Final Report

TRANSITORY RECORD

Intelligent Transportation Systems (ITS) Strategy

Prepared for The City of London
by IBI Group

March 2018

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List of Exhibits

Acronyms and Definitions

ACRONYM	DEFINITION
APC	Automatic Passenger Counters
APS	Accessible Pedestrian Signals
ASA	Automated Stop Announcement
AVLC	Automatic Vehicle Location and Communication
BI	Business Intelligence
CAD	Computer Aided Dispatch
CCTV	Closed Circuit Television
DVR	Digital Video Recorder
EVP	Emergency Vehicle Pre-Emption
GPS	Global Positioning System
GTFS	General Transit Feed Specification
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
LAN	Local Area Network
LTC	London Transit Commission
MAC	Media Access Control
MDT	Mobile Data Terminal
MMS	Maintenance Management System
OBC	On-Board Computer
PA	Public Address
RT	Rapid Transit
RTMP	Rapid Transit Master Plan
TPAP	Transit Project Assessment Process
TSP	Transit Signal Priority
UPS	Uninterruptible Power Supply
VMS	Variable Message Sign

1 Introduction

The Intelligent Transportation Systems (ITS) Strategy for the London Rapid Transit (RT) is a high level framework that outlines the transit and traffic technology needs and concepts for the future RT system in the City of London (City). The purpose of this report is to provide supplementary detail to the summarized version of the ITS strategy that is outlined in the Environmental Project Report (EPR).

The use of ITS technologies will support the RT system in achieving the goals of providing safe, reliable, efficient, environmentally friendly, and attractive transit service that will be a catalyst for change in the City of London. By studying the user needs, and existing transit and traffic technologies available in the City, the applicable ITS technologies for the RT system can be identified to develop an ITS strategy.

The development of the ITS strategy is divided into:

- **Section 2**: Highlights the background information that is used for the ITS strategy development;
- **Section 3:** Identifies the user needs from the different background information;
- **Section 4:** Describes the different ITS technologies, maps them against the user needs, and provides a future system concept for the RT system; and
- **Section 5:** Recommends desirable and optional technologies for the RT system.

2 Background Information

To support the development of the ITS strategy, a variety of sources were referenced including:

- The ITS Architecture for Canada;
- Existing City documents:
  - The London Transit Commission (LTC) Route Structure and Service Guideline Review by Dillon Consulting Limited, dated April 2015;
  - The LTC Technology Plan dated February 19th 2016 developed by IBI Group; and
  - The council-approved Rapid Transit Master Plan (RTMP), by IBI Group, dated July 2017.

  Subsections 2.1, **2.2**, and **2.3** provide a brief summary of each of the above reports, and their relevance to the ITS strategy;
- The Shift Rapid Transit website (http://www.shiftlondon.ca);
- The City of London website (http://www.london.ca);
- The LTC website (http://www.ltconline.ca);
- Conference calls with the City's Roadway Lighting & Traffic Control division representative were held on August 16th, 2016 and November 28th, 2016. These conference calls provided an overview of the existing state of the City's traffic

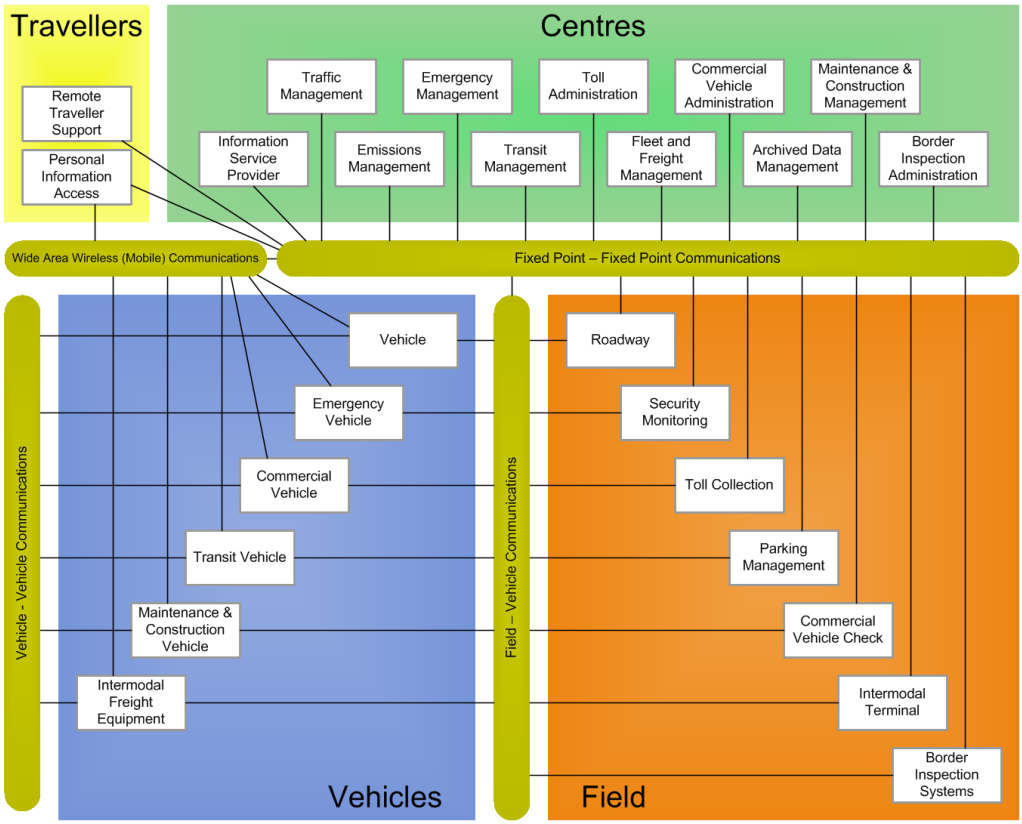
management system (including traffic signal central system and roadside devices, such as traffic signal controllers and TSP detection system);

- An email (dated September 28th, 2016) from the City's Roadway Lighting & Traffic Control division which addressed a number of questions regarding the existing and future states of the ITS elements used for the traffic management system; and
- A conference call with representatives from the LTC and the City's Roadway Lighting & Traffic Control division held on October 6th, 2016. A number of items were discussed and clarified including:
  - Existing ITS technology inventories by both LTC and the City's Roadway Lighting & Traffic Control division;
  - User needs for the RT system; and
  - Future ITS technologies that would be applicable for the RT system.

2.1 ITS Architecture for Canada

The ITS architecture for Canada provides a unified framework to guide the coordinated deployment of ITS programs within the public and private sectors, as described in Exhibit 2-1. This framework is a basis for the description of the physical components and the data flows within and between systems that are part of an overall ITS architecture. The physical components include travellers, vehicles, roadside devices, and control centres. In the ITS strategy, the ITS architecture framework is used as a basis to develop the RT system concept and technology interfaces. More information on this architecture can be found at the ITS Canada website (https://www.itscanada.ca/about/architecture/).

Exhibit 2-1: ITS Architecture for Canada



2.2 London Transit Commission Route Structure and Service Guideline Review and Transit Network Rapid Transit Integration Strategy and Financial Plan

The studies were performed by Dillon Consulting Limited to review the existing LTC route structure and services, and to develop a plan moving forward for the next five (5) years (Route Structure Review). The Rapid Transit Integration Strategy how the LTC fixed route services can be integrated with the RT system and highlighted user needs that can be addressed by ITS technologies.

2.3 London Transit Commission Technology Plan

The LTC technology plan is a collection of documents that provides an overview of the existing technologies to support daily LTC operations and maintenance, and identifies LTC's future needs for:

- ITS;
- IT infrastructure;
- Voice systems; and
- Data communications.

The LTC technology plan provides a framework of the proposed transit technologies to be implemented during the period 2015 through 2018, much of which has been completed. These technologies will be expanded where necessary for the RT system.

2.4 Rapid Transit Master Plan

The Rapid Transit Master Plan (RTMP) provides a strategy for building a RT network that meets the City's economic development, mobility, and community building objectives, while still being operationally feasible and economically viable. It is a plan in advance of the TPAP that outlines the corridors and technologies chosen for the RT system.

For the purposes of the ITS strategy, the RTMP document provided:

- User needs that supported the identification of ITS technologies; and
- Preliminary RT Stop designs and ITS technologies needed for the future implementation.

2.5 Existing Transit and Traffic Management Technologies

The LTC currently provides transit services throughout the City through both fixed route and demand based paratransit services. For the RT system deployment, new RT vehicles will be purchased for use, and it is assumed that the technologies available on the RT system will be integrated with the LTC's future fixed route services.

The existing conditions for the LTC's fixed route services are discussed in Exhibit 2-2, and the roadway traffic management systems are presented in Exhibit 2-3. An existing system overview is presented in Exhibit 2-4.

Exhibit 2-2: LTC Existing Systems for Fixed Route Services

ITEM	DESCRIPTION	SOURCES
Computer Aided Dispatch and Automatic Vehicle Location and Communication (CAD/AVLC) System	In 2018, the CAD/AVLC was upgraded to better support dispatch activities and provide efficient responses, as well as provide an enhanced user interface for real time information. In addition to the system found at both of the transit control centres, the fixed route service buses are equipped with an On-Board Computer (OBC) and a Mobile Data Terminal (MDT).	LTC Technology Plan and LTC Work Program Updates
Automatic Passenger Counters (APC)	By the end of 2018, all 213 LTC fixed route service buses in the fleet will be equipped with APC's. Going forward, all new bus purchases will include APC technology.	LTC Technology Plan and LTC Work Program Updates
Automated Stop Announcement (ASA) and Display System	All LTC fixed route service buses are equipped with Trapeze ASA and display system that is integrated with its CAD/AVLC system. This system provides both internal visual and audio next stop announcements, as well as external announcements when the doors are opened at a stop.	LTC Technology Plan and LTC Work Program Updates
CCTV Camera Security System	The Seon CCTV Camera Security System is equipped on LTC fixed route service buses. This consists of four (4) CCTV cameras on 40' buses and six (6) CCTV cameras on 60' buses, with capacity to store up to two (2) weeks of video data on the Digital Video Recorder (DVR). Video segments are uploaded via the shared garage wireless LAN when triggered by a request using a central video management software. Uploaded video segments are stored on central servers for 90 days. The system was updated to current technology for the entire fleet in 2017.	LTC Technology Plan and LTC Work Program Updates
Covert Alarm System	A covert alarm system is integrated with the CAD/AVLC system on all LTC fixed route service buses.	LTC Technology Plan
Farebox Collection System	The GFI CENTSaBILL farebox collection system is equipped on all fixed route service buses. These fareboxes were refurbished 10 years ago.	LTC Technology Plan
Transit Signal Priority (TSP)	All fixed route service buses are equipped with Opticom infrared TSP emitters. This system is system may require an update in order to meet the needs of modern standards.	LTC Technology Plan,

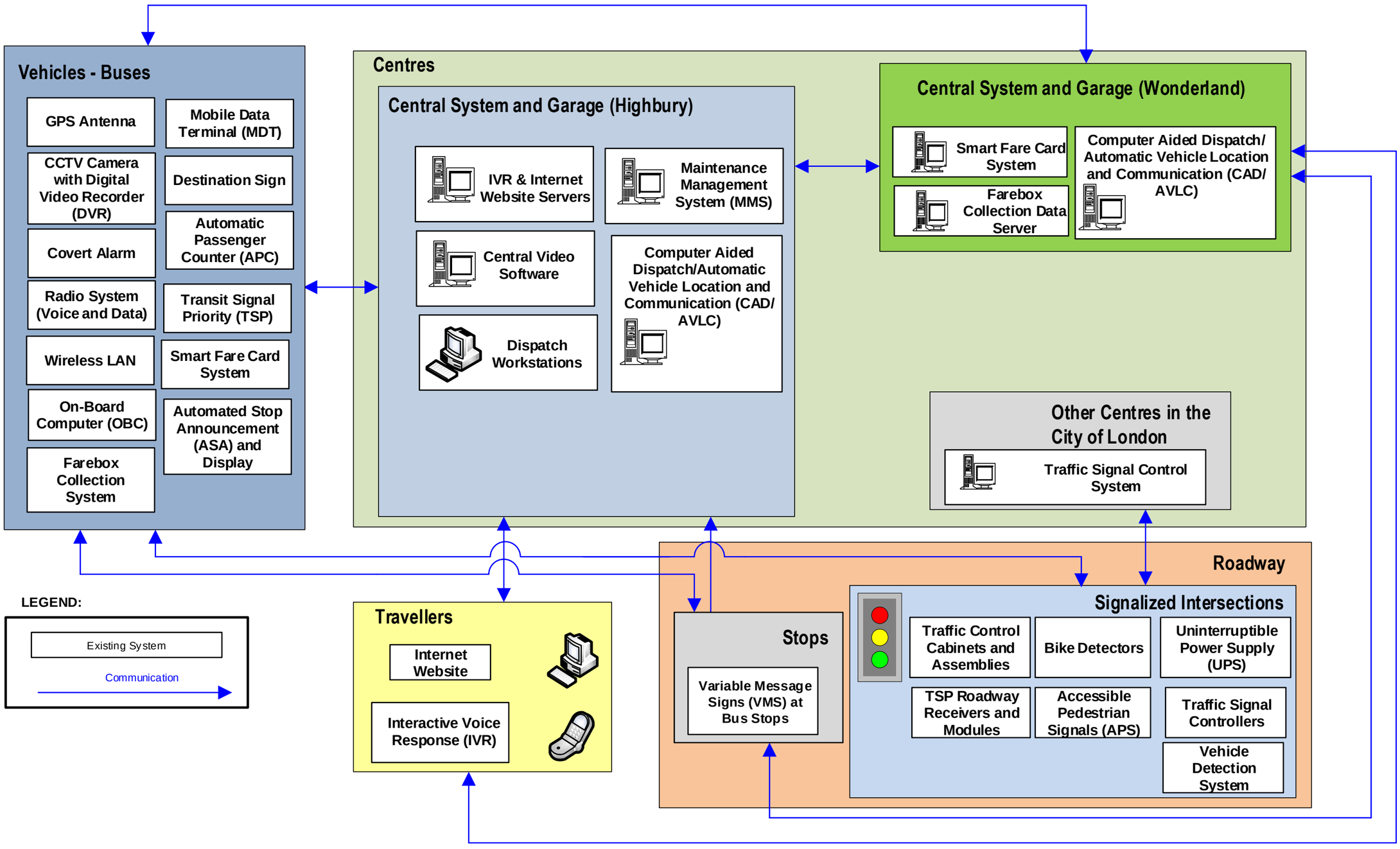
ITEM	DESCRIPTION	SOURCES
Smart Fare Card System	The LTC uses a Scheidt and Bachmann smart fare card system. The system is currently rolled out for users with a monthly transit pass as an option. Paper passes can still be purchased and are accepted. A stored value feature (for single trips) is planned to be rolled out in a near future.	LTC Technology Plan and the LTC Website
Radio Communication System	The radio system used by LTC for their fixed route services is a Tait 400Mhz system. The radio system will be nearing its end of life in the next five (5) years, and a replacement plan is needed moving forward.	LTC Technology Plan
Transit Traveller Information System	LTC's transit traveller information system includes InfoWeb (internet website), Interactive Voice Response (IVR), Variable Message Signs (VMS) at major transit terminals, and General Transit Feed Specification (GTFS) schedule data that supports Google transit trip planner. The system also provides for service information to be sent directly to the LTC corporate social media accounts as well as to any transit riders signed up for direct notification.	LTC Technology Plan and LTC Work Program Updates
Transit Control Centre	There are two (2) transit control centres, one at Highbury and one at Wonderland. Both centres serve different functions, as illustrated in Exhibit 2-4.	LTC Technology Plan
Maintenance Management System (MMS)	LTC has an Enrich MMS to track inventories and ensure all buses are well maintained for operation.	LTC Technology Plan

Exhibit 2-3: Existing Traffic Management Systems and Roadway Equipment

ITEM	DESCRIPTION	SOURCES
Communication System	Leased Bell lines and fibre communication technologies are found along the RT corridor.	The September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division
Traffic Signal and Central System	Siemens M52 and M32 traffic signal controllers are used at signalized intersections throughout the City. There is one Intellight X3L ATC controller installed in order to deal with a complex dual left turn movement. These traffic signal controllers are currently integrated into a Siemens Tactics Traffic Central System.	The September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division and the November 28th, 2016 conference call with the City's Roadway Lighting and Traffic Control Division.

ITEM	DESCRIPTION	SOURCES
TSP Receiver	Opticom infrared TSP receiver is currently in place at selected locations.	LTC Technology Plan and the September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division
Emergency Vehicle Pre-Emption (EVP)	Opticom infrared EVP system is currently deployed.	The September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division
Vehicle Detection System	Inductive loop vehicle detectors are deployed at selected signalized intersections across the City.	City of London website
Bicycle Detection System	Wavetronix bicycle detectors are installed at selected signalized intersections across the City.	The September 28th, 2016 email from City's Roadway Lighting & Traffic Control division
Accessible Pedestrian Signals (APS)	Polara APS systems are equipped at selected signalized intersections across the City.	The September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division
Media Access Control (MAC) Address Readers	BlueMAC portable Bluetooth MAC address readers can be deployed at different locations on demand.	The September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division
Uninterruptible Power Supply (UPS)	UPS systems are equipped at selected intersections across the City. The City has established a UPS standard for traffic signal and electrical design.	The September 28th, 2016 email from the City's Roadway Lighting & Traffic Control division

Exhibit 2-4: Existing Transit and Traffic System Architecture



3 User Needs Identification

User needs for the ITS strategy were collected through a variety of sources identified in **Section 2**. The list of user needs is presented in Exhibit 3-1. It is important to note that only user needs that can be addressed by ITS technologies are captured in the exhibit.

Exhibit 3-1: User Needs for the RT System

NO	USER NEEDS	SOURCES
1	A safe and secure environment for RT operators and passengers across the RT system.	RTMP
2	Safe and sufficient last mile access to and from the RT stops for all passengers.	RTMP
3	A fast, frequent, and reliable RT system to make RT a competitive mode of transportation against the auto mode of travel.	RTMP
4	Strategic road corridor optimization and enhancements in order to support the RT system.	RTMP
5	Provide a high quality transit ride.	RTMP
6	Increase the carrying capacity of the City's roadways.	Shift Rapid Transit Website
7	Reduce greenhouse gas emissions across the City.	Shift Rapid Transit Website
8	Encourage active transportation modes in the City to promote public health and reduce the environmental impact of transportation.	City of London Website
9	Improve the safety of the roadways in the City for all users (including pedestrians, cyclists, motorists, and transit users)	City of London Website

4 Technology and System Concept

This section identifies and discusses the transit and traffic technologies that can potentially address the user needs (noted in the previous section) in order to develop an ITS system concept for the RT system. This system concept shows the relationship between the different ITS technologies identified and serves as a high level guideline for the future ITS technology implementation. This section is divided into three (3) subsections:

- **Section 4.1** describes the different transit and traffic technologies;
- **Section 4.2** maps the technologies to the user needs as identified in the above section; and
- **Section 4.3** presents a future RT system concept design with the associated interfaces.

4.1 Transit and Traffic Management Technology

A selection of ITS technologies were identified to meet the user needs. The direct relationship to the user needs are highlighted in the next subsection. A brief description and benefits for each technology are outlined below. In addition, the integration requirements of these transit and traffic management technologies are also identified. Note that the final technology designs will be determined during the detailed design of the RT system.

The ITS technologies for transit are described below.

Communication System is critical to the function of any ITS technologies. Most transit ITS technologies on the RT vehicles will rely on wireless communications for data exchanges with the transit control centres, runningway, and roadway ITS devices. Data and voice communication networks are important for supporting transit operations, maintenance, and incident management. The communication system includes various combinations of equipment to support communication with RT vehicles and non-revenue vehicles (e.g. supervisor and maintenance vehicles), as well as fixed-end equipment at RT stops, transit control centres, and garages. In addition, the communication system can also support the traffic signal control and operation, as well as coordination with other City's agencies (e.g. City's Roadway Lighting & Traffic Control division and emergency services). CCTV camera images, incident records, and transit vehicle locations can be exchanged among centres. For these purposes, wired communication, such as fibre network and leased services could be considered.

- **CAD/AVLC System** assists with the real time monitoring and dispatch of the RT vehicles. It analyzes service data from the vehicles in order to improve service performance, and the efficiency of system operations. This system includes:
  - AVLC, a computer-based vehicle tracking system that monitors the position of a transit vehicle and relays its location to a central system. Positioning information can be transmitted in real-time using wireless communications infrastructure to provide a tracking capability for RT vehicles; and
  - CAD, software that allows the core AVLC function to display the position of every RT vehicle for dispatchers. This information is updated every 15 seconds on a map or schematic along with additional data on operational status.

CAD/AVLC system also includes other on-board components on RT vehicles, including GPS antenna, OBC, and MDT, which serve as the information link between transit control centres and the RT vehicles.

LTC has recently upgraded the existing CAD/AVLC system in order to support dispatchers with prioritizing issues and providing more efficient responses to incidents. For the RT system, the enhanced CAD/AVLC used for LTC's fixed route services will be integrated for use on RT vehicles and dispatch.

- **Fare Collection System** has a number of components that include:
  - A central server handles fare management activities in back office, such as fare transaction processing and reporting; and
  - Field devices such as smart fare card readers, ticket vending machines, and cash fareboxes can be deployed on-board RT vehicles or off-board at RT stops. While the off-board fare collection can reduce passenger boarding times and increase passenger convenience, fare enforcement will be required. In addition, as a benefit, fare collection technologies such as smart fare card and ticket vending machine can eliminate the acceptance of cash, coins, and paper transfers by the RT vehicle operators.

  The fare collection system for the RT system will integrate with the existing LTC fare collection and smart fare card systems in order to provide a single fare system across the City.
- **Security System** consists of a variety of technologies that communicate with the transit control centres and emergency services to provide safety for both operators and passengers of the RT system. These technologies include:
  - **CCTV Cameras** (on vehicles and at RT stops) which can capture raw video data for either local monitoring (i.e. for processing), remote monitoring, or for local storage (e.g. DVR). Microphones can also be integrated with CCTV cameras to capture audio. Security features can also be connected to the AVLC and pass on vehicle location along with the surveillance data to the transit control centres. The CCTV cameras and microphones can enhance the safety of the RT system as incidents can be monitored in real-time and/or also reviewed historically.
  - **Covert Alarms** allow RT vehicle operators to notify transit control centres and/or emergency services of an incident on RT vehicles. Combined with the communication system and AVLC, covert alarms can automatically notify the dispatchers, via the CAD system, that an emergency has arisen along with exact location of the vehicle. This improves the safety of the RT vehicle operator and the passengers on the vehicle in an event of an emergency where no other communication methods are possible; and
  - **Emergency Call Boxes** at RT stops which contain a communication system that connects the passengers with the transit control centres and/or emergency services in an event of an emergency. It can also be integrated with the CCTV camera system at RT stops so the passengers who are using the emergency call box can be seen by the dispatchers. The emergency call boxes typically have a connection with the Uninterruptible Power Supply (UPS) and backup communication systems to ensure that these devices work even in event of a power or communications failure.

  LTC currently has a CCTV camera security system deployed on their fixed route service buses with a central video software at the transit control centre at Highbury.

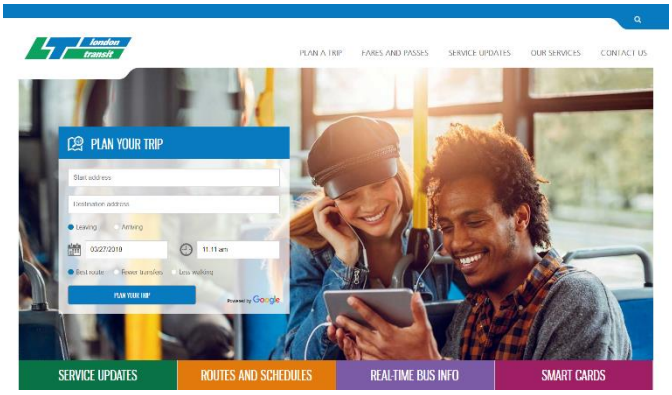
These existing systems could be enhanced and will be integrated with the RT system.

- **Transit Signal Priority (TSP)** allows transit vehicles to attain better mobility at traffic signal intersections by providing expedited treatment over general traffic. This system can improve transit travel time and reliability. A TSP system includes CAD/AVLC with OBCs, traffic management system (traffic signal central system and traffic signal controllers), and transit vehicle detection system. Depending on the design of the TSP system, the TSP functionalities can reside in the central system or local traffic signal controllers. The functionalities include TSP strategies and processing, parameter setup, and event logging.

  The transit vehicle detection system is used to identify the transit vehicle in general traffic. In response to transit vehicles being detected, active priority will temporarily alter the timings of traffic signal phases at one or more downstream intersections to accommodate the priority call from the vehicle through a communication system. Active transit priority can be split into two (2) groups, conditional and unconditional priorities. Note that an active TSP algorithm that requests priority only if specific predetermined conditions are satisfied (e.g. schedule adherence, passenger loading, door status). Active TSP strategies typically include phase insertion, phase skipping, phase rotation, green extension, and red truncation. The exact location of TSP enabled intersections and the strategy will be determined based on the traffic operations impact to road users (e.g. transit, general traffic, pedestrians, and cyclists) and the needs of the RT system.

  In addition to the infrared TSP detection system that is currently deployed for LTC fixed services, other TSP detection and communication systems could be considered and applied to the RT system, such as radio, GPS, and Wi-Fi.

- **Transit Traveller Information System** provides traveller information in different ways to enhance passenger experience including visually or hearing impaired passengers. The traveller information subsystems are currently integrated with the CAD/AVLC system to ensure the information to be more accurate and reliable. With this integration, the system disseminates information such as schedule information, expected vehicle arrival or departure time, as well as other information such as incidents, service advisories, and other ad-hoc messages. The different traveller information subsystems include:



  - **VMS and ASA Displays** that provide static and/or real-time information to passengers on vehicles (ASA Display) and at RT stops (VMS) through text and picture based changeable electronic signs. This subsystem also supports hearing impaired passengers. LTC currently has some VMSs deployed at major transit terminals and ASA Displays on their fixed route service buses;
  - **ASA and Public Address (PA) System** that performs similar functions as the VMS and ASA Displays, however provide this information audibly rather than through text. The ASA system announces the next stop on a RT vehicle

through text-to-speech or pre-recorded messages. The PA system allows the dispatchers/supervisors/operators to provide ad-hoc messages at RT stops and RT vehicles. Both these systems help and improve the experience for visually impaired passengers riding RT vehicles. LTC currently has audible ASA displays on all fixed route service buses; and

- Other transit traveller information subsystems that can be applicable for the RT system such as Internet websites (e.g. LTC's existing InfoWeb), IVR, and Mobile Phone Applications. Currently, LTC's fixed route service also provides trip planning information to Google through the GTFS. All existing LTC subsystems could be enhanced for the RT system.

- **ITS Elements Cabinet** at the RT stops houses ITS devices and their supporting communication devices such as modems. UPS are typically used to ensure ITS elements have backup power when there is a power failure.
- **Maintenance Management System (MMS)** supports the tracking, monitoring, and management of the RT fleet, facilities, assets, and inventory. Some of the items that are tracked by the MMS can lead to maintenance work, scheduled maintenance, and fuel monitoring. The MMS enhances the reliability of the RT system, improves the efficiency, reduces fuel consumption, and minimizes maintenance costs.
- **Reporting System** includes Business Intelligence (BI) tools and data warehouses that support data analytics from various sources across the RT system such as APC ridership data, fare collection information, and the bus operation data from the CAD/AVLC system (e.g. schedule adherence). The reporting system helps service planning team to understand the performance of the RT system, support future planning to improve passenger experience, and identify solutions to increase the efficiency of the system.
- **Wi-Fi System** can be provided on-board RT vehicles and at RT stops to allow passengers to connect to Wi-Fi using their mobile devices. This service would improve the passenger experience throughout the RT system.

The traffic ITS technologies communicate with the traffic signal control centre to help improve traffic flow along the RT corridors. This is done using real time and historical traffic performance monitoring and data gathered through ITS technologies. This information leads to better allocation of traffic signal green time, traffic signal progression, and a more efficient use of roadway capacity to serve RT vehicles and general traffic. These signal timings can be changed in real time or with pre-planned signal timings (e.g. by time of day, day of week, and/or event). In order to support these efforts, a variety of monitoring, detection, and traffic signal control elements can be used that include:

- **Traffic Signal Controllers and Traffic Signal Central System**. The traffic signal controllers take inputs from the TSP and vehicle detection system in order to operate and change traffic signal timing. The traffic signal controllers are connected with the traffic signal central system so that the signals can be updated with new signal timing plans on a regular basis or in real time. The system can improve travel times and reliability by reducing delay and increasing progression along corridors through the proper allocation of green time at traffic signals. The existing City traffic signal controllers could be enhanced or upgraded to meet the RT system needs;
- **CCTV Cameras** that help traffic dispatch operators monitor and validate the roadway traffic conditions. The captured images can be viewed through a dispatch workstation or on a display wall at the traffic management centre. Depending on the needs of these images and City's privacy policy, DVR can be deployed to store the

images. The CCTV cameras are typically found along the roadway or at intersections;

- **Read-Time Data Feeds** that provide information through a variety of mediums including third party data providers (e.g. Google Traffic, Inrix, Waze, etc.), 511 services, or other third party providers (e.g. in-vehicle navigation systems). The information provided to these data feeds could include travel times, route planning, and event information (e.g. construction, incidents, special events etc.). Depending on the outcome of the City's assessment of these technologies, they can be integrated as part of the RT systems to minimize the impacts to non-RT users;
- **VMS** that provide advance notification and warning of traffic pattern changes. The messages displayed on the VMS will be either travel time, pre-planned route change messages, or ad-hoc messages created by the traffic dispatch. They are generally found at mid-block of the roadway before traffic hot spots or locations with frequent disruption (e.g. at-grade rail crossings), so that general traffic drivers can make driving decisions before the next intersection. However, this technology is less commonly used on arterials due to limited road space and high maintenance costs;
- **Vehicle Detection Systems** are used in order to detect the performance of RT corridor and nearby arterials as well as detect the presence of a vehicle in order to trigger a movement at a signalized intersection. By detecting vehicles at signalized intersections, they improve the efficiency of an intersection by only allocating a green signal when a vehicle is present. Additionally, they can report on the performance of a corridor and relay this information back to traffic dispatch in real time. Vehicle detection systems usually encompass two (2) methods of data collection. These technologies include:
  - Sensor technology, that can be intrusive (e.g. inductive loop detectors, magnetometers, micro-loops) or non-intrusive (e.g. radar, video, microwave, laser). This technology is used for both performance measurement and vehicle detection at signalized intersections. Currently, radar detection systems are one of the sensor types that are commonly used in the City to detect vehicle and bikes. Furthermore, the City's existing inductive loop will need to be enhanced for the use on the RT corridors and nearby arterials so that they can detect multiple vehicle types, including bikes; and
  - Automatic vehicle identification technology, such as MAC address readers can capture and measure the travel metrics (e.g. travel time, origin-destination trends, etc.) of a vehicle travelling within a sensor network. The City's existing Bluetooth MAC address readers could be integrated and/or enhanced and provide travel information to the general traffic through VMS or other real time data feeds.
- **Train Detection Systems** can be used at railroad crossings to detect the presence of an oncoming train. This system would trigger the modification of signal timings at surrounding intersections to better manage capacity constraints at the railroad crossing during a train crossing event. As well, this could be integrated with the TSP system to limit the delay of RT vehicles at railroad crossings. Train detection systems can be applied using intrusive or non-intrusive means similar to sensor based vehicle detection systems. For the RT system, this technology would be applicable at the Canadian Pacific railroad crossing on Richmond Street;
- **Bike Detectors** are used to detect the presence of a bike within a defined zone, actuate bike signal, and differentiate it from other traffic. The bike detection system

improves the safety and encourages active transportation in the City. The existing bike detection system could be integrated into the RT system;

- **Accessible Pedestrian Signals (APS)** provides audible sounds (either through consistent sounds or messages) to indicate that the walk signal is on. The APS technology is installed at intersections in order to support visually impaired pedestrians. The City APS standard could be used for the intersections along the RT corridor; and
- **Traffic Signal Control Cabinets and Assemblies** house ITS elements found on the roadway. They can be outfitted with a UPS to provide power to intersections in an event of a power loss. The City currently has several UPS being installed at the high traffic volume corridors.

4.2 Technology Mapping

This subsection performs a technology mapping exercise to identify the applicable ITS technologies for the RT system identified in the above **Section 4.1**. The mapping exercise demonstrates the relevance of each ITS technology in relation to the user needs for this ITS strategy through a relationship as illustrated in Exhibit 4-1.

Exhibit 4-1: Technology Mapping

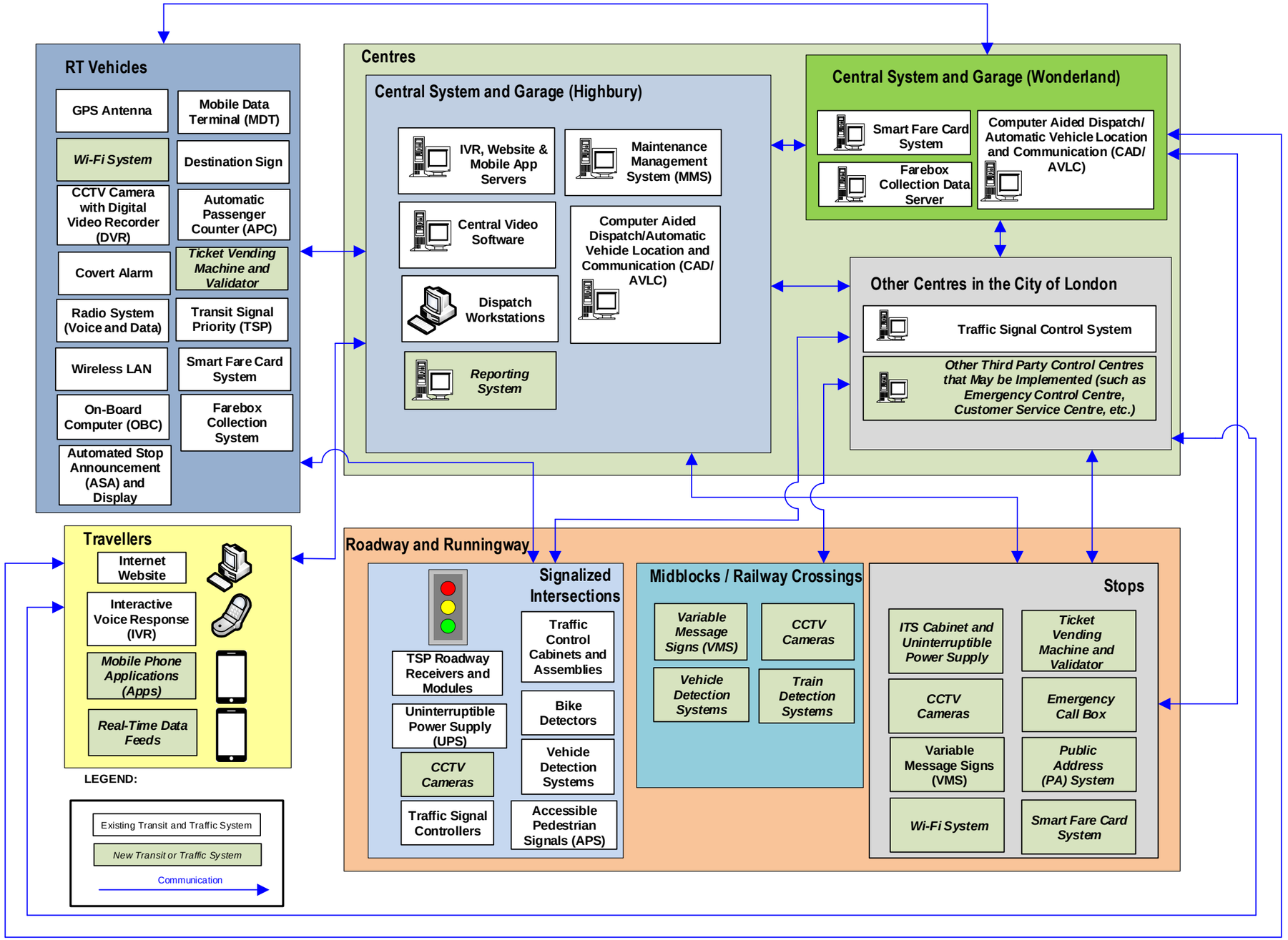
NO	USER NEEDS	COMMUNICATION SYSTEM	CENTRAL SYSTEM					RT VEHCILES														TRAVELLERS				FIELD EQUIPMENT (ROADWAY)										FIELD EQUIPMENT (RT STOPS)							
			CAD/AVLC SYSTEM	MAINTENANCE MANAGEMENT SYSTEM (MMS)	CENTRAL VIDEO SOFTWARE	FARE COLLECTION SERVERS	REPORTING SYSTEM	GPS ANTENNA	ON-BOARD COMPUTER (OBC)	RADIO SYSTEM	WIRELESS LAN	TRANSIT SIGNAL PRIORITY (TSP)	AUTOMATIC PASSEGNER COUNTER (APC)	AUTOMATED STOP ANNOUNCEMENT (ASA) AND DISPLAY	COVERT ALARM	CCTV CAMERA AND DIGITAL VIDEO RECORDER (DVR)	MOBILE DATA TERMINAL (MDT)	DESINTATION SIGN	WI-FI SYSTEM	SMART FARE CARD SYSTEM	FAREBOX COLLECTION SYSTEM	TICKET VENDING MACHINE AND VALIDATOR	MOBILE PHONE APPLICATIONS (APPS)	INTERACTIVE VOICE RESPONSE (IVR)	INTERNET WEBSITE	REAL-TIME DATA FEEDS	TRAFFIC SIGNAL CONTROLLER	TSP ROADWAY RECEIVERS AND MODULES	TRAFFIC SIGNAL CONTROL CABINETS, ASSEMBLIES	BIKE DETECTORS	VEHICLE DETECTION SYSTEMS (VEHICLE DETECTION AND MAC ADDRESS READERS)	TRAIN DETECTION SYSTEMS	ACCESIBLE PEDESTRIAN SIGNAL	UNINTERRUPTIBLE POWER SUPPLY	CCTV CAMERAS (AT INTERSECTIONS)	VARIABLE MESSAGE SIGNS (VMS)	TICKET VENDING MACHINE AND VALIDATOR	SMART FARE CARD SYSTEM	PUBLIC ADDRESS (PA) SYSTEM	VARIABLE MESSAGE SIGNS (VMS)	CCTV CAMERAS (AT RT STOPS)	EMERGENCY CALL BOX	ITS CABINET AND UNINTERRUPTIBLE POWER SUPPLY	WI-FI SYSTEM
1	A safe and secure environment for RT operators and passengers across the RT system.	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓								✓	✓	✓						✓	✓		✓				✓	✓	✓	✓	✓	
2	Safe and sufficient last mile access to and from the RT Stops for all passengers.	✓	✓		✓																			✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	
3	A fast, frequent, and reliable RT system to make the RT a competitive mode of transportation against the auto mode of travel.	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	
4	Strategic road corridor optimization and enhancements in order to support the RT system.	✓																							✓	✓	✓	✓		✓	✓	✓		✓	✓										
5	Provide a high quality transit ride.	✓	✓	✓		✓	✓	✓		✓		✓		✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓								✓	✓	✓	✓	✓	✓	✓	✓	✓
6	Increase the carrying capacity of the City's roadways.	✓																							✓	✓	✓	✓		✓	✓	✓		✓	✓										
7	Reduce greenhouse gas emissions across the City.	✓																							✓	✓	✓	✓		✓	✓	✓		✓	✓										
8	Encourage active transportation modes in the City to promote public health and reduce the environmental impact of transportation.	✓																						✓	✓	✓					✓	✓												
9	Improve the safety of the roadways in the City for all users (including pedestrians, cyclists, motorists, and transit users)	✓																							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓									

4.3 System Concept

An ITS systems concept was developed for the RT system based on the technologies identified in **Section 4.1**. Exhibit 4-2 presents the overall RT system architecture design. Key system interfaces identified are:

- Integration between on-board RT devices (CAD/AVLC, MDT, Fare Collection System, Destination Signs, ASA, etc.) and the OBC, to improve transit operation, and enhance passenger safety and experience;
- Interface between ITS devices at the RT stops (e.g. VMS, PA, Transit Traveller Information System) and the CAD/AVLC system to provide updated information to passengers to enhance their experience on the RT system.
- Interface between all transit vehicles (RT and LTC fixed route services) and the traffic signal central system and controllers for TSP;
- Interface between the transit control centre and other City's operation centres for traffic, transit, and emergency coordination purposes using a wired communication system; and
- Interface between roadside traffic control equipment (i.e. intersection and mid-block) and traffic signal control system to maintain general traffic operations.

Exhibit 4-2: Proposed ITS System Concept for the RT System



5 Recommendations

Based on the technologies outlined in **Section 4**, a number of recommendations can be concluded. In this section, the transit or traffic systems technologies from Exhibit 4-2 are categorized into different categories which include:

- Group 1: Recommended technologies (for new or replacements);
- Group 2: Recommended technologies to be expanded (using existing technologies); or
- Group 3: Optional technologies.

The exact new and replacement technologies can be further investigated during the detailed design. Note that any technologies recommended in this section should be provisioned for as part of the design of that element or category (i.e. RT stops, runningways, roadways, intersections centres, and vehicles). For example, the RT stop design shall provide adequate spacing to accommodate the existing technologies in addition to any new recommended technologies.

The recommendations are outlined in Exhibit 5-1 below. A system concept based on the recommendations in this section is shown in Exhibit 5-2.

Exhibit 5-1: Recommended and Optional Technologies

TEHCNOLOGY	GROUP 1: RECOMMENDED	GROUP 2: RECOMMENDED TO EXPAND (USING EXISTING TECHNOLOGIES)	GROUP 3: OPTIONAL	COMMENTS
Transit ITS				
Communication System (RT Stops, Midblocks, and Signalized Intersections)	✓			A new installation of fibre optic communications along the RT corridors is recommended in order to meet the needs of all the new ITS elements for both RT stops and roadways.
Communication System (RT Vehicles)	✓			The enhancement of the existing LTC fixed route radio system is recommended in order to accommodate the RT system.
On-Board Devices (RT Vehicles)		✓		The expansion of the existing onboard GPS Antenna, Wireless LAN, MDTs, APCs, ASA, display, and OBCs to be installed the new RT vehicles is recommended. Existing specifications found on LTC fixed route services can be used.
CAD/AVLC (RT Vehicles and Centres)		✓		The enhanced CAD/AVLC used for LTC's fixed route services will be integrated for use on RT vehicles and dispatch.
Ticket Vending Machine and Validator (RT Vehicles and RT Stops)	✓*		✓*	*These systems would only be recommended if the RT system adopted an off-board fare collection system. *If on-board fare collection was still performed, these systems would only be optional.
Smart Fare Card System (RT Vehicles, RT Stops, and Centres)		✓		The existing smart fare card system is recommended to be expanded to accommodate the new RT system on both vehicles and RT Stops. The system at the centres would need to be expanded in order to accommodate the new systems, such as licenses and IT infrastructure.
Emergency Call Box (RT Stops)	✓			The installation of this system is recommended at RT stops to ensure a safe environment for passengers during normal operations and in the event of an emergency.
CCTV Cameras and DVR (RT vehicles and Centres)		✓		The existing system is recommended to be expanded onto new RT vehicles. It should be noted that covert alarms are already integrated as part of this system.
CCTV Cameras and DVR (RT Stops)	✓			This will require a new system purchased for RT stops as they ensure a safe environment for passengers at RT stops.
TSP Roadway Receivers and Modules (RT Vehicles and Signalized Intersections)	✓			A new system is recommended as the current TSP receivers and emitters deployed in the City of London are not up to modern standards. This would be essential to ensure that the technology remains relevant for the future moving forward. It should be noted that depending on the TSP system deployed, the system may require modules for the roadside traffic controllers and the central traffic signal control system.
Variable Message Signs (VMS) (RT Stops)			✓	The installation of this system is recommended in order to provide real time information to passengers which may include next bus arrival or changes/status of the service. This is also crucial as it is an Accessibility for Ontarians with Disabilities Act (AODA) requirement for transit facilities and vehicles.
Public Address (PA) System and Speakers (RT Stops)	✓			The installation of this system is recommended as they complement VMS signs (which could be enhanced and expanded for the RT system) at RT stops and are crucial to relay passenger information during normal operations and in the event of an emergency. The integration of these two systems is also crucial as it is an AODA requirement for transit facilities and vehicles.
ITS Cabinet and Uninterruptible Power Supply (UPS) (RT Stops)	✓			These elements are recommended in order to house the ITS elements and provide power in an event of a power loss.
Mobile Phone Applications (Apps) (Travellers)			✓	This item for the RT system would only be optional since there are other existing traveller information tools (such as LTC's InfoWeb and IVR) that will be integrated with the RT system.
Maintenance Management System (Centres)		✓		This existing system is recommended for expansion in order to meet the needs of the new RT vehicles.
Reporting System (Centres)	✓			A new system is recommended to support service planning team to understand the performance of the RT system, support future planning to improve passenger experience, and identify solutions to increase the efficiency of the system.
Wi-Fi Systems (RT Vehicles and RT stops)			✓	This system would be optional as while they enhance the passenger experience and they are not crucial to the operations of the RT system.

TEHCNOLOGY	GROUP 1: RECOMMENDED	GROUP 2: RECOMMENDED TO EXPAND (USING EXISTING TECHNOLOGIES)	GROUP 3: OPTIONAL	COMMENTS
Traffic ITS				
Traffic Signal Controllers (Signalized Intersections)	✓			This system is recommended for replacement in order to accommodate the new TSP functionalities proposed.
Central Traffic Signal Control System (Centres)	✓	✓		This system is recommended for replacement in order to accommodate the new TSP functionalities proposed.
CCTV Cameras (Signalized Intersections and Midblocks)	✓*		✓*	*This system is recommended at intersections in order to support the traffic management. *It is only optional at midblock locations as most of the congestion is found at intersections.
Real-Time Data Feeds (Travellers)			✓	This item would be optional depending on the outcome of the City's assessment of the different technologies.
Variable Message Signs (VMS) (Midblocks) and Vehicle Detection System (Midblocks)			✓	These two systems are only option as they would only monitor and track the performance of general traffic and providing this information to general traffic on and near the RT corridor and not provide any direct benefit to the RT system operations.
Bicycle Detectors and Accessible Pedestrian Signals (APS)		✓		These two systems are recommended for an expansion to all RT system intersections.
Train Detection Systems (Railway Crossings)	✓			This system is recommended for installation at the Richmond Street Canadian Pacific railway crossing to support traffic management and RT vehicle operations.
Traffic Control Cabinet Assemblies including Uninterruptible Power Supply (UPS)	✓			This system is recommended for an expansion to all signalized intersections on the RT system.
Other Third Party Centres (Centres)			✓	These other centres such as emergency control centre and customer service centre are third party systems that may connect with the RT system. The deployment of these centres is defined as optional.

Exhibit 5-2: System Concept with Recommendations