DURHAM – SCARBOROUGH
Bus Rapid Transit

Appendix B3 – Intelligent Transportation Systems (ITS) Strategy

Prepared for Metrolinx
by IBI Group & Parsons

Final Report

Intelligent Transportation Systems (ITS) Strategy

Prepared for Metrolinx
by IBI Group with Parsons

May 2020

Document Control Page

CLIENT:	Metrolinx
PROJECT NAME:	Durham-Scarborough Bus Rapid Transit Corridor EA/TPAP
REPORT TITLE:	Intelligent Transportation Systems Strategy
IBI REFERENCE:	119887
VERSION:	V2.0
DIGITAL MASTER:	J:\119887_Mx_DS_BRT\5.0 Design (Work) Phase\ITS Strat Plan\Comments \TTR_DSBRT_ITSStrategy_2020_05_12_2.0
ORIGINATOR:	Graham Devitt, Marc Tan
REVIEWER:	Andrew Wong
AUTHORIZATION:	Mike Corby
CIRCULATION LIST:	
HISTORY:	V1.0 – Draft Report to Metrolinx V2.0 – Final Report to Metrolinx

Table of Contents

List of Exhibits

Acronyms and Definitions

ACRONYM	DEFINITION
AODA	Accessibility for Ontarians with Disabilities Act (AODA)
APC	Automatic Passenger Counters
APS	Accessible Pedestrian Signals
ASA	Automated Stop Announcement
AVL	Automatic Vehicle Location
BI	Business Intelligence
BRT	Bus Rapid Transit
CAD	Computer Aided Dispatch
CCTV	Closed Circuit Television
CV	Connected Vehicle
DRT	Durham Region Transit
DS	Durham-Scarborough
DSRC	Dedicated Short Range Communication
DVR	Digital Video Recorder
EA/TPAP	Environmental Assessment/Transit Project Assessment Process
EDR	Emergency Detour Route
EVP	Emergency Vehicle Pre-Emption
GPS	Global Positioning System
GTFS	General Transit Feed Specification
GTHA	Greater Toronto and Hamilton Area
ITS	Intelligent Transportation Systems
IVR	Interactive Voice Response
LAN	Local Area Network
LOS	Level of Service
MAC	Media Access Control
MDT	Mobile Data Terminal
MMS	Maintenance Management System
MOU	Memorandum of Understanding
MTO	Ministry of Transportation of Ontario
PA	Public Address
RESCU	Road Emergency Services Communication Unit
RTP	Regional Transportation Plan

ACRONYM	DEFINITION
SPaT	Signal Phasing and Timing
TMP	Transportation Master Plan
TSP	Transit Signal Priority
TTC	Toronto Transit Commission
UPS	Uninterruptible Power Supply
VMS	Variable Message Sign

1 Introduction

The Intelligent Transportation Systems (ITS) Strategy for the Durham-Scarborough (DS) Bus Rapid Transit (BRT) Corridor is a high-level framework that outlines the transit and traffic technology needs and concepts for the upgraded and expanded DS BRT route. The DS BRT will connect Oshawa and Toronto via Highway 2, through the Regional Municipality of Durham (Durham Region) and the City of Toronto, and Ellesmere Road through the City of Toronto. The purpose of this report is to outline an ITS strategy in support of the Environmental Assessment/Transit Project Assessment Process (EA/TPAP).

The use of ITS technologies will support the BRT corridor in achieving the goals of providing safe, reliable, efficient, environmentally friendly, and attractive transit service that will be a catalyst for changes in both Durham Region and the City of Toronto. By studying the user needs, and existing transit and traffic technologies available across the BRT corridor, the applicable ITS technologies for the BRT system can be identified to develop an ITS strategy for the future expansion.

The development of the ITS strategy is divided into five (5) sections:

- **Section 1:** Introduces the ITS strategy for the EA/TPAP;
- **Section 2**: Highlights the background information that is used for the ITS strategy development;
- **Section 3:** Identifies the user needs based on the background information;
- **Section 4:** Describes various ITS technologies, and identifies the ITS technologies that can respond to the user needs to provide a future BRT system concept; and
- **Section 5:** Recommends desirable and optional ITS technologies for the BRT.

2 Background Information

This section provides background information to develop the ITS strategy including information regarding the BRT corridor (**Section 2.1**), the existing ITS infrastructure along the study corridor (**Section 2.2**), and the different sources of information used in the preparation of this report (**Section 2.3**).

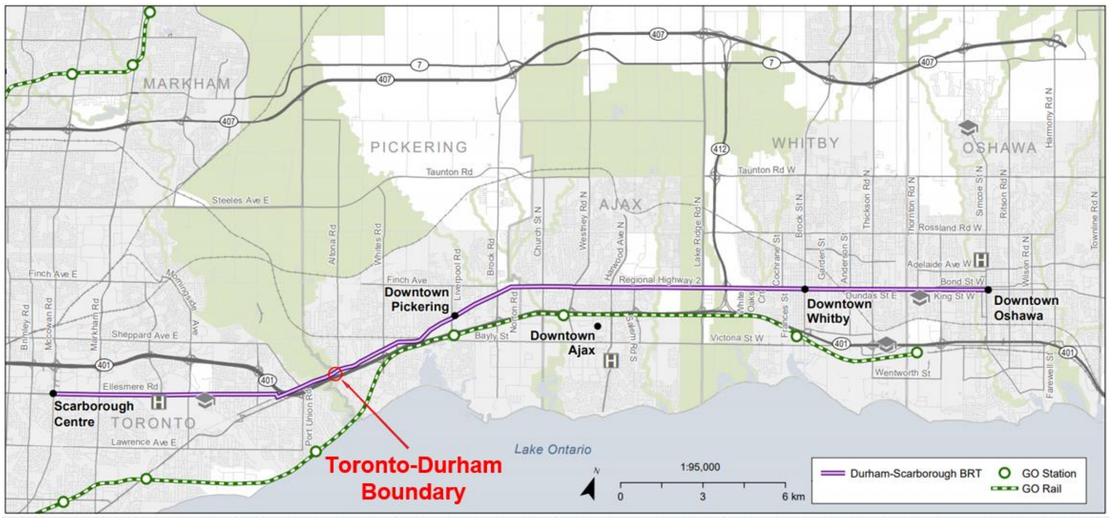
2.1 Study Corridor

The Highway 2-Ellesmere Road BRT corridor (the Corridor) is shown in in Exhibit 2-1. As the Corridor serves both Durham Region and the City of Toronto, the existing and future ITS technologies and infrastructure must be considered for both municipalities and the Greater Toronto and Hamilton Area (GTHA) as a whole. Currently, three (3) transit agencies run fixed-route buses along the Corridor:

- Durham Region Transit (DRT);
- Toronto Transit Commission (TTC); and
- GO Transit.

As part of this strategy, the existing ITS infrastructure of each must be considered in the BRT ITS strategy to properly discuss suggestions, improvements, and potential next steps. It should be noted that no TTC routes presently travel into Durham Region. As such, it is assumed in the future that TTC buses will only run along the City of Toronto section of the Corridor (west of the border with Durham Region as indicated on Exhibit 2-1).

Exhibit 2-1: DS-BRT Corridor Map



In Pickering and Ajax west of Salem Road, Highway 2 is a designated Emergency Detour Route (EDR) for traffic diversions from Highway 401, which is managed by the Ministry of Transportation Ontario (MTO). In the event of an emergency on Highway 401, staff at the Durham Region traffic management centre may implement signal timing plans along the Corridor to better accommodate diverted highway traffic. In future design work, this functionality should be considered as BRT operations could be impacted during Highway 401 emergency events.

2.2 Existing ITS Infrastructure

DRT, TTC, and GO Transit each provide fixed-route bus service in the Corridor with traffic signals operated under the jurisdiction of Durham Region and the City of Toronto. For this ITS strategy, the existing technologies for each transit agency and road authority were compiled, based on a variety of sources. Existing fixed route bus ITS infrastructure and conditions are discussed in Exhibit 2-2, and the existing roadway traffic management systems and technologies along the Corridor are described in Exhibit 2-3. An overview of the existing systems is presented in Exhibit 2-4.

Exhibit 2-2: Existing ITS Systems for Fixed Route Services Serving the Corridor

ITEM	DESCRIPTION	SOURCE(S)
Computer Aided Dispatch and Automatic Vehicle Location (CAD/AVL) System	Fixed route DRT and GO buses are equipped with similar CAD/AVL systems provided by the same vendor. Through the use of a GPS antenna, Vehicle Logic Unit (VLU), and Mobile Data Terminal (MDT), real-time location data is provided to transit management centres via mobile data networks. TTC fixed route buses are fully equipped with CAD/AVL systems. Vehicles contain a GPS antenna, Intelligent Vehicle Network (IVN), and Mobile Data Terminal (MDT) which communicate with transit management centres via mobile data networks.	Durham Region Connecting Communities (2007) Metrolinx INIT System Design Document (2012) Highway 2 BRT TSP Study (2018) TTC Vision System Architecture (2017)
Automatic Passenger Counters (APC)	Some DRT and GO Transit fixed route service buses are equipped with APC technology. All current TTC fixed route buses are equipped with APC technology.	Durham Region Connecting Communities (2007) Metrolinx INIT System Design Document (2012) TTC Vision System Architecture (2017) Discussions with TTC staff
Automated Stop Announcement (ASA) and Display System	All DRT, TTC, and GO Transit fixed route service buses are equipped with ASA technology that is integrated with their respective CAD/AVL system. These systems provide both internal visual and audio next stop announcements using onboard Variable Message Signs (VMS) and onboard Public Address (PA) systems to comply with the Ontarians with Disabilities Act (AODA).	Durham Region Connecting Communities (2007) TTC Vision System Architecture (2017)
CCTV Camera Security System	All DRT, TTC, and GO Transit fixed route service buses are equipped with CCTV cameras with Digital Video Recorders (DVRs).	Durham Region Connecting Communities (2007) TTC website
Covert Alarm System	A covert alarm system is integrated with the respective CAD/AVL system on all DRT, TTC, and GO Transit fixed route service buses.	Durham Region Connecting Communities (2007) TTC website
Farebox Collection System	Farebox collection systems are equipped on all fixed route DRT, TTC, and GO buses. Cash fare is accepted on all buses.	Durham Region Connecting Communities (2007) TTC website

ITEM	DESCRIPTION	SOURCE(S)
Smart Fare Card System	All DRT, TTC, and GO Transit fixed route buses are equipped with Presto smart fare card system that is operated by Metrolinx in partnership with different transit agencies.	DRT, TTC, GO Transit websites
Transit Signal Priority (TSP)	Selected DRT fixed route buses (PULSE) are equipped with TSP radios, which communicate TSP requests to roadside modules via 900MHz radios. All TTC fixed route buses are equipped with TSP transponders. Selected signalized intersections are equipped with TSP antennas installed in-pavement. As TSP systems in Durham Region and City of Toronto operate differently from one another, varying in onboard detection equipment, field detection equipment, TSP strategies, and priority request algorithms. Currently, compatibility and interoperability between the two systems are seen as challenges due to these differences. In addition, the independent governance of the two systems can lead to additional coordination required for integration and Operation and Maintenance (O&M) support.	Highway 2 BRT TSP Study (2018) City of Toronto website
Radio Communication System	All DRT, TTC, and GO Transit fixed route buses are equipped with radio communication technology. DRT uses unique channels on the GO Transit radio infrastructure for their communications.	Metrolinx INIT System Design Document (2012) TTC Vision System Architecture (2017)
Wireless LAN	All DRT, TTC and GO Transit fixed route buses are equipped with Wireless LANs used for communication of vehicle logged data to transit management centres.	Metrolinx INIT System Design Document (2012) TTC Vision System Architecture (2017)
Transit Traveller Information System	DRT, TTC, and GO Transit each operate internet websites, real-time Short Message Service (SMS) vehicle location data, Interactive Voice Response (IVR), and General Transit Feed Specification (GTFS) schedule data that supports Triplinx trip planner. GTFS schedule data has been integrated into some third party smartphone applications. Real-time location data is also available through third party applications.	Metrolinx INIT System Design Document (2012) TTC Vision System Architecture (2017)
Maintenance Management System (MMS)	MMSs are employed for all fixed route DRT, TTC, and GO buses.	N/A

ITEM	DESCRIPTION	SOURCE(S)
Transit Management Centre	Transit management centres for each transit agency are found at the following locations: • DRT Raleigh Garage, 710 Raleigh Avenue, Oshawa; • TTC Hillcrest Complex, 1138 Bathurst Street, Toronto; • TTC Davisville Office, 1900 Yonge Street, Toronto (TTC); and • GO Transit Network Operations Centre, 155 Cornwall Road, Oakville.	N/A

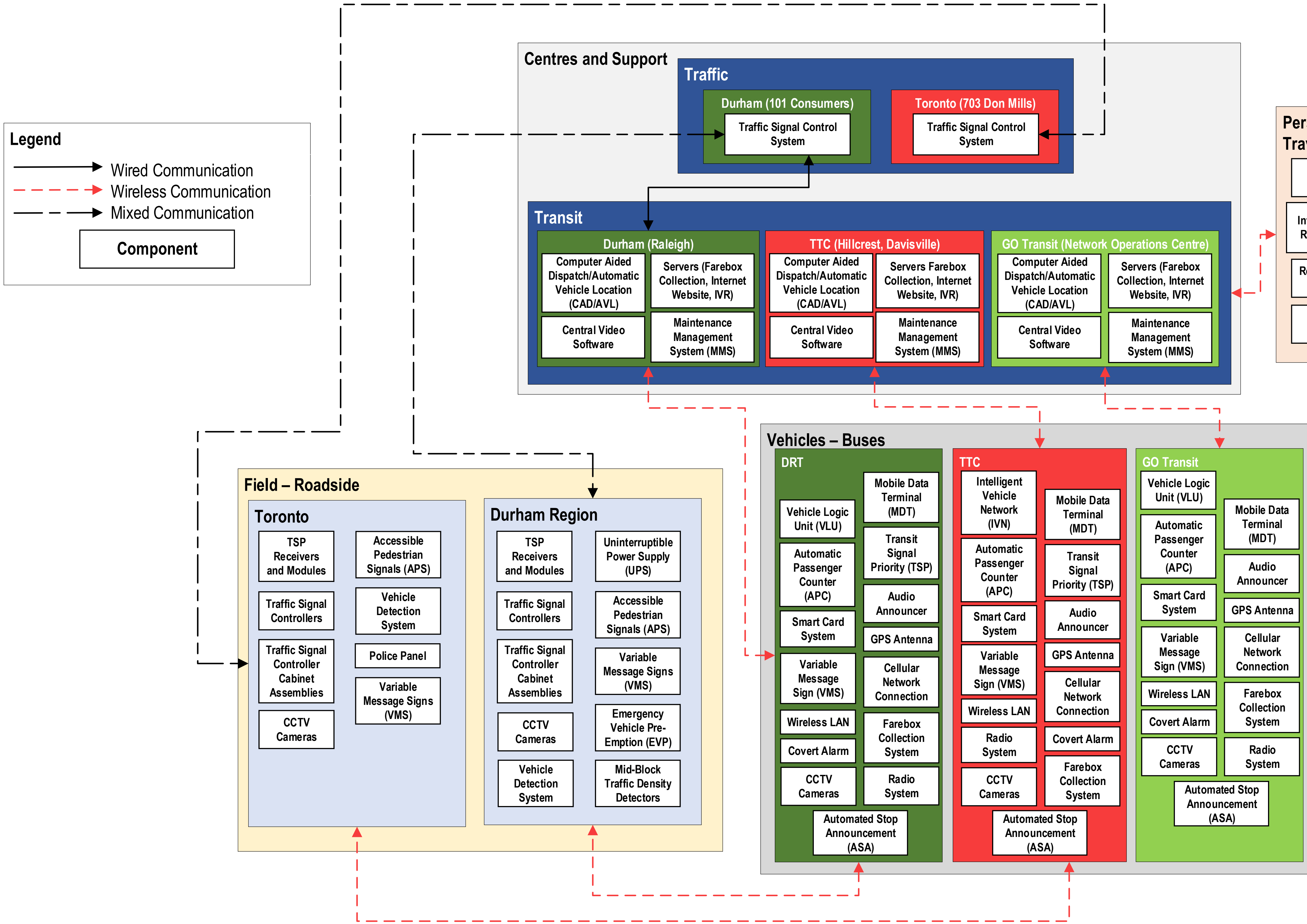
Exhibit 2-3: Existing Traffic Management Systems and Roadway Equipment

ITEM	DESCRIPTION	SOURCES
Central Traffic Signal Control System Communication Network	A mix of fibre and wireless communication technologies are found along the Corridor managed by the City of Toronto and Durham Region. Future rollouts of fibre communication are planned for more of the Corridor for Durham Region's network expansion. In addition, Durham Region is investigating communications installation between Durham Region's traffic management centre and DRT's to share live CCTV footage.	Highway 2 BRT TSP Study (2018) Discussions with Durham Region Traffic Engineering staff
Traffic Management Centre and Central Traffic Signal Control System	Durham Region operates an Aria central traffic signal control system. All Corridor signalized intersections within Durham Region communicate with the Aria system. The traffic management centre is located at 101 Consumers Drive in Whitby. The City of Toronto operates a TransSuite central traffic signal control system. All Corridor signalized intersections within the City of Toronto communicate with the TransSuite system. The traffic management centre is located at 703 Don Mills Road. The City of Toronto is expanding its network of traffic adaptive smart signals on several corridors, including Ellesmere Road of the Corridor, though no timeframe has been set. Durham Region is currently investigating the pilot of traffic adaptive signals in 2020. However locations have not been determined at this time.	N/A

ITEM	DESCRIPTION	SOURCES
TSP Receiver	Durham Region Corridor signalized intersections are equipped with TSP receivers (900 MHz antennas connected to roadside modules) with the exception of signalized intersections in downtown Oshawa that operate in a one-way direction. Two (2) City of Toronto Corridor signalized intersections are equipped for TSP, using in-pavement antennas designed to detect the on-vehicle transponder. These include: • Southbound left phase for buses travelling from McCowan Road onto Ellesmere Road; and • Northbound left phase for buses travelling from Military Trail onto Ellesmere Road. (Not applicable for BRT buses as this is off the route);	Highway 2 BRT TSP Study (2018) City of Toronto website City of Toronto Open Data Portal
CCTV Cameras	CCTV cameras are currently equipped at several signalized intersections across the Corridor in Durham Region and the City of Toronto. Durham Region plans for future installation at all major/major intersections and some road segments, including 20 additional CCTV cameras on Highway 2 in 2020. Durham Region is currently developing a Memorandum of Understanding (MOU) with DRT on the sharing and retention of Durham Region's CCTV feed. Video deployment from Durham Region's Traffic Management Centre to the DRT Transit Management Centre is scheduled for 2020. Currently, CCTV sharing between jurisdictions is not done. However, cross-jurisdictional footage sharing must be considered between DRT, TTC, and GO Transit Corridor-wide.	Discussions with Durham Region Traffic Engineering staff Road Emergency Services Communication Unit (RESCU) website
Emergency Vehicle Pre-Emption (EVP)	Durham Region Corridor signalized intersections are equipped with infrared EVP equipment for fire services. In the City of Toronto, EVP is only deployed at signalized intersections adjacent to select fire halls. A fixed hardware connection from the fire hall to the adjacent signalized intersection is used to implement a pre-emption routine for fire service vehicles. This technology is currently under review in the City of Toronto.	Discussions with Durham Region Traffic Engineering staff City of Toronto Open Data Portal

ITEM	DESCRIPTION	SOURCES
Vehicle Detection System	Inductive loop vehicle detectors and other non-intrusive detection systems are deployed at many signalized intersections across Durham Region and the City of Toronto. Particularly for buses, taxis, and delivery trucks, a detector is currently deployed on Triton Road for eastbound vehicles turning onto McCowan Road, the main bus terminal exit of Scarborough Town Centre. For this particular location, if a vehicle is detected, a dedicated phase is inserted into the signal timing plan. Note that this system for these vehicles at Triton Road is done with traditional vehicle detection and it does not use a TSP receiver. This is because the Triton Road access to Scarborough Town Centre bus terminal is a dedicated bus, taxi, and delivery vehicle only roadway.	Discussions with Durham Region Traffic Engineering staff City of Toronto website
Variable Message Signs (VMS)	Portable roadside VMSs are used in Durham Region and the City of Toronto. Signs are typically deployed for major construction work, or for emergency road repairs. In addition, in Durham Region, contractor-provided portable roadside VMSs are installed with a communication interface between the signs and the TMC.	Discussions with Durham Region Traffic Engineering staff
Accessible Pedestrian Signals (APS)	APS systems are equipped at selected signalized intersections across Durham Region and the City of Toronto. Going forward all new and reconstructed signals in Durham Region and the City of Toronto will be equipped with APS. The City of Toronto is currently exploring new models of APS. Existing signals without APS are currently being retrofitted.	Durham Region and the City of Toronto Open Data Portals Discussions with Durham Region Traffic Engineering staff
Uninterruptible Power Supply (UPS)	UPS systems are equipped at selected signalized intersections in Durham Region along the Corridor. Going forward all new and reconstructed signals in Durham Region will be equipped with UPS. Existing signals without UPS are currently being retrofitted. UPS systems are equipped at selected signalized intersections across the City of Toronto. As of 2016, no signalized intersections along the Corridor are equipped with UPS, although UPS is planned for some signalized intersections on the Corridor.	Discussions with Durham Region Traffic Engineering staff City of Toronto Electrical Traffic Control Devices Maintenance Document (2015)
Mid-block Detectors	In Durham Region, mid-block detectors are used for measuring vehicle volume, occupancy, speed, and road segment Level Of Service (LOS).	Discussions with Durham Region Traffic Engineering staff

Exhibit 2-4: Existing Transit and Traffic System Architecture along the Corridor



2.3 Sources of Information

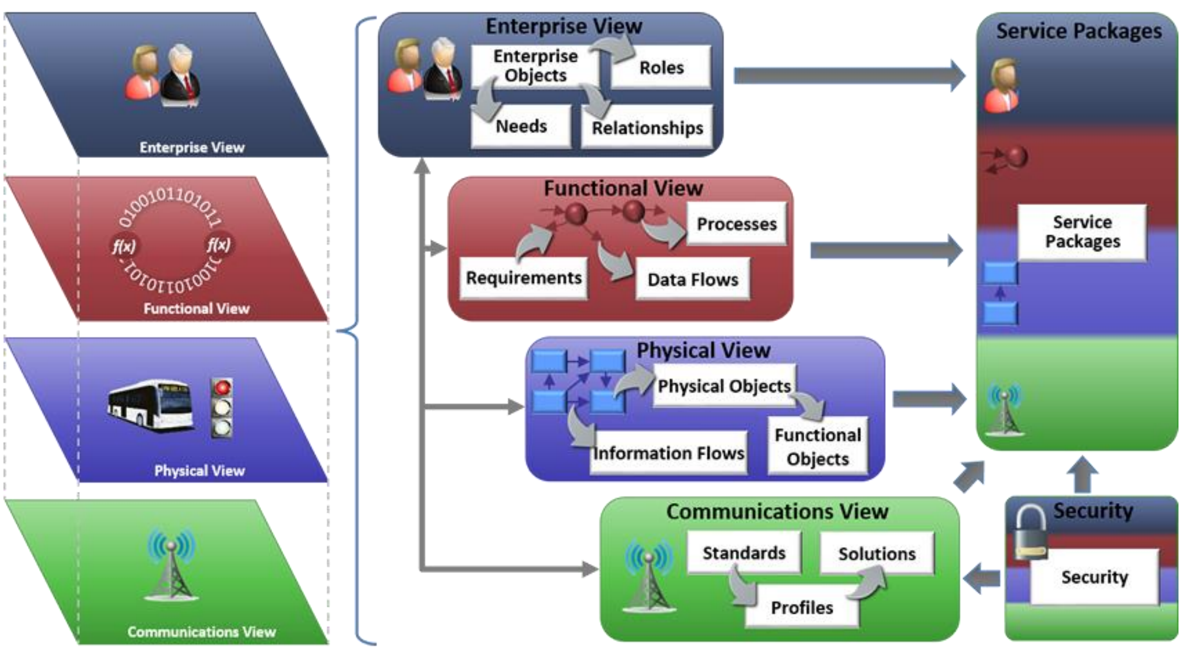
To support the development of the ITS strategy and the needs, a variety sources were referenced including:

- The ITS Architecture for Canada;
- The Durham Region Transportation Master Plan 2017;
- The Durham Region Transit Five-Year Service Strategy;
- Metrolinx 2041 Regional Transportation Plan;
- Metrolinx 2017 Transportation Systems Management for the GTHA; and
- The City of Toronto 2016 Congestion Management Plan.

2.3.1 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 its updated architecture, released in May 2020 (Exhibit 2-5). As part of this overall framework, the Physical View focuses on the physical components and the data flows within and between systems that are part of an overall ITS architecture. Specifically, the physical components include personal, support, vehicles, field, and centres. In the ITS strategy, the ITS architecture framework Physical View is used as a basis to develop the BRT ITS 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 2-5: ITS Architecture for Canada



2.3.2 Durham Region Transportation Master Plan 2017

Durham Region's Transportation Master Plan (TMP) was developed by IBI Group and published by Durham Region in late 2017. The plan identifies strategic directions to address its guiding principles, forming the basis of Durham Region's current and future transportation planning. The ITS strategy considered these strategic directions in determining user needs for Durham Region's BRT. Additionally, the plan recognizes the importance of ITS solutions to improve operational aspects of transit including:

- Congestion mitigation;
- Reduction of transit emissions; and
- Improved safety for road users.

2.3.3 Durham Region Transit Five-Year Service Strategy

In 2016 DRT developed a vision with implementation goals for its transit network in 2020. Five (5) guiding principles are outlined to facilitate transit planning in Durham Region, stating that transit services should be:

- Available;
- Consistent;
- Direct;
- Frequent; and
- Seamless.

These guiding principles helped formed the basis in identification of user needs presented in the ITS strategy.

2.3.4 Metrolinx 2041 Regional Transportation Plan

The Regional Transportation Plan (RTP) developed by IBI Group and published by Metrolinx in 2018 provides insight on addressing traveller needs across the GTHA. These needs directly guide the ITS strategy for all rapid transit projects in the GTHA. Overall, the RTP recognizes the benefit of a network of well-coordinated ITS infrastructure, suggesting the potential implementation of ITS tools and practices including but not limited to:

- Data sharing;
- Signal priority and coordination;
- Centralized monitoring; and
- Multi-modal management.

2.3.5 Transportation Systems Management for the GTHA

Published in 2017, the Transportation Systems Management Discussion Paper for the GTHA supplements the RTP by Metrolinx by developing regional goals and outlining technology-based initiatives to achieve these goals. Goals relate to three (3) principal categories:

- Traveller information;
- Operations; and
- Data and information.

2.3.6 City of Toronto Congestion Management Plan

Since the Corridor falls partially within the City of Toronto, the City's 2016-2020 Congestion Management Plan was reviewed. This plan lists completed improvements and further goals to improve ITS infrastructure including that related to:

- Communication between, vehicles, traffic infrastructure, and traffic management centres;
- Transit data availability and quality; and
- Incident monitoring capabilities.

3 User Needs Identification

User needs for the ITS strategy were collected through a variety of sources identified in **Section 2.3**. 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 DS-BRT Corridor

NO	USER NEEDS	SOURCE OF INFORMATION		
		METROLINX	DURHAM REGION	CITY OF TORONTO
1	Improve the speed and reliability of BRT operations	✓	✓	
2	Provide safe and sufficient first and last mile access for BRT travellers	✓	✓	
3	Facilitate smooth and efficient transit connections between BRT and connecting routes		✓	
4	Encourage active transportation modes by improving their quality and safety	✓	✓	✓
5	Promote sustainability and the reduction of greenhouse gas emissions across the GTHA	✓	✓	
6	Efficiently provide real-time and accurate information to travellers, operators, and management centres (both traffic and transit)	✓	✓	✓
7	Increase transit ridership by striving for high level customer experience	✓		✓
8	Employ innovative and appropriate transit technologies to improve transit quality and experience		✓	✓

4 Technology and System Concept

This section identifies and describes the transit and traffic technologies that can potentially address the user needs (noted in the previous section) to develop an ITS system concept for the BRT corridor. 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 various 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 BRT system concept design with the associated interfaces.

4.1 Transit and Traffic Management Technology

Several ITS technologies were identified that 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. The integration requirements of these transit and traffic management technologies are also identified. It is important to note that the final technology selection will be determined during the detailed design of the BRT corridor. The following four (4) technology categories are presented:

- **Section 4.1.1** – Transit vehicle ITS technologies;
- **Section 4.1.2** – BRT stop ITS technologies;
- **Section 4.1.3** – Transit centre and remote traveller ITS technologies; and
- **Section 4.1.4** – Traffic ITS technologies.

4.1.1 Transit Vehicle ITS Technologies

The following ITS technologies may be found on fixed route buses:

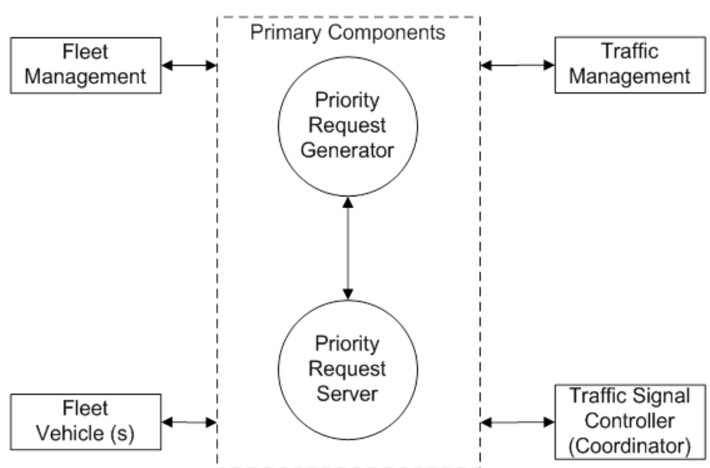
- **Communication System** is a critical component to the function of any ITS technologies. Most transit ITS technologies on the BRT vehicles will rely on wireless communications for data exchanges with the transit management centres, runningway, and roadway ITS devices. Data and voice communication networks are important for supporting transit operations, maintenance, and incident management. The communication system includes various combinations of equipment to support communication with BRT vehicles and non-revenue vehicles (e.g. supervisor and maintenance vehicles), as well as fixed-end equipment at BRT stops, transit management centres, and garages. In addition, the communication system can also support the traffic signal control and operation, as well as coordination with other municipal and regional agencies (e.g. emergency services). CCTV camera images, incident records, and transit vehicle locations can be exchanged among centres. As some portions of Highway 2 are currently equipped with fibre, traffic and transit management centres, BRT stops, and signalized intersections could use fibre as their means of communication with one another along the Corridor. Additional wireless communication methods, such as radio, LTE, and 5G, can supplement the fibre network for ITS communications. While there are drawbacks to these methods, such as signal blockages by trees or tall buildings, their technologies are consistently involving and improving, especially with the evolution of 5G communications. Moving forward, further fibre installations could fully cover the Corridor;

- **CAD/AVL System** assists with the real time monitoring and dispatch of the BRT vehicles. It analyzes service data from the vehicles to improve their service performance and the efficiency of system operations. This system includes:
  - **Automatic Vehicle Location (AVL)**, a computer-based vehicle tracking system that monitors the position of a transit vehicle and relays its location to a central system. Positioning information should be transmitted in real-time using wireless communications infrastructure to provide a tracking capability for BRT vehicles; and
  - **Computer Aided Dispatch (CAD)**, software that allows the core AVL function to display the position of every BRT vehicle for dispatchers. This information is updated frequently in near real time on a map or schematic along with additional data on operational status.

  Physical on-board CAD/AVL components include:
  - **GPS Antenna** used for vehicle location;
  - **Vehicle Logic Unit (VLU)** connecting and managing all on-board bus ITS technology discussed in this section; and
  - **Mobile Data Terminal (MDT)** functioning as the interface for operators. The MDT is a visual display which communicate real-time performance and messages from the transit management centre.

  Together these components serve as the information link between transit management centres, BRT vehicles, and operators. Fixed buses of each transit agency (DRT, TTC, and GO Transit) send their CAD/AVL data to the agency's respective transit management centre. Additionally, the CAD/AVL system has the capability to communicate real-time transit management and GTFS real-time data to Durham Region's and City of Toronto's traffic management centres to facilitate traffic signal operations during incidents requiring transit diversions or breakdown requiring signal operation adjustments;

- **Transit Signal Priority (TSP)** allows transit vehicles to attain better mobility at traffic signal intersections by providing expedited treatment over general traffic, improving transit travel time and reliability. A TSP system includes AVL with a VLU, 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



Source: Highway 2 BRT TSP Study (2018)

in the central system, the vehicle, 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 of 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, and door status). Active TSP strategies typically include phase insertion, phase skipping, phase rotation, green extension, and red truncation.

Presently, DRT and TTC onboard TSP devices only communicate with the roadside modules of their respective jurisdictions. GO buses do not contain TSP devices. For more reliable bus operation along the Corridor, TSP could be installed on GO buses and TSP devices on buses for all transit agencies could be able to communicate with roadside modules in both Durham Region and the City of Toronto. The TSP architecture and agreements between transit agencies, the City of Toronto, and Durham Region will be determined in future project agreements and detailed design.

It is also important to note that any detailed design and operations will need to consider if TSP should operate during traffic diversion timing plans that are currently in effect along EDR in Durham Region as well as proposed BRT sections near or at 400-series highway interchanges (such as Highway 412 at Dundas Street and Highway 401 at Kingston Road). These operations will need to be determined with consultation of Durham Region;

- **Automatic Passenger Counters (APC)** are systems installed on transit vehicles to count the number of boarding and alighting passengers at each transit stop. This data can be used by transit agencies to assess ridership at the stop, corridor, and route levels to assist with transit planning decisions and adjustments. APC technology is found in the form of weight detectors or light beams, or can be integrated with the onboard farebox collection system. Presently, all DRT, TTC, and GO buses are equipped with APC technology, and the data generated could be useful for decisions regarding the BRT corridor;
- **Wi-Fi System** can be provided on-board BRT vehicles to allow passengers to connect to Wi-Fi using their mobile devices. GO Transit is currently conducting an ongoing pilot project by introducing Wi-Fi onto some of its buses. This service would improve the passenger experience throughout the BRT corridor;

- **Fare Collection System** has a number of components that include field devices such as smart fare card readers, ticket vending machines accepting cash and credit cards, and cash fareboxes can be deployed on-board BRT vehicles or off-board at BRT stops. On-board fare collection technologies, such as smart fare card readers, can be placed at every door of the bus to allow for all-door boarding. 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 BRT vehicle operators.

Source: Go Transit Website

  Presently, a centralized Presto system gathers and processes smart card payments from all transit agencies serving the Corridor (DRT, TTC, and GO Transit) while each agency handles its respective cash fare transactions. Note that these different transit agencies have their own respective fare pricing collected by Presto and cash fares. It is intended that the fare collection system for the BRT corridor will integrate with the existing fare collection of the respective agency and Presto smart fare card systems. The fare structure will be determined in future project agreements and detailed design;

- **Automated Stop Announcement (ASA) Displays** that provide static and/or real-time information to passengers on vehicles through text and picture based changeable electronic signs. This subsystem also supports hearing impaired passengers. DRT, TTC, and GO Transit all currently have ASA Displays on their fixed route service buses;

- **Public Address (PA) System** that performs similar functions as the ASA Display, however provide information audibly rather than through text. The ASA system announces the next stop on a BRT vehicle through text-to-speech or pre-recorded messages. The PA system allows the dispatchers/supervisors/operators to provide ad-hoc messages at BRT stops and BRT vehicles. Both these systems help and improve the experience for visually impaired passengers riding BRT vehicles; and

- **On-Board Vehicle Security System** consists of a variety of technologies that communicate with the transit management centres and emergency services to provide safety for both operators and passengers of the BRT corridor. These technologies include:

  - **CCTV Cameras** which can capture raw video data for 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 AVL and pass on vehicle location along with the surveillance data to the transit management centres. The CCTV cameras and microphones can enhance the safety of the BRT vehicle as incidents can be monitored in real-time and/or also reviewed historically; and

  - **Covert Alarms** which allow BRT vehicle operators to notify transit management centres and/or emergency services of an incident on BRT vehicles. Combined with the communication system and AVL system, 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 BRT vehicle operator and the passengers on the vehicle in an event of an emergency where no other communication methods are possible.

DRT, TTC, and GO Transit currently have security systems installed on their buses. As well, CCTV camera security systems deployed on their fixed route service buses with central video software at their respective transit management centres. Front-facing cameras have been installed on TTC buses and can be installed on all buses serving the Corridor. Image sharing from these existing systems can be integrated with the BRT corridor and processed at their respective centres in compliance with the privacy policy of each municipality;

4.1.2 BRT Stop ITS Technologies

BRT stops typically have some or all of the following technologies:

- **Variable Message Signs (VMS)** at BRT stops provide real-time and scheduled information about bus arrivals. Real-time information is gathered from the CAD/AVL system described in **Section 4.1.1**;
- **ITS Elements Cabinet** at the BRT stops house 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;
- **Off-Board Fare Payment System** allowing passengers to purchase and validate their transit fare prior to transit arrival. By doing so, transit operations improve with reduced dwell time and increased speed and reliability. The system is comprised of two components:
    - **Smart Card and Cash Fare Machine** where travellers can tap smart cards or pay cash or credit card to purchase tickets; and
    - **Ticket Validator** to validate cash or credit-purchased tickets with a timestamp.

Source: York Region Transit

- **Public Address (PA) System** to communicate messages to passengers at BRT stops as described in **Section 4.1.1**;
- **Wi-Fi System** for passenger use at BRT stops as they wait for the next bus. This operates as described in **Section 4.1.1**;

- **BRT Stop Security System** consists of similar technologies to on-board systems including:
  - **CCTV Cameras** to improve safety of BRT stops. These operate as described in **Section 4.1.1**; and
  - **Emergency Call Boxes** which contain a communication system that connects the passengers with the transit management centres and/or emergency services in an event of an emergency. It can also be integrated with the CCTV camera system at BRT 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 UPS and backup communication systems to ensure that these devices work even in event of a power or communications failure.

Source: York Region Transit

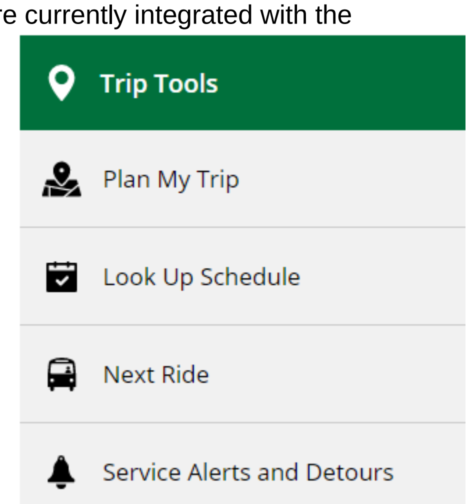
- **Uninterruptible Power Supply (UPS)** supplies the ITS equipment listed above with electricity in the event of a power loss affecting the surrounding area. UPSs are particularly important for ensuring traveller safety by providing power to the BRT stop security system. Additionally, by providing power to other ITS devices, traveller information systems and BRT operations may still perform at an acceptable level. UPSs at BRT stops along the Corridor could be an effective way to maintain a high service standard for BRT operations in the event of a power loss.

4.1.3 Transit Centre and Remote Traveller ITS Technologies

The following ITS technologies are managed by the transit management centre and made available to travellers remotely:

- **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/AVL system to ensure the information to be more accurate and reliable. With this integration, the system disseminates information such as scheduling, expected vehicle arrival or departure time, as well as other information such as incidents, service advisories, and other ad-hoc messages. Transit traveller information subsystems include:
  - Internet websites (e.g. durhamregiontransit.com for DRT and Triplinx by Metrolinx);
  - Interactive Voice Response (IVR); and
  - Mobile phone applications.

  Other transit traveller information subsystems that can be applicable for the BRT corridor include Mobile Phone Applications. Currently, fixed route service for DRT, TTC, and GO Transit also



Source: Durham Region Transit Website

provides trip planning information to Google Maps through the GTFS;

- **Fare Collection Central Server** handles fare management activities in the transit management centre, such as fare transaction processing and reporting;
- **Maintenance Management System (MMS)** supports the tracking, monitoring, and management of the BRT 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 BRT system, improves the efficiency, reduces fuel consumption, and minimizes maintenance costs; and
- **Reporting System** includes Business Intelligence (BI) tools and data warehouses that support data analytics from various sources across the BRT corridor such as APC ridership data, fare collection information, and the bus operation data from the CAD/AVL system (e.g. schedule adherence). The reporting system helps service planning team to understand the performance of the BRT corridor, support future planning to improve passenger experience, and identify solutions to increase the efficiency of the system.

4.1.4 Traffic ITS Technologies

The traffic ITS technologies communicate with the traffic management centres to help improve traffic flow along the BRT 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 BRT vehicles and other road users, including general traffic, pedestrians, cyclists, and goods movement. 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, response, and traffic signal control elements can be used that include:

- **Traffic Signal Controllers and Traffic Signal Central System**. The traffic signal controllers take detector inputs from the vehicle, pedestrian, transit vehicle, emergency vehicle and cyclist detection systems to activate and time traffic signal displays. The traffic signal controller is connected with the central traffic signal control 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 by improving progression along corridors through the proper allocation of green time at traffic signals. In current practice, MTO's Freeway Traffic Management System (COMPASS) coordinates with Durham Region's Traffic Management Centre to override signal timing plans in the event of an emergency on Highway 401 requiring traffic diversion. Some level of signal coordination for transit vehicles operations performance can be considered for adjacent signals across the Durham Region/City of Toronto border. Note that the City of Toronto is currently piloting adaptive smart signals, which allow for traffic signal timings to adapt to roadway demand through vehicle detection systems. As well, Durham Region is currently investigating the pilot of traffic adaptive signals in 2020. However, locations have not been determined at this time;

Source: Google Maps

- **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 the respective privacy policies of Durham Region and the City of Toronto, DVR can be deployed to store the images. The CCTV cameras are typically found along the roadway, at intersections, or at BRT stops. Image sharing between municipalities and transit management centres can be implemented along the Corridor in compliance with the privacy policies of each municipality;
- **Emergency Vehicle Pre-Emption (EVP)** that allow for priority at traffic signals for fire trucks, ambulances, and other emergency vehicles. EVP allows for more rapid and efficient incident response for emergency services. Installing EVP along the Corridor could improve the safety of travellers on the BRT as well as the safety of the community. The existing TSP infrastructure could be enhanced to support EVP;
- **Real-Time Data Feeds** that provide information through a variety of mediums including third party data providers (e.g. HERE, Inrix, Waze), 511 services (i.e. Ontario 511), or other third party hardware (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). Internet websites present this information to travellers (Durham: https://apps.durham.ca/Applications/Traffic/TrafficWatch; Toronto: https://www.toronto.ca/services-payments/streets-parking-transportation/road-restrictions-closures/rescu-traffic-cameras/). These technologies can be integrated with the BRT corridor to better inform travellers in of BRT operations in real-time;
- **VMSs** that provide advance notification and warning of traffic pattern changes. The messages displayed on the VMS could relate to travel time, pre-planned route change messages, or ad-hoc messages created by the traffic dispatch. The latter is particularly important for the Durham Region EDR section of the Corridor by displaying information regarding disruptions occurring on Highway 401. Implementing permanent VMSs at select locations along the Corridor would improve information dissemination to bus operators and regular road users, however considerations including power and communication connections to the VMSs, management of VMS messaging, and community impact must be taken into account prior to installation. They are generally found 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;

Source: City of Toronto Website

- **Vehicle Detection Sensor Systems** at intersections are used to detect the presence of a vehicle 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. These systems 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, in-pavement inductive loop detectors are one of the sensor types that are commonly used in the GTHA and across the Corridor to detect vehicles and bicycles, though newly installed detectors in Durham Region are all non-intrusive;

- **Bicycle Detectors** that detect the presence of a bicycle within a defined zone, actuate bicycle signal, and differentiate it from other traffic. The bicycle detection system improves the safety and encourages active transportation throughout the GTHA. Newly installed non-intrusive bicycle detectors in the City of Toronto and Durham Region could be integrated into the BRT corridor;
- **Bluetooth Traffic Detectors** that detect travel times and congestion of travelling vehicles within a small road section. They can be found at intersections or mid-blocks between intersections. This data can be reported to the traffic management centre to assess the performance of traffic signals and detect roadway disruptions. Bluetooth detectors are scheduled to be deployed at several intersections along the Corridor in 2020 in Durham Region. Traffic detectors could be a useful performance tool for traffic patterns across the Corridor;
- **Connected Vehicle (CV)** technology which facilitates communication between buses and other vehicles, road infrastructure, and other road users. CV systems include sensors (such as ultrasound, LIDAR, camera etc.) that are able to communicate to one another through Dedicated Short-Range Communications (DSRC) or 5G technology. Such systems alert bus operators to conditions in their surrounding environment including the positions of other vehicles, unsafe road conditions, and traffic signal phases. CV technology can largely be achieved by enhancing the existing communication system along the Corridor, with vehicle-to-infrastructure communication occurring through the use of TSP as discussed in **Section 4.1.1**;
- **Uninterruptible Power Supply (UPS)** add-on units to provide electricity for roadside devices in the event of a power loss, as discussed in **Section 4.1.1**;
- **Accessible Pedestrian Signals (APS)** that provide audible sounds (either through consistent sounds or messages) to indicate the walk signal for the visually impaired. In accordance with the AODA, all new traffic signals in Durham Region and the City of Toronto come equipped with APS and all existing signals are currently being retrofitted with the technology; and
- **Traffic Signal Control Cabinets and Assemblies** which 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. UPS installation is underway in Durham Region and the City of Toronto along several high traffic volume corridors.

4.2 Technology Mapping

This subsection performs a technology mapping exercise to identify the applicable ITS technologies for the BRT corridor 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 identified in **Section 3** as illustrated in Exhibit 4-1.

Overall, this mapping shows how a combination of ITS technologies, including a communication system, at centres, on vehicles, at stops, and along the roadside, can address the identified user needs. The system concept is described next in **Section 4.3.**

Exhibit 4-1: Technology Mapping

NO	USER NEED		CENTRES					BRT VEHICLES														ROADSIDE													BRT STOPS								REMOTE INFO			
		COMMUNICATION SYSTEM	COMPUTER ADIDED DISPATCH / AUTOMATIC VEHICLE LOCATION (CAD/AVL)	MAINTENANCE AND MANAGEMENT SYSTEM (MMS)	SERVERS (SMART CARD, FAREBOX COLLECTION, INTERNET WEBSITE, IVR)	CENTRAL VIDEO SOFTWARE	TRAFFIC SIGNAL CONTROL SYSTEM	VEHICLE LOGIC UNIT (VLU)	MOBILE DATA TERMINAL (MDT)	AUTOMATIC PASSENGER COUNT (APC)	TRANSIT SIGNAL PRIORITY (TSP)	SMART CARD SYSTEM	AUDIO ANNOUNCER	VARIABLE MESSAGE SIGN (VMS)	GPS ANTENNA	WIRELESS LAN	CELLULAR NETWORK CONNECTION	COVERT ALARM	CCTV CAMERAS	AUTOMATED STOP ANNOUNCEMENT (ASA)	FAREBOX COLLECTION SYSTEM	TRAFFIC SIGNAL CONTROLLERS	TRAFFIC CONTROL CABINETS AND ASSEMBLIES	TSP RECEIVERS AND MODULES	UNINTERRUPTIBLE POWER SUPPLY (UPS)	ACCESSIBLE PEDESTRIAN SIGNALS (APS)	VEHICLE DETECTION SYSTEM	CCTV CAMERAS	EMERGENCY VEHICLE PRE-EMPTION (EVP)	BICYCLE DETECTORS	TRAFFIC RESPONSIVE CONTROL	ADAPTIVE TRAFFIC CONTROL	VARIABLE MESSAGE SIGN (VMS)	MID-BLOCK BLUETOOTH DETECTORS	VARIABLE MESSAGE SIGN (VMS)	PRESTO / CASH FARE MACHINE	UNINTERRUPTIBLE POWER SUPPLY (UPS)	EMERGENCY CALL BOX	CCTV CAMERAS	WI-FI SYSTEM	PUBLIC ADDRESS (PA) SYSTEM	TICKET VALIDATOR	INTERNET WEBSITE	INTERACTIVE VOICE RESPONSE (IVR)	REAL-TIME SMS INFORMATION	THIRD PARTY APPS
1	Improve the speed and reliability of BRT operations	✓	✓	✓	✓		✓	✓	✓		✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓				✓	✓				✓	✓					✓	✓	✓	✓	✓
2	Provide safe and sufficient first and last mile access for BRT travellers	✓	✓		✓	✓	✓					✓		✓								✓			✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	Facilitate smooth and efficient transit connections between BRT and connecting routes	✓	✓		✓	✓		✓	✓			✓		✓	✓		✓			✓						✓					✓	✓										✓	✓	✓	✓	✓
4	Encourage active transportation modes by improving their quality and safety																					✓				✓	✓	✓		✓	✓												✓	✓	✓	✓
5	Promote sustainability and the reduction of greenhouse gas emissions across the GTHA		✓	✓	✓		✓				✓	✓									✓	✓	✓	✓					✓	✓	✓	✓				✓						✓				
6	Efficiently provide real-time and accurate information to travellers, operators, and management centres	✓	✓	✓		✓		✓	✓	✓		✓		✓	✓	✓	✓		✓	✓	✓	✓					✓	✓					✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	✓
7	Increase transit ridership by striving for high level customer experience	✓			✓		✓				✓	✓	✓	✓				✓	✓	✓	✓			✓	✓	✓		✓		✓					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	Employ innovative and appropriate transit technologies to improve transit quality and experience	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓

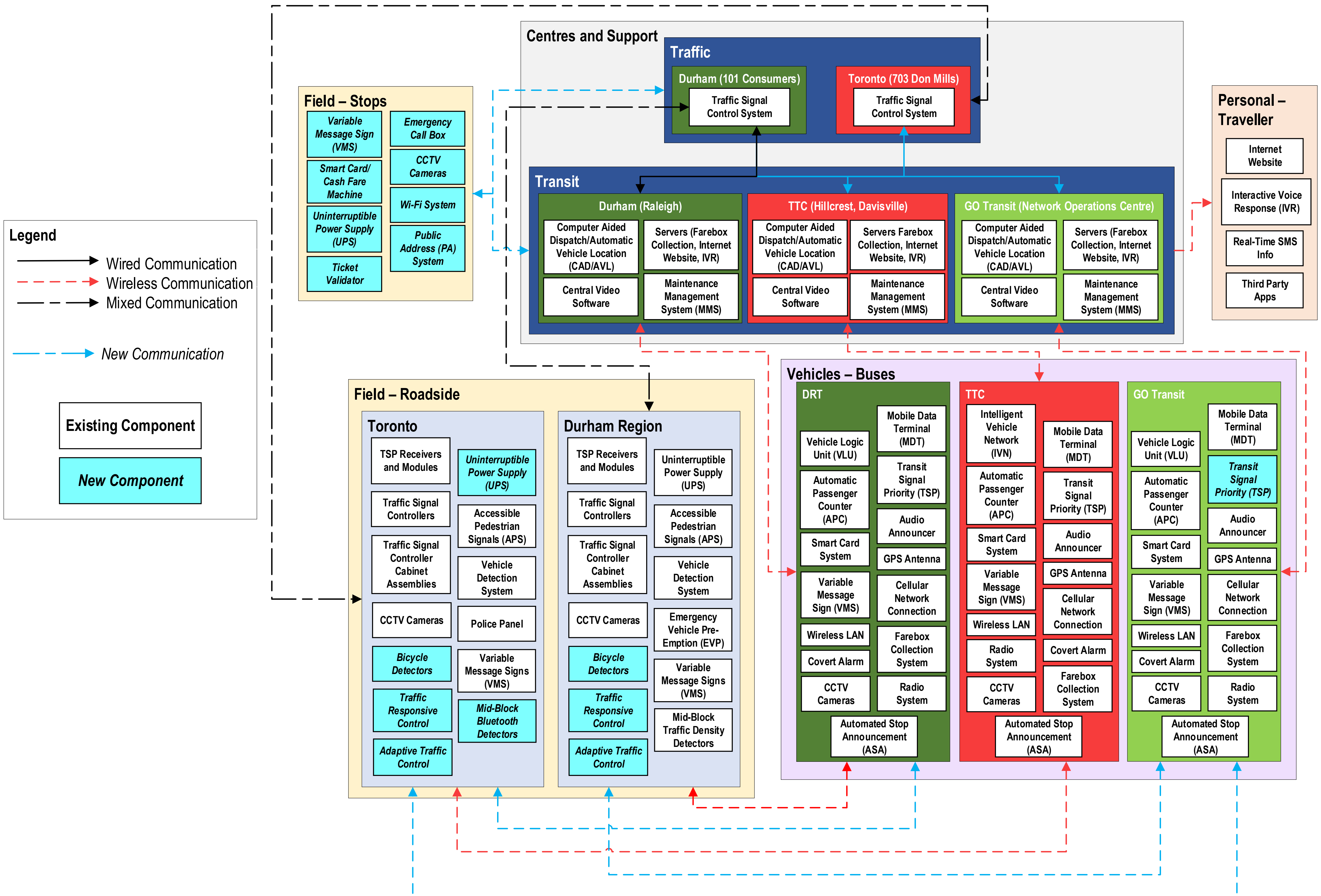
4.3 System Concept

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

- Encouragement of data sharing between transit and traffic management centres through CAD/AVL (real-time data, GTFS data) and the traffic signal control systems (signal phasing and timing data) for better coordination during planned and unplanned events. Similarly, promote stakeholder collaboration to provide high quality traffic and transit services along Highway 2;
- Interoperability between all fixed route buses serving the Corridor and roadside infrastructure in Durham Region and Toronto. This would include implementation of TSP devices on DRT, TTC, and GO buses, and communication facilitation between corridor transit vehicles and roadway infrastructure; and
- Deployment of key ITS technologies at BRT stops (VMS to improve data sharing, off-board fare payment systems to reduce BRT dwell times and improve reliability, CCTV cameras to improve safety etc.) with communication interface between stops and transit management centres.

Implementation of this system concept is described in **Section 5.**

Exhibit 4-2: Proposed ITS System Concept for the BRT Corridor



5 Recommendations

Based on the user needs identified in **Section 3** and the existing and potential technologies outlined in **Section 4**, a number of recommendations are provided for the Durham-Scarborough BRT corridor. In this section, the transit or traffic systems technologies from the proposed ITS system concept (Exhibit 4-2) are categorized into three groups:

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

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. BRT stops, roadways, intersections, centres, and vehicles).

The recommendations are outlined in Exhibit 5-1 below. The proposed ITS system concept with implementation recommendations is shown in Exhibit 5-2. This concept is subject to future project agreements between Metrolinx, Durham Region Traffic Division, DRT, City of Toronto Transportation Services Division, and TTC.

This concept will be included in the Transit Project Assessment Process and Preliminary Design Business Case.

Exhibit 5-1: Recommended and Optional Technologies

TEHCNOLOGY	GROUP 1: RECOMMENDED NEW	GROUP 2: RECOMMENDED TO EXPAND OR MAINTAIN EXISTING	GROUP 3: OPTIONAL	COMMENTS
Transit ITS				
Communication System (Centre to Centre)	✓			A new installation of fibre optic communications between all traffic and transit management centres controlling vehicle and traffic signal operations along the Corridor (DRT, TTC, GO Transit management centres, Durham Region and the City of Toronto traffic management centres) is recommended. This inter-jurisdiction communication will allow for better, more consistent, and more manageable BRT operations.
Communication System (Vehicle to Infrastructure)	✓			Communication between DRT fixed route buses and the City of Toronto's TSP roadside modules is recommended. Additionally, similar communication between GO buses and TSP roadside modules in the City of Toronto and Durham Region is recommended.
Communication System (Infrastructure to Centre)	✓	✓		A complete fibre optic communication network between traffic signal controllers and traffic management centres is recommended across the Corridor. While some fibre connections are already in place, some communication is currently done through wireless network technology which should be upgraded to fibre connections.
Computer Aided Dispatch (CAD) / Automatic Vehicle Location (AVL) System		✓		To promote communication and data sharing between traffic and transit management centres, the existing CAD/AVL system is recommended to be expanded to provide real-time transit vehicle information and GTFS data to traffic signal control systems.
Transit Signal Priority (TSP) System (Vehicles and Signalized Intersections)	✓	✓		TSP technology is recommended to be installed in GO buses so that it does not impede the operations of DRT and TTC buses across the Corridor. TSP devices on all DRT, TTC, and GO buses should be upgraded to communicate with roadside modules in both Durham Region and the City of Toronto. The TSP architecture and agreements between transit agencies, the City of Toronto, and Durham Region should be determined in future project agreements and detailed design. Governance of the TSP systems must be considered for collaboration to achieve TSP interoperability. A separate study and implementation plan for Regional TSP would be recommended in advance of any cross-jurisdictional BRT projects in the future to ensure interoperability of these systems TSP interoperability is more achievable with consolidated PULSE, DRT, TTC, and GO Transit stops along the Corridor. Stop configurations will be discussed further in the planning and design phases of the Corridor.
Variable Message Signs (VMS) (BRT 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 an AODA requirement for transit facilities and vehicles. In addition, other advanced measures may be shown on VMS including information on upcoming vehicle crowding.
Public Address (PA) System (BRT Stops)	✓			The installation of this system is recommended to 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 an AODA requirement for transit facilities and vehicles.
Emergency Call Box (BRT Stops)	✓			The installation of emergency call boxes is recommended at BRT stops to provide a safe environment for passengers during normal operations and in the event of an emergency.
CCTV Cameras (BRT Stops)	✓			CCTV cameras for BRT stops are recommended to provide a safe environment for passengers at BRT stops.
Uninterruptible Power Supply (UPS) (BRT Stops)	✓			UPSs are recommended to operate traveller safety components (CCTV cameras, emergency call box) as well as traveller information systems (VMS, PA system) in the event of a power loss.
Smart Card / Cash Fare Machine and Ticket Validator (Vehicles and BRT Stops)	✓			An off-board fare collection system is recommended to improve speed and reliability of BRT vehicles by reducing dwell times. This system would include a smart card machine for travellers wishing to pay with Presto cards or wishing to reload their cards, and a ticket dispenser and validator for those wishing to pay via cash or credit card. Off-board fare payment requires additional transit enforcement. On-board fare collection technologies, such as smart fare card readers, can be placed at every door of the bus to allow for all-door boarding. It should be noted that a future cross border fare integration study for services between Durham Region and Toronto needs to be undertaken to support the operations of this BRT.
Wi-Fi System (BRT Stops)			✓	A Wi-Fi system at BRT stops is optional to enhance the passenger experience.

TEHCNOLOGY	GROUP 1: RECOMMENDED NEW	GROUP 2: RECOMMENDED TO EXPAND OR MAINTAIN EXISTING	GROUP 3: OPTIONAL	COMMENTS
Traffic ITS				
Traffic Signal Control System (Traffic Management Centres)		✓		To promote communication and data sharing between traffic and transit management centres, the existing traffic signal control systems in Durham Region and the City of Toronto are recommended to be upgraded to provide signal phasing and timing (SPaT) data to transit control dispatchers to provide additional real time information at transit management centres. In addition, a collaborative governance overseeing signal coordination that benefits transit vehicles between signals near the Durham Region/City of Toronto border is recommended.
Traffic Signal Controllers (Signalized Intersections)		✓		All traffic signal controllers across the Corridor should be upgraded to comply with the latest industry phasing and safety standards.
Traffic Responsive Control (Signalized Intersections)			✓	Traffic responsive control is an optional component for signalized intersections along the Corridor to more safely and effectively manage queues of traffic arising from unplanned disruptions.
Adaptive Traffic Control (Signalized Intersections)			✓	Adaptive traffic control is an optional component for signalized intersections along the Corridor to better serve stochastic and variable traffic volumes in all directions of intersections. Prior to deployment, adaptive traffic algorithms must be assessed against all modes of transportation and traffic movements in and around the Corridor for any potential biases towards specific modes or traffic movements.
Bicycle Detectors (Signalized Intersections)		✓		Bicycle detection systems are recommended for expansion at signalized intersections across the Corridor in both Durham Region and the City of Toronto.
Uninterruptible Power Supply (UPS) (Signalized Intersections)		✓		UPS systems are recommended for expansion at signalized intersections across the corridor in both Durham Region and the City of Toronto.
Bluetooth Vehicle Detectors (Mid-block)		✓ (Durham Region)	✓ (City of Toronto)	Vehicle detectors are optional to monitor and track the performance of general traffic and provide this information to general traffic on and near the BRT corridor, and do not provide any direct benefit to the BRT system operations. Mid-block Bluetooth detectors are currently planned for deployment at locations on the Corridor in Durham Region, while no plans are in place for these detectors in the City of Toronto.

Exhibit 5-2: Proposed ITS System Concept with Implementation Recommendations