Data

A. Point-to-point data circuits are generally to be avoided in favor of networked data connections.

B. Where necessary, point-to-point data circuits are implemented to transport data to and from a field device, and the host computer at the CCF. These devices usually employ a serial communications interface.

C. Historically, these circuits are implemented using a sub-rate data circuit on the communications backbone; however, the availability of such services is becoming rare.

10.4 Transport System LAN Definitions

(a) This subsection identifies the independent data networks to be established within the communication system. Additional data networks beyond those identified may be required by design.

(b) SCADA LAN

(i) The SCADA LAN is an Ethernet network carried on the communications network. It transports all communications between the CCF host computer at OMSF and field SCADA equipment, and remote workstations located at crew rooms and maintenance facilities. This system is typically used for functions such as operator sign-in, train orders and special instructions, and maintenance access to SCADA information.

The SCADA LAN shall operate on dedicated fibre optic cable strands.

(c) Intercom LAN

(i) This LAN is an Ethernet network carried on the communications network. It transports voice intercom traffic between field locations and the intercom servers.

(d) Telephone LAN

(i) This LAN transports telephone traffic between field locations and the telephone servers.

(e) Security Access Control LAN

(i) The Security Access Control LAN transports all access control data between local controllers in the field and the central management server, located at CCF.

(f) Rail-to-Earth LAN

(i) The Rail-to-Earth (or Stray Current Measuring LAN) transports stray current measuring data from field measuring units, generally located at traction power substations, to the stray current monitoring workstation.

(g) Traction Power LAN

(i) The Traction Power LAN is an Ethernet network carried on the CTS. It transports networked communications between traction power substations and a maintenance terminal at the traction power maintenance office. Typically this network is used for transport of detailed substation information that is not sent to CCF.

(h) Fare Collection LAN

(i) The Fare Collection LAN is an Ethernet network carried on the communications network. It transports all network communications between ticket vending machines located at light rail platforms and the centralized Revenue Management System.

(i) The fare collection LAN shall operate on dedicated fibre optic cable stands.

(i) CCTV LAN

(i) The CCTV LAN carries all CCTV images captured in the field to the CCTV servers located at the CCF. Conversely, it carries camera control commands, where applicable, to the field equipment.

(ii) The CCTV LAN shall operate on dedicated fibre optic cable stands.

(j) Transit Management System LAN

(i) The Transit Management System LAN is an Ethernet network carried on the communications network. It transports all communications between TMS field devices located at light rail stops and the centralized transit management system.

(k) Traffic Signal Control System LAN

(i) The Traffic Signal Control System LAN is an Ethernet network carried on the communications network. It transports all communications between traffic signal control field devices located at signalized intersections and the centralized traffic signal control system.

(ii) The Traffic Signal Control System LAN shall operate on an independent fibre optic cable from other LRT systems.

(l) Administrative LAN

(i) The Administrative LAN transports communications between administrative connection nodes at light rail hubs and the Stage 1 LRT Communications Network. Typically this network is used for transport of maintenance support data, email and other operations related data, and support of network workstations located in the field.

(m) Fire Alarm System LAN

(i) The Fire Alarm System LAN transports all data communications between each FACP, located in the field, and the Master Fire Alarm Panel located at the CCF.

(ii) The fire alarm system LAN shall operate on dedicated fibre optic cable stands.

10.5 Field Equipment Technical Requirements

(a) A communications cabinet is required at each field communications node. Communications equipment requires housing in environmentally controlled cabinets. Where necessary HVAC systems shall be integrated within the cabinet.

(b) Whether the communications equipment is in a house, room, or cabinet, the following design requirements apply. The room, house, or cabinet for each communications node shall be sized to accommodate and be equipped with:

(i) Where a room may be required it is preferred to have a minimum interior footprint of 10’ x 11’ for the communication room.

(ii) Three feet minimum, with cable management hardware between racks.

(iii) Outlet strips for each rack wired to UPS and house power.

(iv) Ground bus bars for each rack.

(v) Overhead raceway serving racks and backboard.

(vi) Rack height (excluding raceway) is recommended with maximum of 7'-0".

(vii) Backboard—Provide for termination of all copper signal cables and placement of cable entrance protection.

(viii) Gigabit Ethernet switch with a minimum of 50% spare ports.

(ix) Fiber splice/patch panel for splicing/terminating the fiber backbone cable and any additional fiber cables for local runs.

(x) Fiber optic media converters as required.

(xi) SCADA RTU, with a minimum of 16 inputs and 8 outputs

(xii) SCADA I/O Termination hardware

(xiii) Equipment to provide real time passenger information (public address and variable message signs) for the adjacent platform(s)

(xiv) Equipment to provide for at least 8 CCTV cameras for the adjacent stop.

(xv) UPS with sealed batteries with thermal runaway protection shall be provided and sized to carry the load for all equipment for that communications node for a minimum of 90 minutes, assuming the lowest allowable environmentally controlled temperature.

(xvi) The UPS battery charger shall be sized to carry the load for all equipment for the communications node and still recharge the batteries within 24 hours.

(xvii) UPS capacity shall be calculated based on all available rack spaces being occupied and a power requirement of 1000 Watts per rack, minimum, in order to provide for future equipment additions. This power requirement shall also be used as the basis for calculating room cooling requirements.

(xviii) Telephone/intercom system between field sites and CCF.

(xix) Power management hardware within substation back to the Control Centre.

(xx) Environmental control shall be provided to maintain the temperature in the case/room between 15 and 32 degrees Celsius.

(xxi) Interior lighting plans for houses shall be coordinated with the comprehensive equipment and furnishings layouts to minimize shadows from suspended equipment, raceways and equipment racks.

(xxii) Power wall receptacle locations shall be coordinated with equipment layout and requirements. Provide a minimum of two receptacles per wall.

(xxiii) Each room/house/cabinet shall report status of intrusion detection, fire alarm, and access control to CCF via SCADA.

10.6 SCADA System Requirements

(a) Requirements for the SCADA RTU are provided as follows:

(i) Solid-state, microprocessor-based with logic elements and auxiliary components configured on easily replaceable plug-in modules.

(ii) Provide interchangeability of modules; all RTUs shall be of a common design.

(iii) Capability to continue operations with the loss of communication to CCF as a result of either communication equipment failures or CCF failures.

(iv) Operate normally unattended. RTU logic and configuration data shall reside in non-volatile memory.

(v) Perform self-tests upon power up and on command from local test equipment and from CCS. Self-tests shall also be performed by input/output subsystems and input/output cards.

(vi) Provide for maintenance of input/output circuits (including disabling power to output circuits) and safe replacement of input/output cards while power is applied. Possess the capability to continue operation in outdoor weather conditions with 0 to 95% humidity (non-condensing).

(vii) Operate within a power supply range of plus or minus 5% of its nominal value and a frequency range of plus or minus 1% of its nominal value.

(viii) Capability to continue operation in the electromagnetic environment where they will be located, such as traction power substations, train control cases/houses, traffic cabinet and communications equipment rooms or houses or cases or cabinets.

(ix) Support local initialization and troubleshooting with either a local control panel or workstation or portable test equipment.

(x) Be modular in design to provide expansion of performance and capacity by adding subsystem modules. This shall include the ability to add a minimum of 20% more input/output subsystem modules.

(xi) Supplied with hardware and software tools and documentation for reconfiguration and expansion.

(b) RTU Inputs and Outputs

(i) RTUs shall support discrete inputs and outputs via relay contact closures (or optically isolated solid-state equivalents such as silicon controlled rectifiers). All discrete inputs to the RTU shall be of the same type. All discrete outputs by the RTU shall be of the same type. The following RTU input and output requirements shall be met:

A. Digital inputs to the RTU shall be from Form C relay contacts. The sensing voltage DC power supply shall be in the RTU domain.

B. Input and output signals shall be electrically isolated from the RTU.

C. RTU shall generate outputs via relays. Relays and transient suppression circuits shall be provided. RTU interface relays and relay contacts shall have a MTBF, at rated loads, of 5,000,000 cycles or more.

D. RTU outputs shall be momentary contact closures with a time duration that is stable and adjustable.

E. RTUs shall prevent unintended action such as energizing output circuits upon power-up and power-restore.

F. A serial digital data interface may be used between the RTU and other processor-based devices, such as Train-to-Wayside Communications (TWC). All serial interfaces to RTUs shall be optically isolated.

(c) RTU Wiring and Cabling

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

A. Signals between the RTU and train control houses/cases shall terminate at one centralized location.

B. Signals between RTU and Tractor Power Substations (TPSS) sites shall terminate at one centralized location.

C. RTU terminations shall include test points and rapid disconnect.

D. All wires and cables shall be labeled using a logically consistent labeling convention.

(d) RTU Networking

(i) RTUs shall utilize an Ethernet connection via the CTS to communicate with the CCF. Error correction and detection schemes shall be used utilizing an industry standard (such as CCITT CRC-16) and, at a minimum shall:

A. Detect all errors of up to 16 contiguous bits

B. Detect at least 99% of all error bursts greater than or equal to 16 bits

10.7 Communications Transmission System (CTS)

(a) A fiber optic Communications Transmission System shall be installed along the LRT Right of Way to connect the various field voice, data and video signals between the field and the CCF as follows:

(i) A minimum Gigabit Ethernet network shall be installed, with a layer-2 node at each major node.

(ii) Switches shall be modular, and industrially rated. A minimum of 6 Ethernet ports will be dropped at each major node location. A minimum of 50% spare ports of each type shall be provided. The Ethernet ports will accommodate any IP traffic required for the stop, substations and signal rooms. Generally, all traffic on the CTS will be Ethernet based.

(iii) The network switch shall be equipped with fiber ports to interconnect with remote devices.

(iv) All Ethernet circuits shall be routed through an RJ-45 patch panel.

(v) Power Sources: The CTS shall be powered by the UPS during emergencies.

(vi) Temperature: The CTS equipment shall be capable of operating within an ambient temperature range of 0˚C to + 50˚C.

(vii) Capacity: The CTS and its associated conduit system shall be sized to accommodate future anticipated growth, including possible commercialization. The single-mode fiber optic cable shall consist of a minimum of 48 fibers or the number of fibers required plus

100% spare fibers, whichever is greater. All mainline cables shall be installed in inner duct. Each mainline communications conduit shall be provided with inner duct for current and future use.

(viii) System Redundancy: Redundant communication links shall be established between all field communications nodes and the CCF to ensure that all functions at LRT corridor including LRV vehicles are operating nominally and safely. The communication backbone shall be a fully redundant network with self-healing network ring topology in case of operational failures at major nodes.

(ix) Dark Fiber

A. Dark fiber optic fibers are required for intra-system connections by certain non-communication systems, for example, traction power transfer trip and train control express cables or networks.

B. Project Co may install dark fibres for specific Project Co uses.

10.8 Telephone/Intercom System

(a) Blue Light Telephones: Blue Light Telephones, also designated 'Emergency Telephone,' are required at Tractor Power Substations (TPSS).

(b) Telephones: Standard push button dial telephones shall be provided in Communications equipment spaces, Signal equipment spaces, Traction Power Substations, Operation Rooms and other designated locations. Generally, these telephone sets shall be IP based instruments, featured for internal (LRT) calls only.

(c) Passenger Assistance Intercoms: Passenger Assistance Intercoms will connect transit passengers to an operator at the OMSF through a hands-free two way communication system using Voice Over IP. Operator at the OMSF will have ability to forward the call to either the Transit Security Control Centre or the Region of Waterloo Customer Service Call Centre depending on the nature of the call. Passenger Assistance Intercoms will be located at LRV platforms. Details of the Passenger Assistance Intercom Systems is in Schedule 15-2 Article 9.

10.9 Closed Circuit Television (CCTV)

(a) Closed circuit television (CCTV) equipment is required to provide security surveillance at each light rail stop and other selected locations.

(b) Field equipment generally consists of fixed dome cameras in heated housings.

(c) CCTV cameras shall be IP based utilizing H.264 encoding.

10.10 Remote Security Rooms

(a) Where remote security/surveillance rooms are required, they shall be equipped with the following communications features, at a minimum:

(i) Telephone/intercom system

(ii) Ethernet access into communication network

(iii) Access control system

10.11 Light Rail Vehicle to CCF Communication

(a) Wireless Access points shall be set up along the LRT corridor to provide a full seamless Wi-Fi coverage as the communication link between LRV and CCF via the CTS.

10.12 Central Control Facility and SCADA

(a) CCF and SCADA shall operate as a homogenous control system. This system provides indications from field equipment to the CCF and controls from the CCF to field equipment.

(i) SCADA RTUs provide the interface between the field equipment and the Communications Transmission System (CTS), which includes the communication backbone.

(b) Safety Constraints on CCF/SCADA Subsystem

(i) Modifications to the CCF/SCADA subsystem shall be such that no action or lack of action by the users or any malfunction of the CCF/SCADA subsystem equipment can cause an unsafe condition. Should the CCF/SCADA subsystem become completely inoperative, for any reason, the Stage 1 LRT System shall continue to operate normally and safely.

(ii) SCADA Remote Terminal Units (RTUs) shall operate in an unattended mode. The CCF system equipment shall continue operation in the event of failure of RTUs, and upon return to service of failed equipment, automatically resume normal monitoring and management of that equipment.

(c) Response Times

(i) The elapsed time from the first possible detection by an RTU or equivalent field device of an alarm or change of state, until display at the CCF shall not exceed 2.0 seconds, unless otherwise approved.

(ii) When a user enters a command for any individual device control, the RTU or shall generate the associated output signal, in the field, in no more than 2.0 seconds, unless otherwise approved. In the event a device equivalent to an RTU is used, the network shall deliver the command to the equivalent device in no more than 2.0 seconds, unless otherwise approved.

(iii) When a user requests a display, the completed display shall appear on the screen in not more than 2.0 seconds, unless otherwise approved.

(d) Central Control Communications Grounding

(i) The CCF system equipment shall utilize two independent grounding systems. One grounding system shall be for equipment grounding and the other for electronic signal grounding. The grounding systems shall interface to connection points in the Central Control Equipment Room (CCER) and the Central Control Facility Control Room

10.13 Central Control Facility and the Fire Alarm System

(a) The Fire Alarm System shall provide the Master Fire Alarm Panel at the CCF with notifications from the FACPs located in the field.

(b) The communication network between each FACP and the Master Fire Alarm Panel, shall adhere to the latest version of NFPA 72 (National Fire Alarm and Signaling Code), and ULC S542-06

(Installation of Fire Alarm Systems); which require both a primary and alternate communications path.

(c) Project Co shall be responsible for the design and the ongoing maintenance and operational cost of the primary and alternate communication services.

10.14 Light Rail Transit Radio System

(a) Light rail transit radio system communications system shall be provided. The system shall allow for communications between the following:

(i) Trains and controllers

(ii) Trains and Rail Supervisors

(iii) Rail Supervisors and Controllers

(iv) Non-revenue vehicles and Controllers

(v) Maintenance personnel and Controllers

(vi) Trains and maintenance personnel

(vii) Controllers and other emergency response personnel along the ROW

(viii) Trains and emergency response teams

(ix) Rail Supervisors and emergency response teams

(b) Project Co shall supply and install a two-way radio communication system on-board LRVs which can be integrated into the existing Region of Waterloo voice radio system and the onboard systems. The current trunked voice radio system used by the Region is described below:

(i) Operates on EDACS network at 800 MHz (With 25KHz channel bandwidth)

(ii) Simulcasting techniques used to provide wide-area coverage. The existing simulcast control system was replaced with the latest, GPS based, equipment in 2010.

(iii) The EDACS technology is currently being supplied by Harris Corporation.

(c) Project Co shall anticipate for the future upgrade of the two-way radio communication system to the P25 standard. The cost of this upgrade will not be included in the base submission.

10.15 Communications with Canadian National Rail

(a) Project Co shall supply and install required communications devices at the CCF to enable communications with Canadian National. This may include a radio based communication system, or other CN approved means.

10.16 Central Control Facility and Connections to the Region's Control Centres

(a) Communication connections between field devices and the Region's centres, as well as between the CCF and the Region's centres, for the purpose of the submission, shall be made via fibre at up to four (4) communication splice enclosures in the field along the LRT alignment. The Region will be responsible for bringing fibre from their control centres to the demarcations points along the LRT right-of-way for Project Co to complete the installation and splice connections. Project Co shall also provide the necessary ducts and chambers for cable routing between the demarcation point and the communication splice enclosure.

(b) Backup C2C connections shall also be provided at the CCF via leased secured DSL services for connections between the CCF and the Region's GRT Control Centre for the purpose of supporting security operations and LRT vehicle location information. Project Co shall be responsible for the operational cost of the leased services.