Transit Technology Toolkit

January 2023

Ministry of Transportation

Ontario

Prepared for the Ontario Ministry of Transportation by Left Turn Right Turn

TABLE OF CONTENTS

1 INTRODUCTION

The transportation sector is undergoing a transformation as emerging mobility modes, app-based innovations, automation and connectivity enter the technological landscape. Transit systems are at the centre of this transformation by providing efficient and accessible services to Ontarians and by exploring innovative ways to remain competitive and enhance the user experience. Amid changing travel patterns and consumer behaviour, transit system operators must identify and harness technologies to improve service offerings to customers.

Transit systems in Ontario and around the world are using technology to improve operations and customer experience. For example, Computer-Aided Dispatching/Automatic Vehicle Location (CAD/AVL) technology allows transit systems to leverage communication to improve operational efficiency and customer experience. Transit systems using smart fare collection simplify the payment process for customers, while reducing operational costs for transit systems and reducing the risks of human error associated with manual fare collection.

The types of solutions deployed by transit systems of different sizes and resources vary in range from bespoke integrated all-encompassing systems to individual applications and sometimes spreadsheets. In addition to resources and funding, the types of technology solutions that small and rural communities can deploy are impacted by differences in technology complexity, availability, affordability and the availability of effective wireless communications networks.

This Transit Technology Toolkit is a resource for Ontario municipalities and transit systems providing information on tools and best practices to leverage emerging and innovative transit technologies. It is intended to help transit systems explore and navigate the latest transit technologies and build internal knowledge to consider adopting new approaches.

1.1 How to use this toolkit

This document is a collection of resources and is not intended to be read from front to back. Readers are encouraged to navigate to the relevant resources as needed from the document, using the table below or the table of contents for guidance. At the highest level, this document introduces the different transit technologies (Section 2) and provides useful information to support technology programs within organizations (Section 3-6). The appendices include useful tools and templates for organizations to use, build and draw from.

The Toolkit includes the following sections:

Section	Contents
Section 1: Introduction	• project background • description of the transit technology lifecycle • description of the different maturity levels of technologies
Section 2: Transit Technologies	• high-level summary of the technologies • detailed descriptions and information about transit technologies
Section 3: Lifecycle: Planning	• best practices for: o how transit systems can evaluate their needs o weigh potential options, and o make plans for the right technologies to address those needs
Section 4: Lifecycle: Procurement	• best practices for: o establishing a procurement strategy o developing and publishing procurement documents o evaluating vendor responses
Section 5: Lifecycle: Implementation	• best practices for: o configuring the solution to meet defined requirements o reengineering business processes o undergoing system installations, testing and staff training
Section 6: Lifecycle: Administration and Maintenance	• best practices for: o maximizing investments in technology through system monitoring o troubleshooting support o refresher training and data collection
Appendices	• glossary of relevant terms • sample RFP evaluation template • list of transit technology vendors

Section	Contents
	• sample project action log template • sample risk register template • sample IT administrator job description • typical ITS technology lifespans • budgeting tables • sample RFP library • detailed case studies

Audience: This document is intended for a diverse audience of transit stakeholders. Suggested readers of the Transit Technology Toolkit include:

- Transit system leaders who can learn about transit technologies and their implementation at a glance;
- Technical and planning staff who can dive deeper into the specifics of new transit technologies; and
- Broader audiences of transit professionals, researchers and community members seeking to gain a deeper understanding of emerging and established transit technology.

1.2 Methodology

The Ministry of Transportation engaged consulting firm Left Turn Right Turn (LTRT) in 2022 to develop this Transit Technology Toolkit. The toolkit was developed with engagement from a variety of provincial and municipal representatives. The Ministry of Transportation (MTO), The Ministry of Economic Development, Job Creation and Trade (MEDJCT), the Ontario Centre of Innovation (OCI), and Metrolinx participated in a visioning workshop. LTRT reviewed the results of a survey of communities in Ontario conducted by MTO to better understand initial thoughts and challenges identified by these communities. Survey results indicated:

- There is a significant gap between smaller municipalities, particularly those operating in rural, remote, or Indigenous communities, and larger transit systems in Ontario in their capacity to maximize the benefits of transit technology.

- While larger municipalities are exploring significant innovations in customer experience, such as improved fare collection and real-time information, many smaller communities struggle with the high cost and lack of "right-sized" technologies to enable simple operational and customer-facing improvements. In such circumstances, there may be some opportunities for collaboration among transit operators/municipalities to spread costs.

- Enabling infrastructure and resources, such as adequate cellular coverage and sufficient training and capacity building may be a challenge to deploying technologies within smaller and more remote communities.

A review of literature and best practices based on lessons learned from the deployment of various technology-enabled transit innovations was undertaken. From that research, a Jurisdictional Scan report was done, providing an initial assessment of potential technologies and their use in leading jurisdictions.

Next, a series of in-depth case studies were conducted highlighting how transit technologies have been adopted by municipalities around Ontario. The case studies were gathered through scheduled interviews with agencies and system vendors, and outline lessons learned, as well as potential benefits and challenges for implementation. The case studies included:

TABLE 1: ENGAGEMENT CONDUCTED FOR THE CASE STUDIES IN THIS TOOLKIT

Topics	Year of Implementation	Interviewee
Implementing a Trunked Radio System for Transit Operations	2021	Thunder Bay
Deploying CAD/AVL through the Metrolinx Joint Procurement Program (City of Sault Ste. Marie)	2021	Sault Ste. Marie
Developing a Transit Technology Plan	2021	Bracebridge
Deploying an Integrated Specialized and Conventional On-Demand Technology (Milton Transit)	2021	Spare Labs
Planning the Transition of Specialized Transit Technology Systems	2018	Thunder Bay
Deploying CAD/AVL Through the Metrolinx Transit Procurement Initiative (TPI)	2018	Consat
Operating an Integrated Transit Technology Suite	2016	Bracebridge
Planning for a new Electronic Fare Collection system	Upcoming	Sault Ste. Marie
Implementing GTFS without Traditional Transit Technology	N/A	Norfolk County

Topics	Year of Implementation	Interviewee
On-Demand funding support for Mohawk Council of Akwesasne	N/A	Pantonium

The best practices and lessons learned captured through the research was coupled by the industry experience brought by the consulting team to inform the development of this Toolkit.

1.3 The Transit Technology Lifecycle

The typical lifecycle for a transit technology can be broken up into four stages: Planning, Procurement, Implementation, and Administration/Maintenance.

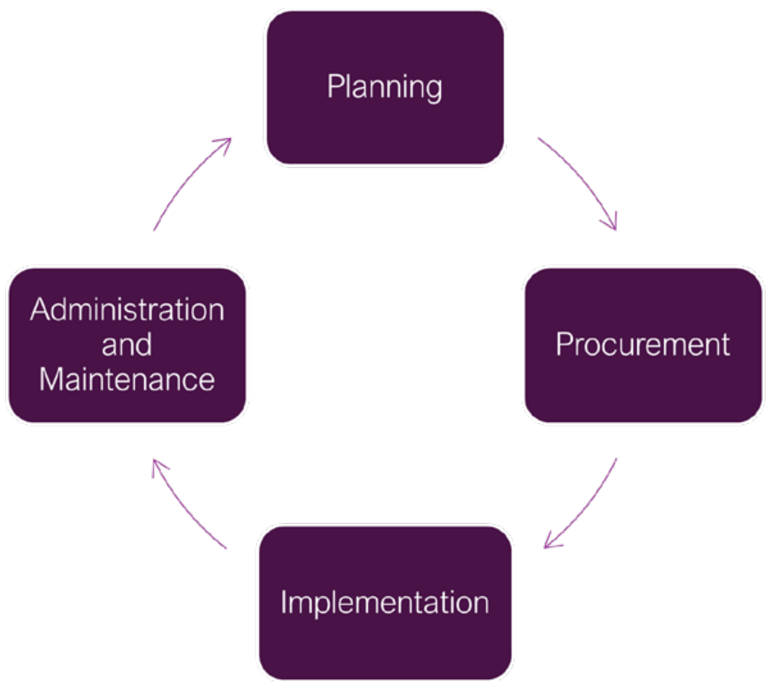

FIGURE 1: THE TRANSIT TECHNOLOGY LIFECYCLE

In the Planning Stage, organizations identify their service objectives and business needs to determine what type of technology solutions will best meet those needs. They then secure funding and establish a formal project.

In the Procurement Stage, organizations develop specifications, engage and select vendors through formal procurement processes, and negotiate contracts.

The Implementation Stage involves working with the vendor to install or upgrade hardware and/or software, and undertake testing and training to ensure the system is successfully in place and staff are ready to use it.

The Administration and Maintenance Stage is when the systems are in use by members of the organization. This stage includes the work to ensure that everything is up-and-running smoothly, problems are dealt with, and organizations strive to maximize the value of their investment. As systems approach end of life, analysis is done to measure the performance of the service and the cycle begins anew with Planning for an upgrade or a replacement. During this stage, there is often an ongoing vendor relationship with a service level agreement, as specified in the contract. Sections 3 through 6 provide a more detailed discussion of each of the four stages of the transit technology lifecycle.

1.4 Technology Maturity

The maturity of a technology represents how 'evolved' a given technology is and corresponds to the prevalence of vendors and solutions in the market that are developed to a reasonable point where minimal flaws can be expected. When planning for technology, it is important to know the maturity of various technologies in the market to determine if and how they should be procured. As such the technologies presented in this toolkit have been categorized into the following four levels of maturity based on their application and prevalence in the industry.

New: Technology that is largely conceptual and is in its early stages of development and testing, with no or limited number of deployments.

> *Technology Example: Automated buses and emerging standards for data sharing of demand-response services (GTFS-flex, GOFS)*

Improving Technology: Technology that has been developed and is operational in limited environments (typically pilots or small-scale implementations), with expected benefits that have not been widely realized. Pilot projects allow for a comprehensive evaluation to ensure the new technology is meeting program objectives. Additionally, pilots enable a fulsome understanding of operational and customer experience. Emerging or evolving technology will have initial troubleshooting and bugs that are discovered and addressed with time.

> *Technology Example: On-demand scheduling systems and open payments such as debit/credit and mobile payments.*

Mature Technology: Technology that has been used for a long time with proven evidence of benefits. Mature technology is consistent in performance, with minimal issues and often has continued development to improve features and functionality. At this point, vendors may provide limited to minimal support.

> *Technology Example: Computer-Aided Dispatch / Automatic Vehicle Location (CAD/AVL) Systems and PRESTO (fare card system).*

Aging Technology: Technology that has antiquated features or no longer has continued development. Aging technologies typically cease to meet changing business needs and are trying to compete with other emerging or mature technologies in the market that provide better capabilities.

> *Technology Example: Manual interfaces for data collection from field and on-board devices.*

The performance of a technology increases as it goes through the first three stages, with the peak performance in the mature stage. Performance eventually begins to decline as the technology ages and vendors decrease or cease new updates and developments. This trend can be plotted on an S-curve as shown in the figure below[1].

[1] The MITRE Corporation. Assessing Technology Maturity. https://www.mitre.org/publications/systems-engineering-guide/acquisition-systems-engineering/acquisition-program-planning/assessing-technical-maturity

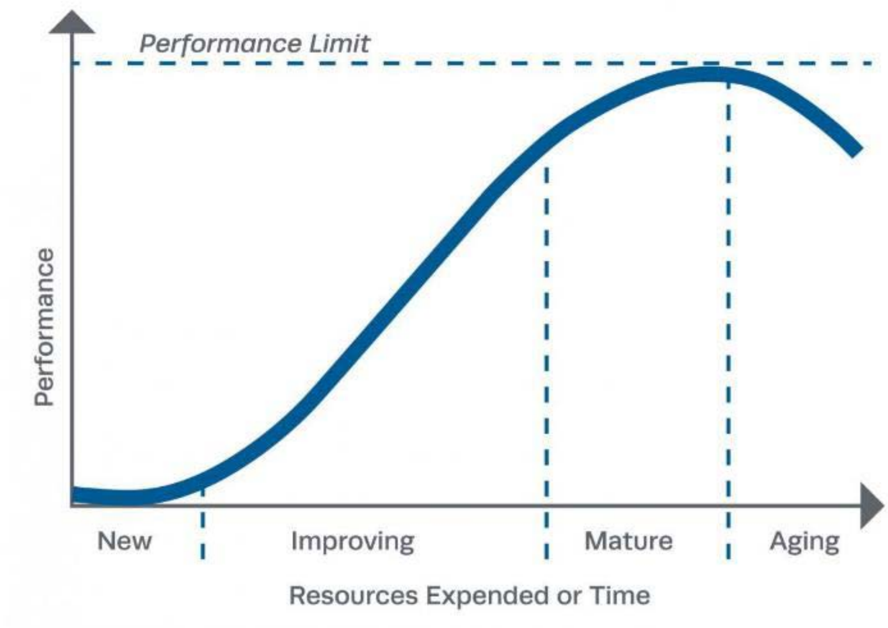

FIGURE 2: THE FOUR STAGES OF TECHNOLOGY MATURITY

Although new technologies are expected to improve with time, it is important to note that not all technologies will go through the four stages of maturity, or may proceed through certain stages very rapidly. Some new technologies undergo a ‘hype cycle’ where there is over-inflated enthusiasm on the capabilities of a new system. There is typically a lot of interest and coverage of the technology and expectations among potential customers are high. However, after early adoption, the hype of the technology falters as expectations are unmet. Eventually, further research and development may go into the technology and lead to improvements, however it is common that the technology does not get adopted globally and ultimately becomes obsolete.

Transit technologies are continually evolving, and new innovations are common across the industry. As such, the business owners of various transit technologies and information technology (IT) administrators who maintain the systems should keep track of technology developments in the market to inform the assessment of their own systems and to determine procurement strategies. Staff can keep up to date on technology developments by attending vendor demonstrations, webinars, relevant training courses and transit technology conferences. The Canadian Urban Transit Association (CUTA) and Ontario Public Transit Association (OPTA) are two institutions that hold annual conferences and trade shows where various transit technologies and innovations are highlighted. US-based organizations including the National Center for Applied Transit Technology, an organization focused on technological solutions for small, rural and tribal transit systems, the American

Public Transportation Association (APTA), Transportation Research Board (TRP), ITS JPO Professional Capacity Building Program and the National Transit Institute also provide valuable resources, training and networking opportunities.

2 TRANSIT TECHNOLOGIES

There are a variety of technologies that can be leveraged to make a more efficient public transportation system. This section focuses on various technologies that can help to enhance transit services. It outlines the technologies, organized by function and considers both classification and maturity.

Each of the technologies presented in this section provides guidance around the level of appropriateness or saleability for different types of transit systems and communities. Generally, we categorize transit systems and communities as follows:

Large Community Transit: Community meets the CUTA Group 1 - 3 criteria (population of more than 150,000) and may exist within a larger metropolitan area where residents frequently commute to other parts of the region. Examples of transit systems that meet this definition in Ontario include the Toronto Transit Commission, MiWay (Mississauga), Grand River Transit (Waterloo Region), London Transit Commission, Transit Windsor, York Region Transit, Hamilton Street Railway and others.

Small Community Transit: Community meets the CUTA Group 4 or 5 criteria (population of less than 150,000) and may exist within a larger metropolitan area where residents frequently commute to other parts of the region. Examples of transit systems that meet this definition in Ontario include Barrie Transit, CKTransit (Chatham-Kent), Cornwall Transit, Ride Norfolk (Norfolk County), and Welland Transit.

Rural and Remote Community Transit: Transit service within a municipality or Indigenous community that exists outside of a census metropolitan area (CMA) or census agglomeration (CA). Examples of communities that meet this definition in Ontario include Bancroft Community Transit, Bracebridge, Central Hastings Transit, Chippewas of Nawash Unceded First Nation Home and Community Care, and Huron Shores Area Transit.

The table on the following page provides an overall summary of the different technologies and their appropriateness for each of the types of communities, as well as section and page number references for further information.

Table 2: Summary of the technologies listed in this section, including appropriateness and scalability and benefits for various sizes of communities

Table 2 Legend:

Number	Appropriateness and Scalability
0	No significant applications at this scale and unlikely to provide significant benefit
1	Uncommon and with limited applications
2	Common but at reduced scale
3	Universally applied or common but more limited in features and Common and increasingly being adopted
4	Universally applied at this scale

Operations Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Computer-Aided Dispatch (CAD) and Automatic Vehicle Location (AVL)	- Track location of vehicles in real-time - Enables communications between dispatch and operator	4	5	2	Improved Safety, Operational Efficiency, Improved Customer Experience, Improved Data and Reporting	2.1.1.1., Page 29
On-board Announcement System	- Enable the provision of stop and other announcements through audio and visual formats - Typically part of CAD/AVL system	4	4	4	Improved Customer Experience, Improved Accessibility and Equity	2.1.1.2., Page 36
On-board Emergency Alarm	- Enable activation of silent and overt alarms on vehicles with live audio feeds to control system - Typically part of CAD/AVL system	4	4	0	Improved Safety	2.1.1.3., Page 37
Transit Signal Priority (TSP)	- Enable priority treatment at traffic signals	3	0	0	Improved Safety, Environmental Benefit, Improved Customer Experience	2.1.1.4., Page 39

Operations Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Data and Voice Communications	- Enable messaging, video, alerts and alarms through wireless voice network between operators, dispatchers and supervisors - Part of CAD/AVL system	4	3	2	Improved Safety, Operational Efficiency, Improved Data and Reporting	2.1.1.5., Page 41
Performance Monitoring Application	- Display active vehicles on a map or route diagram and indicates on-time performance of each vehicle	4	3	1	Improved Safety	2.1.1.6., Page 43
Control Centre Video Monitoring	- Provide security monitoring of transit facilities and vehicles - Part of CAD/AVL systems	4	3	1	Improved Safety	2.1.1.7., Page 45
Bid/signup Management	- Support automation and management of operator bidding process for new schedules.	3	0	0	Operational Efficiency	2.1.2.1, Page 47

Operations Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Workforce Management	- Support operator and other staff shift and task scheduling/ assignment - Provide data on staff absence, overtime and labour	4	2	0	Operational Efficiency	2.1.2.2., Page 48
Operator Check-in Kiosks	- Enable operators to check-into shifts and confirm assigned work, vehicle number and other operational details using self-serve kiosks	1	0	0	Operational Efficiency	2.1.2.3., Page 50
Yard Management Systems	- Track and monitor transit vehicles within and outside transit facilities for operators and supervisors	2	0	0	Operational Efficiency	2.1.3., Page 51
Specialized Booking/ Reservations and Scheduling	- Enable customers and customer agents to book trips - Enable schedulers to develop trip manifests by automatically	4	2	1	Operational Efficiency, Improved Customer Experience, Improved Data and Reporting, Improved Accessibility and Equity	2.1.4.1., Page 53

Operations Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
	assigning reserved specialized trips to vehicles and operators					
On-demand Booking and Scheduling	- Enable dynamic booking and scheduling of shared transportation services through real-time optimization of operator manifests to accommodate new trips requests	2	1	1	Operational Efficiency, Improved Customer Experience, Improved Data and Reporting, Improved Accessibility and Equity	2.1.4.2., Page 56
Closed Circuit Television (CCTV) Systems	- Enable recording and download of video on-board vehicles and at transit stops/terminals to enhance safety and provide data for review of any incidents	4	1	1	Improved Safety, Improved Data and Reporting	2.1.5.1, Page 59
Wayside Emergency Call Boxes	- Enable customers and other individuals to call emergency services	2	0	0	Improved Safety, Improved Customer Experience, Improved Accessibility and Equity	2.1.5.2., Page 60

Operations Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Precision Curbside Alignment System	- Automated guiding of vehicles to minimize gap between the curb and vehicle door at stations or stops	1	0	0	Improved Safety, Operational Efficiency, Improved Customer Experience	2.1.6.1., Page 61
Station/Platform Adaptive Lighting	- Optimize the required level and usage of lighting to ensure customer safety	2	1	0	Improved Safety, Improved Customer Experience, Improved Accessibility and Equity	2.1.6.2., Page 62
Platform Boarding Gates (Screen Doors)	- Automated shields that prevent track level incidents	1	0	0	Improved Safety, Improved Customer Experience	2.1.6.3., Page 63

Customer Experience Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Fareboxes	- Enables the collection of various fare media before or after boarding	4	3	1	Operational Efficiency, Improved Customer Experience, Improved Data and Reporting	2.2.1.1., Page 64
Smart Cards and Automated Fare Collection Systems	- Enhances fare payment options to customers through card based and account-based systems	3	1	1	Improved Customer Experience, Improved Data and Reporting	2.2.1.2., Page 66
Ticket Vending MachinesTicket Vending Machines	- Enables customers to purchase fare media through self-serve options	2	1	1	Improved Customer Experience, Improved Data and Reporting	2.2.1.3., Page 68
Mobile Ticketing	- Allows customers to purchase and manage fare payments through a mobile application	3	1	1	Improved Customer Experience, Improved Data and Reporting	2.2.1.4., Page 70
RTPI and GTFS/GTFS-RT/GTFS-Flex/GOFS	- RTPI includes the provision of various types of real-time information to customers - GTFS and its subsidiary feeds are	4	2	1	Improved Data and Reporting, Improved Accessibility and Equity	2.2.2.1., Page 71

Customer Experience Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
	standards transit systems use to publish data for 3rd party developers					
Trip/Itinerary Planners	- Support customers to plan their trips through transit operator websites by showing schedule time, fare and route to desired destination	3	2	1	Improved Customer Experience, Improved Data and Reporting	2.2.2.2., Page 73
Wayside Next Bus SignageWayside Next Bus Signage	- Display information related to transit schedule and service within a transit shelter or bus stop	2	1	0	Improved Customer Experience	2.2.2.3., Page 75
Mobile Apps	- Support customers to plan their trips through mobile applications that show various modes, real time traffic and estimated travel times - Draws data from RTPI and GTFS-RT to	3	2	1	Improved Customer Experience, Improved Data and Reporting, Improved Accessibility and Equity	2.2.2.4., Page 76

Customer Experience Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
	provide accurate information to riders					
Mobility-As-A-Service (MAAS)	- Provide customers a seamless travel experience through tools and technology that enable customers to plan and pay for multi-modal trips	1	0	0	Improved Customer Experience	2.2.3., Page 78
Phone Systems	- Enable customer service through automated call response or interactive voice response systems that provide callers with information and call options	4	3	3	Operational Efficiency, Improved Customer Experience	2.2.4.1., Page 79
Customer Relationship Management (CRM)	- Enable efficient customer service through automation of workflow processes and enhanced reporting	3	1	0	Improved Customer Experience, Improved Data and Reporting	2.2.4.2, Page 81

Customer Experience Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Wayside Public Address Systems	- Allow direct and one-way communication of information to customers through announcements	3	1	0	Improved Customer Experience, Improved Accessibility and Equity	2.2.5.1., Page 82
Passenger Wayfinding Technology	- Connect with certain mobile applications through Bluetooth beacons to provide wayfinding information in visual and audible formats	1	0	0	Improved Customer Experience, Improved Accessibility and Equity	2.2.5.2., Page 83
On-board and Wayside WLAN	- Provide internet access on-board vehicles, in stations or at bus shelters to customers	2	0	0	Improved Customer Experience	2.2.5.3., Page 84
On-board and Wayside Infotainment	- Provide information (e.g., next stop, weather, traffic, etc.) in high-quality digital displays to customers in various formats	2	0	0	Improved Customer Experience	2.2.6., Page 85

Service Planning Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Performance Analysis Reporting Tools	- Integrate available data from different systems to enable analysis of historical trends (e.g., reconciling fares with ridership, on-time performance, etc.)	4	3	1	Operational Efficiency, Improved Data and Reporting	2.3.2., Page 87
Geographic Information Systems	- Support the planning and modification of transit routes through mapping and analysis of ridership and demographic trends	4	4	3	Operational Efficiency, Improved Data and Reporting	2.3.2.1., Page 88
Integrated Planning Platforms	- Incorporate historical data with geospatial analysis tools to analyze proposed route scenarios and requirements to support transit planning	4	1	0	Operational Efficiency, Improved Data and Reporting, Improved Accessibility and Equity	2.3.2.2., Page 90
Fixed Route Scheduling Software	- Enable the development of fixed-route transit schedules	4	2	0	Operational Efficiency, Improved Customer Experience, Improved Data and Reporting	2.3.3.1., Page 92

Service Planning Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Runcutting Optimization Software	- Convert transit schedules to create operator shifts (called runs) that operators can work within reasonable constraints - Runcutting software is typically integrated with transit scheduling software	4	0	0	Operational Efficiency, Improved Customer Experience	2.3.3.2., Page 94
Automatic Passenger Counters	- Count number of customers boarding and alighting the vehicle to provide ridership and real-time crowding information	4	1	0	Improved Safety, Operational Efficiency, Improved Data and Reporting	2.3.3.3., Page 95

Maintenance Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
Asset Management Software	- Support the management of assets (e.g., fleet and maintenance equipment) by storing a database of information (e.g., age, purchase price, stocking levels, etc.)	4	2	1	Operational Efficiency, Improved Data and Reporting	2.4.1., Page 98
Vehicle Monitoring System	- Monitor and collect data on vehicle performance and health to inform maintenance processes	3	3	2	Operational Efficiency, Improved Data and Reporting	2.4.2., Page 99
Electric Vehicle Management and Battery Health Monitoring Systems	- Provide data to determine charging strategies by monitoring EV mileage, battery usage	1	1	1	Environmental Benefit, Operational Efficiency, Improved Data and Reporting	2.4.3., Page 101

Management & Administration Technology	General Use	Large Community	Small Community	Rural & Remote Community	Benefits	Section, Page
General Business Applications	- Enable inventory, processing and management of organization wide applications such as human resources, payroll and finance	4	4	4	Operational Efficiency, Improved Data and Reporting	2.5.1., Page 103
Analytics and Business Intelligence Tools	- Provide dashboards used for reporting on key performance indicators such as transit service standards and other organizational metrics	3	1	0	Operational Efficiency, Improved Data and Reporting	2.5.2., Page 104

2.1 Operations

2.1.1 Operating Performance and Route/Schedule Adherence Monitoring

The following table summarizes the various operational technology and systems that provide operating performance and route/schedule adherence monitoring applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Control Centre Video Monitoring	- Provides security monitoring of transit facilities and vehicles - Part of CAD/AVL systems
Performance Monitoring Application	- Displays active vehicles on a map or route diagram and indicates on-time performance of each vehicle
Data and Voice Communications	- Enables messaging, video, alerts and alarms through wireless voice network between operators, dispatchers and supervisors - Part of CAD/AVL system
On-board Announcement System	- Enables the provision of stop and other announcements through audio and visual formats - Typically part of CAD/AVL system
On-board Emergency Alarm	- Enables activation of silent and overt alarms on vehicles with live audio feeds to control system - Typically part of CAD/AVL system
Transit Signal Priority (TSP)	- Enables priority treatment at traffic signals

2.1.1.1 Computer-Aided Dispatch (CAD) and Automatic Vehicle Location (AVL)

CAD/AVL systems help track vehicles in service and communicate their location to customers for trip planning and can help diagnose issues with vehicles. This system actively tracks the location of vehicles in revenue service and can identify issues with operations, such as on-time performance.

Description: Computer Aided Dispatch/Automatic Vehicle Location (CAD/AVL) systems support the overall operations and service management of a transit fleet. CAD/AVL systems are typically comprised of four primary components, including: (1) A Central

Application, (2) A Control Centre from which to manage operations, (3) Customer information tools and technologies, (4) On-board technology

FIGURE 3 TYPICAL COMPONENTS OF A CAD/AVL SYSTEM

These components support operators with functions such as display routing, communications, and automatic stop announcements.

CAD/AVL systems provide transit systems with specific features relative to their service types. For each technology described in the section, specific features available within conventional, specialized and on-demand variations of the technology are highlighted.

See: Appendix I: Case Study - *Deploying CAD/AVL Through the Metrolinx Transit Procurement Initiative (TPI) (City of Timmins)* and *Deploying CAD/AVL through the Metrolinx Joint Procurement Program (City of Sault Ste. Marie)*

General Usage: Large transit systems will depend on CAD/AVL technologies for communicating certain operational information between operators and dispatchers, such as detours, real-time route updates or incidents, or through text-based messaging for non-emergency situations. This technology also helps Transit Control greatly with emergency response. Larger transit operators will often employ dedicated supervisory staff to monitor service throughout the service day. In small communities, CAD/AVL technology may be more limited in its functionality, however if partnering with other transit operators, such as how Timmins deployed their new CAD/AVL system, small communities can benefit from more fully featured systems.

FIGURE 4: DISPATCHER'S MONITOR SHOWING CAD/AVL DISPLAY WITH MICROPHONE

In smaller communities, dedicated CAD/AVL supervision may not be consistently available during the service day (some communities might staff these terminals only during peak periods, for example), but these transit operators will still depend on the system for critical data collection. Rural and remote transit services seldom have the capacity or the need to staff a CAD/AVL terminal with a supervisor and will instead employ AVL-only solutions for data collection and historical performance tracking.

> *Conventional CAD/AVL Systems*: Conventional services have some of the greatest breadth in options and features for CAD/AVL systems in the market, ranging from complex, multi-system implementations capable of supporting thousands of buses, light-rail vehicles and subway trains and hundreds of supervisors, to cloud-based and modular systems that can easily scale down to fleets of less than a dozen vehicles. All but the smallest municipalities have deployed some form of CAD/AVL system, but many full-featured implementations require robust IT support within the organization. Small municipalities may instead rely on AVL features baked into other systems (such as vehicle component monitoring or fare collection systems) and not use the operations management features available within the CAD system directly.

> *Specialized CAD/AVL Systems*: While specialized CAD/AVL systems are available on the market, they depend even more significantly on real-time integration with scheduling and booking platforms. This integration allows the system to dynamically reassign vehicles to adjust for last-minute changes to pickup and drop-off

information for customers by digitally managing and distributing updates to driver manifests. These systems are increasingly expanding to cover on-demand transit services by integrating many of the automated rescheduling and trip assignment algorithms common to those platforms. However, these systems often can remove the need for stop announcements, passenger counters and other advanced CAD/AVL features common to conventional systems.

On-demand CAD/AVL Systems: On-demand transit services rarely have a separate and distinct CAD/AVL system application, since the on-demand platforms have built-in operations and performance monitoring features that function in a similar way to a CAD/AVL. In contrast, several larger conventional CAD/AVL systems are increasingly integrating some on-demand features like dynamic rerouting in support of flexible route services.

CAD/AVL systems are often cornerstone technologies for transit systems, supporting a wide range of operations, reporting and monitoring functions as well as including or integrating with dozens of other systems and technologies locally, on-board vehicles and at the wayside. The following table lists some of the common integrations with CAD/AVL systems and identifies where in this document those other technologies are described.

TABLE 3: SUMMARY OF THE VARIOUS CAD/AVL COMPONENTS AND INTEGRATIONS AS THEY RELATE TO THE TECHNOLOGIES PRESENTED ELSEWHERE IN THIS SECTION

Critical CAD/AVL Components	Section, Page	Upstream Integration (Provides input into CAD/AVL)	Downstream Integration (Requires output from CAD/AVL)	Commonly included in CAD/AVL suite deployments	Commonly procured separately from the CAD/AVL
Performance Monitoring Application	2.1.1.6, p.43	N/A	N/A	Yes (Required for CAD/AVL functionality)	No
Data and Voice Communications	2.1.1.5, p.41	N/A	N/A	Yes (Data required for CAD/AVL functionality)	Yes (Voice only)
On-board Announcement System	2.1.1.2, p.36	No	Yes	Yes	No
On-board Emergency Alarm	2.1.1.3, p.37	Yes	No	Yes	No

Critical CAD/AVL Components	Section, Page	Upstream Integration (Provides input into CAD/AVL)	Downstream Integration (Requires output from CAD/AVL)	Commonly included in CAD/AVL suite deployments	Commonly procured separately from the CAD/AVL
Transit Signal Priority (TSP)	2.1.1.4, p. 39	Yes	Yes	Yes	No
Fare Collection Systems	2.2.2.1, p. 64	No	Yes	Yes	Yes (If CAD/ AVL has a proprietary RTPI source)
Trip/Itinerary Planners	2.2.2.2, p. 73	No	Yes	Yes (if an RTPI or GTFS-rt source is available)	Yes (if an RTPI or GTFS-rt source is available)
Wayside Next Bus Signage	2.2.2.3, p. 75	No	Yes	Yes (if an RTPI or GTFS-rt source is available)	Yes (if an RTPI or GTFS-rt source is available)
Vehicle Monitoring System	2.4.2, p. 99	Yes	Yes	Yes	Yes
Performance Analysis Reporting Tools	2.3.2, p. 87	No	Yes	Yes	Yes
Automatic Passenger Counters	2.3.3.3, p. 95	Yes	Yes	Yes	Yes
Closed Circuit Television (CCTV) Systems	2.1.5.1, p. 59	Yes	No	Yes	Yes
Control Centre Video Monitoring	2.1.1.7, p. 45	No	Yes	Yes	Yes
Operator Check-in Kiosks	2.1.2.3, p. 50	Yes, if features allow	Yes, if features allow	Yes, if being integrated with Workforce Management	Yes
Yard Management Systems	2.1.3, p. 51	Yes	Yes	Yes	Yes

Critical CAD/AVL Components	Section, Page	Upstream Integration (Provides input into CAD/AVL)	Downstream Integration (Requires output from CAD/AVL)	Commonly included in CAD/AVL suite deployments	Commonly procured separately from the CAD/AVL
Precision Curbside Alignment System	2.1.6.1, p. 61	No	Yes	Yes	Yes
Analytics and Business Intelligence Tools	2.5.2, p. 104	No	Yes	Yes	Yes

Separate Integrations	Section, Page	Upstream Integration (Provides input into CAD/AVL)	Downstream Integration (Requires output from CAD/AVL)	Commonly included in CAD/AVL suite deployments	Commonly procured separately from the CAD/AVL
Specialized Booking/Reservations and scheduling	2.1.4.1, p. 53	Yes	No	No	Yes
Fareboxes	2.2.1.1, p.64	Yes (Electronic only)	Yes (Electronic only)	No	Yes
Smart Cards and Automated Fare Collection Systems	2.2.1.2, p. 66	Yes	Yes	No	Yes
Mobility-As-A-Service (MAAS)	2.2.3, p. 78	No	Yes	Yes (if an RTPI or GTFS-rt source is available)	Yes (if an RTPI or GTFS-rt source is available)
Geographic Information Systems	2.3.2.1, p. 88	Yes	No	No	Yes
Integrated Planning Platforms	2.3.2.2, p. 90	No	Yes	No	Yes
Fixed Route Scheduling Software	2.3.3.1, p. 92	Yes	No	No	Yes
Workforce Management	2.1.2.2, p. 48	Yes	Yes	No	Yes

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Locally or cloud-hosted bespoke fully featured CAD/AVL solutions with integration to other transit operator systems such as Scheduling, Signup/Bid, Assignments.	Cloud-hosted fully featured CAD/AVL solutions, or limited CAD/AVL solutions integrated into fare collection systems. Typically, less complex in nature than those implemented for large municipalities.	Complete CAD/AVL solutions are uncommon. AVL-only solutions are increasing in popularity for transit applications after historically being targeted at long-haul carriage companies and road maintenance vehicles for fleet management.

Technology Lifespan: 8 – 12 years with periodic updates from the vendor

Implementation Costs: Refer to Appendix G: Budgeting Tables

2.1.1.2 On-board Announcement System

Description: This function is typically integral to CAD/AVL systems and enables controllers and operators to provide important information on-board vehicles. On-board announcement systems are used to inform customers of where they currently are along a route. The system can also be used to convey real-time service updates or public service announcements.

General Usage: On-board announcement systems can enhance accessibility on vehicles, through leveraging speakers and signage to present audio and visual versions of announcements, benefiting hearing and visual-impaired customers. Automatic volume control can appropriately adjust volume based on ambient noise levels within the vehicle. Typical announcements tell customers about each potential stop. Announcements for each stop must be provided through sound and display when the vehicle approaches the stop so that customers can request a stop. In addition, announcements should also sound and display on the vehicle prior to reaching the next stop. These systems can also announce additional information at key transfer points/destinations, and other key information such as route disruptions or detours.

> *Conventional Service On-board Announcement Systems*: These systems are implemented fleet-wide in order to meet requirements of the Accessibility for Ontarians with Disabilities Act (AODA) and improve the customer experience.

Specialized Service On-board Announcement Systems: Specialized services will derive little benefit from announcement systems due to the dynamic nature of the service. As a result, the driver is responsible for providing messaging to customers. In such circumstances, where customers have vision impairments, it would be beneficial for customers to be able to hear the stop locations of on-demand services.

On-demand Service On-board Announcement Systems: On-demand services will derive little benefit from announcement systems due to the dynamic nature of the service. The only exception would be in situations where vehicles are shared with conventional transit services, and on-demand applications include dynamic rerouting services where stops at fixed points would require annunciation to meet AODA requirements.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Integrated function of CAD/AVL system, with inside and outside speakers on vehicles, providing automatic next stop, route-destination, and public service announcement messaging.	Integrated function of CAD/AVL system, with inside and outside speakers on vehicles, or independent system with operator- or GPS-triggered announcements, with or without an operator microphone	Independent system with operator- or GPS-triggered announcements, with or without an operator microphone.

Technology Lifespan: 8 – 12 years, with annunciator hardware generally lasting the lifespan of the vehicle (up to 12 years), and on-board software dependent on the CAD/AVL system (8 – 12 years)

Implementation Costs: Refer to Appendix G

2.1.1.3 On-board Emergency Alarm

Description: Leveraging both voice and data connectivity to in-service vehicles, CAD/AVL systems typically provide several alarms and alerts based on vehicle performance, as well as emergency alarms for the safety of operators and customers. Emergency alarms provide prioritized alarms and live audio feeds to the control centre. They can be covert, where the safety of the operator or customers could be further endangered if the perpetrator, (for example, armed assailant), knew of the alarm, or overt, where the safety of customers and operator would not be further endangered, and are typically initiated by the operator.

General Usage: On-board emergency alarms are provided for both operators and customers and are used to alert emergency medical, police or fire services. Often times there is a passenger silent alarm, that allows customers to notify the operator about an emergency or security incident on the bus. This is more common on rapid transit vehicles to alert the operator. Additionally, it allows for alerts to be reported on vehicle performance, as well as emergency base alarms for the safety of operators. Emergency alarms provide alarms and live audio feeds to notify the control centre.

On-board Emergency Alarms are relatively ubiquitous across transit services. However, they tend to be more common in applications for transit systems with several vehicles (approximately six or more) and/or service in very high demand situations (vehicle crush loads).

Conventional Service On-board Emergency Alarms: These systems are implemented fleet-wide in order to support operators in covertly and/or quickly signalling to dispatchers that there is an emergency on-board. In these situations, a covert microphone is often capable of recording and transmitting audio, while on-board cameras might be trained on the operator or record at greater framerates to improve quality of coverage.

Specialized Service On-board Emergency Alarms: These systems could have similar features to conventional services. However, these systems are more frequently integrated with emergency services dispatch in order to support rapid emergency medical response to the vehicle in the event of a customer emergency.

On-demand Service On-board Emergency Alarms: These systems are often implemented with similar features as for conventional services. If vehicles and staff are shared with specialized services, then these systems may also be like specialized on-board emergency alarms.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Function of CAD/AVL system, integrated with covert pushbutton at operator's station, providing one-way audio transmission from vehicle to control centre or police. In more advanced systems with sufficient wireless bandwidth, emergency alarm can also initiate live streaming of video from the vehicle to supplement audio feed. Subtle indication on operator's data terminal, confirming that control centre personnel are monitoring.	Function of CAD/AVL system, integrated with covert pushbutton at operator's station, providing one-way audio transmission from vehicle to control centre or police. Potentially no emergency alarm capability besides 911 call from operator cell phone, or operator-initiated call on VHF radio	Likely no emergency alarm capability besides 911 call from operator cell phone, or operator-initiated call on VHF radio. However small systems that still use conventional radio systems may include a silent alarm feature which can be deployed as part of an AVL system.

Technology Lifespan: Upwards of 8-12 years, depending on depth of integration with other systems

Implementation Costs: Refer to Appendix G

2.1.1.4 Transit Signal Priority (TSP)

Description: In more densely populated areas, TSP interconnects connects transit vehicles to the broader transportation network. At intersections, it allows for transit (i.e., busses) to request a traffic signal adjustment based on schedule adherence and/or vehicle loading. Depending on the broader traffic patterns and service status, signal control systems can make traffic signal adjustments, extending or advancing green signals, enabling the improvement of transit service delivery.

General Usage: Transit Signal Priority is a set of operational improvements that dynamically use technology to reduce travel times adjusting the timing of traffic signals typically holding green lights longer or shortening the waiting period for red lights. TSP can be implemented at individual intersections such as those with higher volumes of traffic or along an entire corridor or entire street system. The two types of TSP system architecture include centralized and distributed TSP.

Centralized TSP organizes and manages requests for priority from many vehicles. When vehicle on-board CAD/AVL systems recognize that signal priority would be beneficial (for instance, when the vehicle is running behind schedule), it sends a request to the CAD/AVL central application. The central CAD/AVL application then sends a message to the central traffic signal control application, which determines if priority can be granted. If priority can be granted the central traffic system control application relays the command to the required intersection signals.

Distributed TSP requires that infrastructure be deployed at each intersection where TSP is required. The transit vehicle communicates directly with the local intersection signal controller through pavement loops or wireless networks to request priority. The signal controller determines if priority can be granted and adjusts signal light timing accordingly. Distributed TSP systems require four components, including: a detection system on-board vehicle, a priority request generator, a strategy for prioritizing requests and an overall TSP management system. TSP provides many benefits, including reduced transit travel times, improved schedule adherence, improved transit efficiency, and increased road network efficiency. TSP components are provided by the signal controller system provider.

> *Conventional Transit Signal Priority*: Conventional services have historically been the only transit typologies to implement TSP. The benefits of this technology are very limited in on-demand or specialized applications since it would require significantly greater investment in enabling the technology at additional intersections.

> *Specialized Transit Signal Priority*: Specialized services will derive little benefit from TSP systems for the relative cost of deploying the technology.

> *On-demand Transit Signal Priority*: On-demand services will derive little benefit from TSP systems for the relative cost of deploying the technology. The only exception would be in situations where vehicles are shared with conventional transit services, and on-demand applications include dynamic rerouting services where intersections at fixed points might benefit from TSP.

Maturity: Mature, with centralized TSP increasing in prevalence, particularly as distributed TSP is being replaced.

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Typically involves an on-board emitter, activated by CAD/AVL on-board computer based on schedule adherence and/or passenger loading. Can be deployed with communications between CAD/AVL and Signal Control central servers. Requires wayside equipment to be deployed at intersections. Often deployed only along major, or express regional routes.	Seldomly deployed	Unlikely to provide significant benefit for the cost and complexity of implementation.

Technology Lifespan: Central system alignment with CAD/AVL system (8 – 12 years), with intersection or traffic signal technologies aligned with signal controller lifecycle (12 – 15 years) depending on the format of the implementation.

Implementation Costs: Refer to Appendix G

2.1.1.5 Data and Voice Communications

Description: These suites of applications and technology are tied together with communications networks. Control centre workstations utilize ethernet networks to access the central applications (either locally or cloud-hosted). The central application connects to vehicles through several possible wireless data networks, ranging from publicly available cellular, to various land-mobile radio, and in some cases, Wi-Fi technologies.

FIGURE 5: DISPATCHER VOICE COMMUNICATION MODULE

FIGURE 6: OPERATOR MOBILE DATA TERMINAL (MDT)

General Usage: Data technology provides connectivity for messaging, video, alerts, and alarms. Wireless voice network technologies are also used to enable voice communications between controllers, vehicle operators, and other personnel such as street supervisors and maintenance employees.

See: Appendix I: Case Study- Implementing a Trunked Radio System for Transit Operations (City of Thunder Bay)

Conventional Communications Systems: CAD/AVL systems for conventional fixed-route services depend on cellular coverage to support data communications between vehicles and the central system. Voice communications could be integrated in that data connection (Voice of Internet Protocol or VoIP) or provided through a separate Land-Mobile radio system. In the case of the former, communications hardware (routers, switches, antennae, etc.) can be integrated, while in the latter case, separate hardware would be required to support the data and voice communications.

Specialized Communications Systems: Specialized CAD/AVL systems require similar communications features as conventional CAD/AVL systems. Historically, specialized CAD/AVL systems that had more limited dynamic features (like real-time manifest updates) would depend greater on voice communications and might operate a separate land-mobile radio system in addition to cellular data. This trend is decreasing in favour of more automated, data-rich CAD/AVL systems for specialized transit, and larger communities in particular are moving towards modern VoIP radio systems as well.

On-demand Communications Systems: On-demand operations are heavily dependent on cellular connectivity for data connections. Depending on the service delivery type employed, voice communications may not be necessary. For example, it is uncommon for direct centre-to-vehicle voice communication in the instance that operators are contracted staff of a third-party on-demand transit provider. In local transit operator-delivered on-demand services, these communications systems might more closely resemble those used for specialized transit service.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Ultra High Frequency (UHF) Land-Mobile Radio and/or Public Cellular (LTE-Long Term Evolution) for data and voice communications	UHF and/or Very High Frequency (VHF) Land-Mobile Radio and/or Public Cellular (LTE/3G) for data and voice communications	Very High Frequency (VHF) Land-Mobile Radio and/or Public Cellular (LTE/3G) for data and voice. Note that this is region-specific based on carrier coverage.

Technology Lifespan: Heavily dependent on the availability of network technologies in the area (i.e., the support lifespan of supporting cellular network infrastructure from the common carriers in the region). Voice radio systems (microphones, transmitters, etc.) can otherwise last 12 – 15 years or more depending on the communications infrastructure. Data transmission systems (routers, transmitters, etc.) often require replacement every 5 – 10 years.

Implementation Costs: Refer to Appendix G

2.1.1.6 Performance Monitoring Application

Performance monitoring applications allow staff to monitor operations using dedicated applications. Such applications are typically highly customisable, and integrated with other transit IT systems including scheduling, operator sign-up/bidding, vehicle dispatch/maintenance, voice radio systems, and other business applications. These tools help transit operators monitor various performance measures such as on-time performance of vehicles, as well as access communication features from central operations or a dispatch office.

Description: The primary functions include displaying active vehicles on a map or route diagram and indicating the specific on-time performance of each vehicle. These applications are most frequently accessed by staff on desktop computers, but lighter versions of these applications have been adapted for mobile technologies such as smartphones and tablets to enable on-the-road supervisors with similar features. While simple implementations may provide limited features and customizability, advanced systems often allow individual users to fully customize their display to suite their management style.

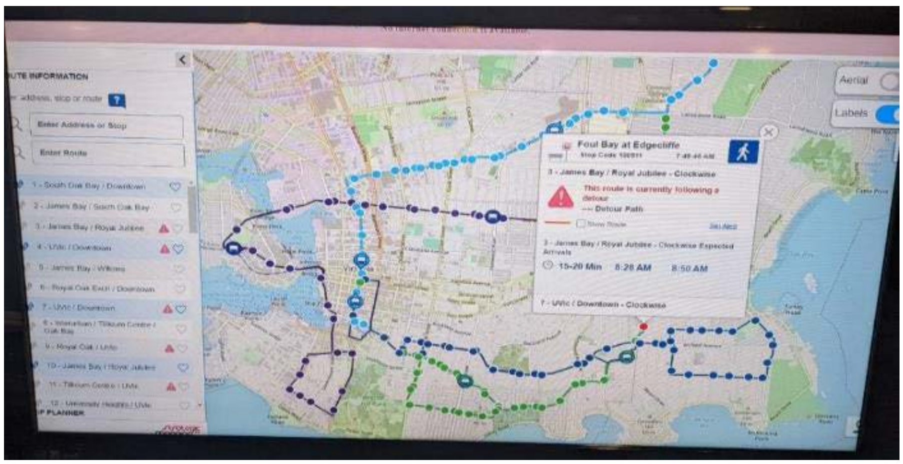

FIGURE 7: DISPATCHER'S SCREEN SHOWING VEHICLE LOCATION AND STATUS ON MAP

General Usage: While most larger transit systems with mature CAD/AVL systems depend on locally installed desktop applications for their primary operations monitoring activities, new entrants in the market are providing cloud-based applications accessible through a web browser. These applications often have more limited customizability and/or features, and are frequently marketed for smaller implementations. Operations supervisors will leverage these tools to monitor on-time performance of vehicles, and access communications features, often from a central operations centre or dispatch office. Road supervision is possible using mobile applications and laptops equipped with cellular data.

Conventional Operations Monitoring:Fixed-route transit systems often provide on-time performance metrics relative to scheduled services. These applications thus allow for management of schedules prior to service launch. Additionally, these are increasingly providing detour support by allowing staff to, in real-time, modify schedules and routes to account for changing operating conditions.

Specialized Operations Monitoring: Specialized transit services operate on dynamic schedules that are known, at best, one day in advance and assigned to vehicles and operators on the day of service. This is a Level of Service (LOS) that varies by municipality according to their policies and system capabilities. Monitoring systems thus provide options for reassigning trip bookings between vehicles in real-time, and, in addition to monitoring on-time performance, also monitor whether a customer is available on time for their pick-up.

On-demand Operations Monitoring: On-demand operations tend to be highly automated based on trip booking requests, and while often require less hands-on monitoring, they frequently have similar features for specialized operations.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Full-featured desktop application or cloud-hosted application, with full communications and detour management functionality.	Full-featured desktop application or cloud-hosted application, with limited communications. Detour management functionality uncommon.	Limited application, increasingly cloud-hosted, with ability to track vehicles, but usually with only AVL functionality (e.g., no communications or on-time performance indicators). Systems are not specialized for transit, and often deployed for tracking public works, post and logistics, or garbage collection vehicles.

Technology Lifespan: 8 – 12 years with periodic updates from the vendor

Implementation Costs: Refer to Appendix G

2.1.1.7 Control Centre Video Monitoring

Description: Control centres often include some level of security monitoring of facilities and vehicles. Video management systems, also known as video management software, can be used in control centre video monitoring. This is a security camera system that collects video from surveillance cameras, records and stores footage to a storage device and provides an interface to both view the live video and access recorded video footage. Larger control centres typically implement video walls, displaying a variety of information including video feeds (platform CCTV, TV news, alarms), providing situational awareness to the controllers focusing on their specific routes, vehicles, or geographical sectors, while smaller implementations could involve a single dedicated monitor or television screen.

General Usage: The control centre enables transit operators to group together control personnel to manage service from a central location. This allows for operators and essential personnel to maintain high levels of situational awareness which can improve safety and security. Control centres also facilitate greater collaboration, efficient big data monitoring and the ability to make better informed decisions, in real-time. Control centre infrastructure is typically provided by the CAD/AVL vendor, but computer and desk displays are sometimes provided by the municipality's IT department.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large video wall constructed of multiple panels, arranged in a rectangular array, complete with video management system, are typical among medium and large transit services. Larger transit services should consider using screens that sequence from camera to camera, depending on how many cameras are on the system. Some transit systems only have on board cameras activated automatically during an incident (e.g., sudden braking) or when it is activated by the operator.	Smaller-scale, multiple large-screen flat panels depending on the number of dispatchers/ supervisors assigned to the task. Smaller transit services could also consider using a dedicated flat screen monitor or access on any supervisor / CAD/AVL terminal with sufficient permissions.	Dedicated flat screen monitor or otherwise accessible on any supervisor terminal with sufficient permissions.

Technology Lifespan: 5 – 8 years (monitors, depending on usage); 8 – 10 years for video management system

Implementation Costs: Refer to Appendix G

2.1.2 Operator Management and Support Software

The following table summarizes the various operational technology and systems that provide operator management and support software applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Bid/signup Management	- Support automation and management of operator bidding process for new schedules
Workforce Management	- Support operator and other staff shift and task scheduling/assignment - Provide data on staff absence, overtime and labour
Operator Check-in Kiosks	- Enable operators to check-into shifts and confirm assigned work, vehicle number and other operational details using self-serve kiosks

2.1.2.1 Bid/signup Management

Description: An operator bid/signup management system enables operators to bid on shifts, extra work and or vacation time-off based on seniority levels. Operator bidding or sign-up can occur four-six times a year based on how often the municipality updates schedules. When a new service schedule and runs are created, this information is fed into a bid/sign-up management system to enable operators to sign-up for shifts. The operator sign-ups also form the basis of payroll as the number shifts assigned is required to determine pay. As such, modern operator bid/sign-up systems are also integrated with payroll systems to feed in operator work assignment data.

General Usage: The processes and technologies for managing the workforce are critical to ensuring that operators know their work assignments and that services can adapt to the myriad of events that can occur on any given day of service. In the absence of a system, the bidding process is often conducted by posting the updated service schedule and available work shifts in the garage for operators to manually sign up or bid on shifts and time-off. The prevalence of automated systems enables operators to bid using kiosks installed in garages or online employee portals. The system is typically configured to ensure organization and union rules are incorporated into system parameters. Automating the process improves the efficiency and reduces user errors.

Maturity: Improving and increasing in prevalence

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Transit service providers may deploy kiosks or terminals within a garage of the operator division. Additionally, transit systems occasionally deploy a web-based portal allowing secure access to the sign-up materials from any device. Implementation of these systems is contingent on union agreement.	Seldomly deployed, but transit systems in this category with a larger number of operators, or a workforce that is not always present (e.g., large number of part-time operators) may benefit from web-based portal applications.	Unlikely to provide significant benefit for the cost and complexity of implementation.

Technology Lifespan: 8 – 12 years

Implementation Costs: Refer to Appendix G

2.1.2.2 Workforce Management

Description: Workforce management software is a suite of tools that helps transit systems ensure that employees are at the right place, at the right time. Workforce management software is commonly accessible through desktop and mobile programs that help transit systems manage staff scheduling. Additionally, workforce management software allows transit systems to see business metrics such as peak periods, or by hour, where a greater number of employees may be needed for example.

General Usage: Typically, workforce management software has common functionalities. Labour scheduling helps manage employees' skills and requirements more effectively.

Additionally, such technology ensures that the operator assigned is properly trained for the work (e.g., vehicle type, special service). This also helps to manage staff who are "return to work" (e.g., returning to work from short/long term disability). Time and work data collection allows transit systems to capture and report detailed information about the use of labour. Leave management allows for organizations to manage time-off requests with higher level insight into how this can affect staffing and labour distribution. Tasks and activity management allows for organizations to view a more detailed look of labour management requirements needed to help with decision making required for activity-based management. Lastly, such software allows for organizations to track and record time and shift attendance. This can be used by organizations to streamline and automate the process, by applying rules against reported times based on company requirements or policy.

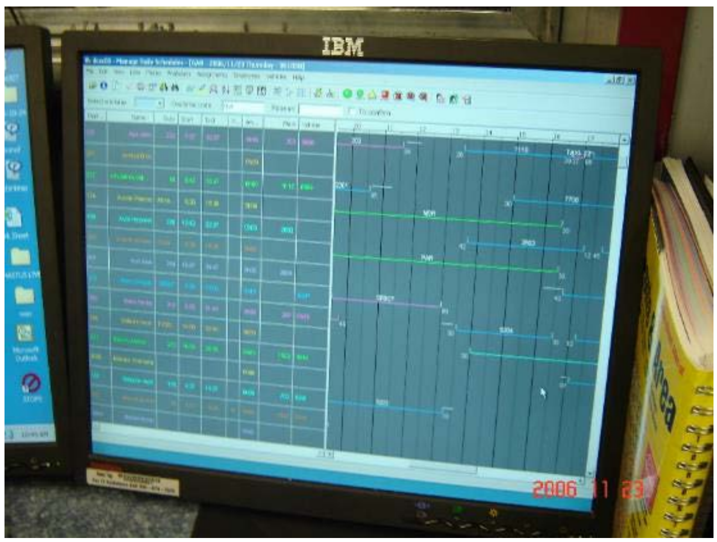

FIGURE 8: OPERATOR MANAGEMENT SOFTWARE INTERFACE

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large transit systems will deploy a transit-specific tool due to the scale and complexity of the services and operator arrangements. Organizations will depend	Smaller transit services may use a very basic level of workforce management to keep track of a smaller number of operators. These	Unlikely to provide significant benefit for the cost and complexity of implementation.

on these systems for appropriately tracking overtime, time off requests, licensing and certification, training and many other critical aspects of operator workforce management.	systems may or may not be transit-application specific.	

Technology Lifespan: 8 – 12 years

Implementation Costs: Refer to Appendix G

2.1.2.3 Operator Check-in Kiosks

Description: Operator check-in kiosks allow for a convenient way for operators to check-in using self-serve kiosks. These typically consist of a computer and monitor, with an application running enabling operators to check-in, confirm their assigned work, vehicle number and vehicle parking location. This technology helps to speed up the dispatching process.

General Usage: Transit systems may use operator check-in kiosks to allow an automated process for managing work for operators. This functionality is typically provided as a module of the CAD/AVL system, and interfaces with yard management, schedule, and workforce management integrations. This technology can also enable organizations to track on-time attendance and absenteeism.

Maturity: Mature and increasing in prevalence in certain applications

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Appropriate to deploy as large transit systems can be dealing with many drivers and the potential for significant bottlenecks in communication at the start or end of shifts.	Unlikely to provide significant benefit for the cost and complexity of implementation.	Unlikely to provide significant benefit for the cost and complexity of implementation.

Technology Lifespan: 5 – 12 years depending on hardware deployed

Implementation Costs: Refer to Appendix G

2.1.3 Yard Management Systems

Technology	General Use
Yard Management Systems	- Track and monitor transit vehicles within and outside transit facilities for operators and supervisors

Description: Yard Management Systems provide high-resolution vehicle location within garages and outside in their yards, identifying specific parking spaces and tracking movement. The systems use a series of transmitting ID tags on vehicles, combined with numerous sensors spread across the facility, triangulating on vehicle signals to calculate precise locations. Yard management functions enable tracking of vehicle location (even when the vehicles cannot pick up GPS signals), scheduling of vehicle and maintenance assignments, as well as running reports on inventory and performance to allow operations to stay on track. In some cases, Yard Management Systems can integrate with asset management systems, tying into workorder management. They can provide parking assignments to operators as they return from service, automating some yard functions based on the next scheduled task for the vehicle, including maintenance, cleaning, inspections, or additional service assignments.

General usage: The primary use of this is to find the location of a vehicle, so that operators can find and know where a specific vehicle is located. This allows for efficiency with the transit operator, as time is not spent looking for vehicles in the yard. Additionally, by using such technology, drivers know exactly which vehicle they should take and exactly where it is, so they are able to depart on schedule. Secondary functionality includes automation of some yard functions such as parking and work assignments.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Yard management systems may be considered by larger transit systems, as they manage a large fleet and have access to several	Unlikely to provide significant benefit for the cost and complexity of implementation.	Unlikely to provide significant benefit for the cost and complexity of implementation.

large storage and maintenance facilities.		

Technology Lifespan: 8 – 12 years

Implementation Costs: Refer to Appendix G

2.1.4 Demand Responsive Transit Software

The following table summarizes the technology and systems that provide demand responsive transit software applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Specialized Booking/Reservations and scheduling	- Enable customers and customer agents to book trips - Enable schedulers to develop trip manifests by automatically assigning reserved specialized trips to vehicles and operators
On-demand Booking and Scheduling	- Enable dynamic booking and scheduling of shared transportation services through real-time optimization of operator manifests to accommodate new trips requests

Demand Responsive Transit (otherwise known as on-demand transit) software and associated systems provide an all-in-one solution for transit providers. The software includes a booking system for customers to arrange a trip, as well as the back-end routing and driver interface to allow it to enter into service.

On-Demand Transit Toolkit

In response to growing interest in exploring ODT services in Ontario, Metrolinx and the Canadian Urban Transit Association (CUTA) have jointly developed an On-Demand Transit Toolkit published online June 6, 2022. The ODT Toolkit was developed as a resource for transit agencies, municipalities, and service providers considering ODT as an option for their communities. Drawing from best practices, academic, and industry research, the Toolkit outlines design and implementation strategies for municipalities and transit service providers to consider when exploring ODT as a transportation option. In addition to the information on operating on-demand transit services, the ODT Toolkit also outlines different technology and software that is currently used.

View the On-Demand Transit Toolkit: https://cutaactu.ca/news-resources/on-demand-transit-toolkit/

2.1.4.1 Specialized Booking/ Reservations and Scheduling

Description: Specialized planning software includes both booking/reservations and scheduling modules or components within the same system. Specialized booking/reservations allow for customers to book a door-to-door shared ride accessible transit service, where the customer has to be eligible to use the specialized service. Customers can call in or go online and book their trips. Many systems support automated text or phone reminders to clients about their planned trip.

Service scheduling is a critical element that directly impacts the efficiency, reliability, and capacity of your service. As part of the scheduling process, Service Schedulers are responsible for developing the daily service schedules and preparing operator runs, also called manifests. For most transit systems this involves using the scheduling software, although some smaller organizations may do this manually. The software will allow the scheduler to develop and optimize schedules based on all the booked trips, considering multiple factors including customer restrictions and conditions, vehicle availability, operator availability and operator breaks as per the collective agreement. Some transit systems have agreements with private contractors or taxi companies to provide additional ridership capacity when there is insufficient space on the primary specialized service.

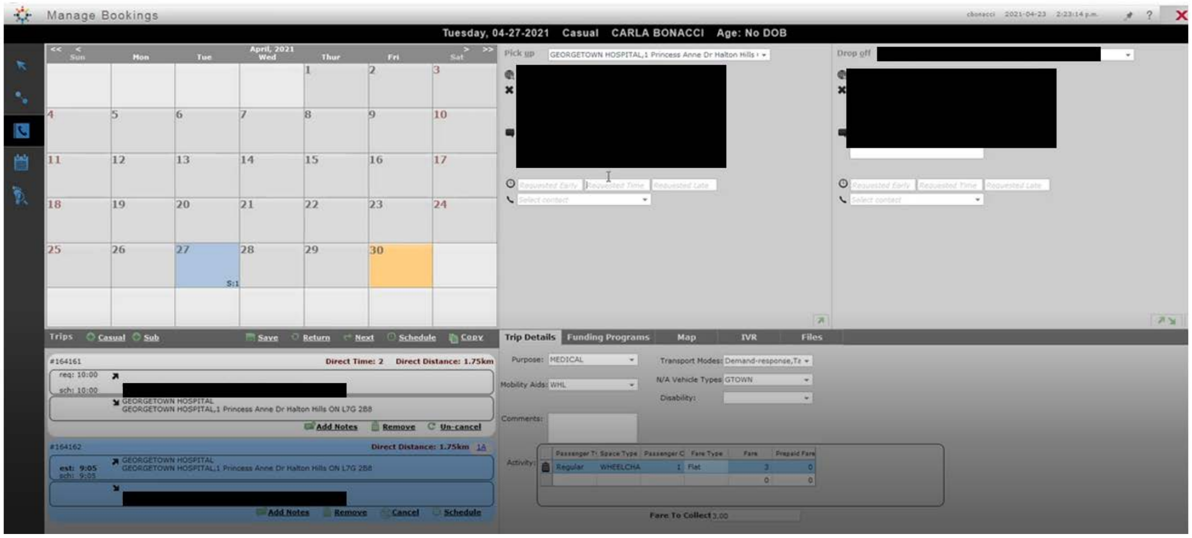

FIGURE 9: SPECIALIZED TRIP RESERVATIONS INTERFACE

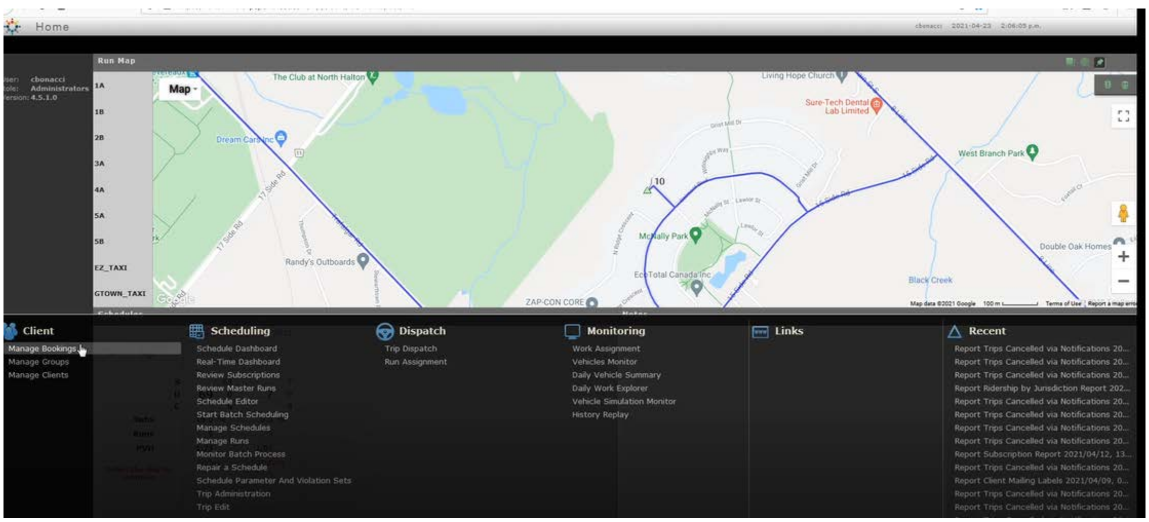

FIGURE 10: SPECIALIZED TRIP SCHEDULING INTERFACE

General Usage: Customer accounts are created during the eligibility process (includes client info, eligibility conditions, vehicle restrictions, favourite destinations, etc. in accordance with the AODA) and contact centre agents can use trip booking software to take requests from customers. Web and telephone-based booking services offer specialized transit users the ability to access self-serve features to book trips and check upcoming rides.

Most transit systems use scheduling systems to automate the scheduling process. Automation can work in the form of batch schedules and real-time optimization. Batch scheduling automation takes all booked trips and optimizes them with the available vehicles and operators for the day. Systems that re-batch will typically run this process every night, with separate schedules for the next several days. This process allows them to have a sense of how much capacity they have left to book trips when customers call to request new trips. Batch processing must always be done ahead of the service day. Any additional requests or manifest changes after the batch is completed must be made manually.

A recent trend in the industry has been to introduce real-time optimization to constantly make small adjustments to improve the schedule based on when requests are received. Real-time optimization can create manifests (operators' itinerary of trips to be delivered) ahead of a service day but are also increasingly being applied to support same-day trip requests. With the advent of advanced on-demand trip booking algorithms, vendors are increasingly able to offer the ability for transit systems to accept real-time booking requests and dynamically update driver manifests.

Many modern platforms can enable transit systems to integrate different services. Integration can happen in multiple ways from sharing booking platforms to sharing the fleet and rides. For example, all customers (specialized and non-specialized) may be able to book trips using the same mobile app or call centre to book on-demand trips. Once booked, the same fleet of vehicles can be used interchangeably to serve all customers. In addition, based on the service delivery policies of transit systems, specialized and non-specialized customers can also share rides to connect to fixed route systems.

It is important to note that when implementing a specialized booking/reservation and scheduling system, municipalities must meet the Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) obligations related to storing and handling personal information of customers.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Medium and large transit operators will utilize a system to reserve and schedule specialized trips. Specialized booking reservations may use a variety of platforms for	Many small municipalities have systems for reserving and scheduling specialized trips. Those that do not will resort to manual methods (e.g.,	Rural and remote transit services typically do not have software systems and depend on manual methods (e.g., paper slips, spreadsheets) to take trip

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
customers to be able to book trips including calls, websites and mobile applications. Sophisticated systems will enable large transit operators to use real-time optimization of schedules to offer same-day booking options, which provides customers with increased flexibility.	paper slips) for recording trip requests, and undertake scheduling using spreadsheets.	reservations and create manual schedules.

Technology Lifespan: 4-8 years

Implementation Costs: Refer to Appendix G

See: Appendix I: Case Study- Planning the Transition of Specialized Transit Technology Systems (City of Thunder Bay)

2.1.4.2 On-demand Booking and Scheduling

Description: On-demand transit is a technology-enabled publicly shared transportation service. The system can be configured to enable customers to use an app to book, pay and track their ride. Drivers can use it to validate fares, as well as receive dynamically routed pick-up and drop-off instructions, configured by on-demand scheduling software. Driver manifests (itineraries) are continuously re-optimized based on rider demand as well as local changing traffic conditions to ensure travel times are optimized for each trip. As a result, shared on-demand rides can serve customers in low density areas or efficiently connect customers to fixed route transit by filling the first/last mile gap in public transit.

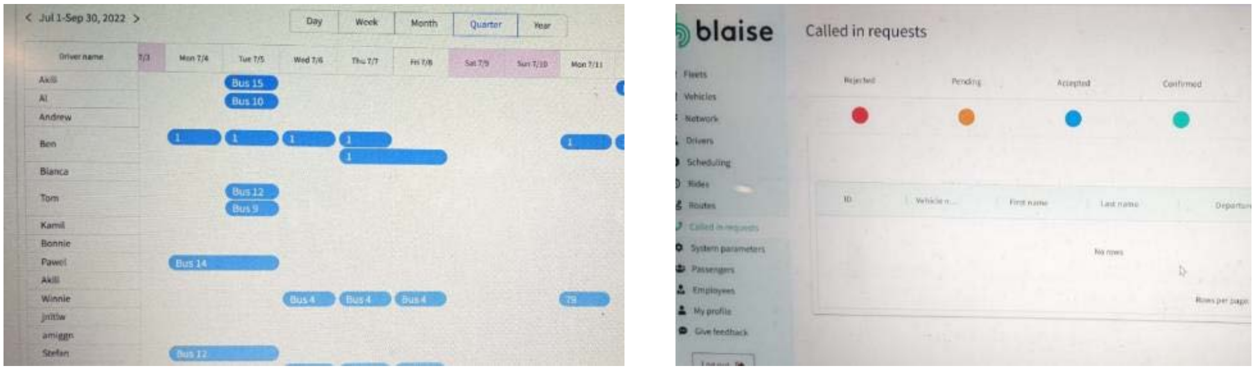

FIGURE 11: ON-DEMAND BOOKING AND SCHEDULING SOFTWARE MODULES

General Usage: On-demand booking and scheduling systems enable municipalities to provide service more flexibly and dynamically for their customers in low density areas or serve specific communities. On-demand services often have no fixed route or schedule. The technology allows for the flexibility to book a ride in advance and often as early as within 15 minutes through a provided mobile application and a website. Municipalities, however, also provide a call-in option to provide customer support and trip booking for those who may not be comfortable or able to use these applications. With this technology, there are service objectives that are baked in with the software (e.g. maximum wait time and on-board travel time).

Trip requests, once booked, are then passed through an automated scheduling algorithm which dynamically assigns each trip to available vehicles. Once assigned, customers can often track the arrival time of a vehicle within their application, and operators are notified of their next trip pick-up and drop-off on a companion application available on-board. Many of the operator-facing applications found onboard the transit vehicle are installed on Commercial-off-the-Shelf (CotS) hardware such as ruggedized Android tablets.

It should be noted that 3rd party service providers in the on-demand transit space are often responsible for providing, as part of their contract, the on-demand booking and scheduling software to support their operations. In this case, the service provider is responsible for the on-going maintenance and upkeep related to the system.

It is also important to note that when implementing an on-demand booking and scheduling system, municipalities must meet the Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) obligations related to storing and handling personal information of customers.

Maturity: Improving

Appropriateness/Scalability:
The prevalence of on-demand booking and scheduling systems is directly tied to the increasing deployments of on-demand transit in Ontario. Any modern on-demand transit service will require supporting software.

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Larger municipalities are considering the use of on-demand services to replace low-performing routes, expand into low-density neighbourhoods or increase the span of service in the evenings and weekends. Additional resources may be required to support customers with the transition and use of the new technology. Alternative options may need to be implemented to support customers without data access or those who are dependent on cash fares.	On-demand transit may be a viable replacement or supplement for fixed-route transit in low performing areas or time-periods. However, many smaller municipalities also have a customer base. Additional resources may be required to support customers with the transition and use of the new technology. Alternative options may need to be implemented to support customers without data access or those who are dependent on cash fares.	Rural and remote communities are grappling with the different costs for providing transit in their communities. On-demand transit has gained prominence in recent years as a service that can be started rather simply and quickly, allowing communities to introduce transit to more residents.

Technology Lifespan: TBD, most on-demand tools are in their first generation, but anticipated lifespan is 4-8 years with regular and frequent updates from the vendor.

Implementation Costs: Refer to Appendix G

See: Appendix I: Case Study- Deploying an Integrated Specialized and Conventional On-Demand Technology (Town of Milton)

2.1.5 Safety and Security Systems

The following table summarizes the technology and systems that provide safety and security systems applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Closed Circuit Television (CCTV) Systems	- Enable recording and download of video on-board vehicles and at transit stops/terminals to enhance safety and provide data for review of any incidents
Wayside Emergency Call Boxes	- Enable customers and other individuals to call emergency services

2.1.5.1 Closed Circuit Television (CCTV) Systems

Description: Modern onboard and wayside CCTV video surveillance systems rely mainly on IP-based technology to provide direct access to the information necessary for supervising and adjusting operations during transit. Such systems support live viewing and data recording both on-board/wayside and remotely at the operations control center. In order for such technology to be implemented, robust network infrastructure communications is needed.

FIGURE 12: ON-BOARD CCTV CAMERA

General Usage: Considering customer safety and perception of safety as a priority, security system technology at stops and on-board vehicles that enhance safety is important. Closed Circuit Television (CCTV) can be implemented both on-board and at stops, allowing for remote monitoring and assessment of selected areas. Transit operators can use such footage to monitor the system, including bus arrival and departures, customer movement and surveillance related to customer safety. On vehicles, CCTV systems can work in conjunction with emergency alarms, recording high-frame rate video for law enforcement, and/or streaming video for real-time viewing by transit security or local law enforcement providing situational awareness for emergency response. In stations and on platforms, CCTV systems are often integrated with emergency call boxes to provide visibility to callers and evolving situations. Some of these systems only record when there is an incident on board and/or when activated by the operator.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Commonly deployed on all transit vehicles. Occasionally deployed at select stations and transit terminals to improve the passenger experience and safety.	Increasingly common on all transit vehicles. Uncommon, but could be deployed at select stations and transit terminals to improve the passenger experience and safety.	Seldomly deployed but could provide benefit in niche applications as technology costs decrease. Such benefits include customer movement such as who enters and exits vehicles.

Technology Lifespan: 5 – 12 Years

Implementation Costs: Refer to Appendix G

2.1.5.2 Wayside Emergency Call Boxes

Description: This physical interface allows customers to press a button that triggers a phone call to the control centre, or directly to 911, and can be set up to locally trigger strobe lighting, drawing attention to the platform. Advanced deployments include integration with CCTV systems, such that a button push/call placed on the emergency call box initiates adjacent cameras to focus on the call box and additionally pops up video at the control centre, providing visual situational awareness accompanying the audio call.

General Usage: These call boxes are used to report an emergency and can allow for customers to feel an increased perception of safety while at stops. Emergency communications play an important role in all environments. Acquiring call/boxes is an effective way to improve security and safety.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Occasionally deployed at select stations and transit terminals to improve the passenger experience and safety.	Uncommon, but could be deployed at select stations and transit terminals to improve the passenger experience and safety.	Unlikely to provide significant benefit for the cost and complexity of implementation.

Technology Lifespan: 12 – 15 years

Implementation Costs: Refer to Appendix G

2.1.6 Additional Operations Technologies

The following table summarizes the various technology and systems that provide additional operational applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Precision Curbside Alignment System	- Automated guiding of vehicles to minimize gap between the curb and vehicle door at stations or stops
Station/Platform Adaptive Lighting	- Optimize the required level and usage of lighting to ensure customer safety
Platform Boarding Gates (Screen Doors)	- Automated shields that prevent track level incidents

2.1.6.1 Precision Curbside Alignment System

Description: Precision Curbside Alignment Systems provide an operations-focused technology that enhances safety at stops and reduces the dwell time associated with boarding and deploying a ramp for mobility devices. With a precision alignment system, a vehicle is guided when it approaches a stop to ensure to minimize the gap between the vehicle entrance and the curb.

General Usage: Modern guidance systems can reduce the gap between a vehicle door and the curb to less than two inches, like light rail and commuter rail vehicles. The autonomous system supports operators and is a step towards leveraging fully autonomous technology.

Maturity: Improving, but uncommon

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Occasionally implemented along dedicated corridors or at stations. For example, along a dedicated guideway for a Bus Rapid Transit (BRT) corridor.	Unlikely to provide significant benefit for the cost and complexity of implementation.	Unlikely to provide significant benefit for the cost and complexity of implementation.

Technology Lifespan: TBD, anticipated lifespan between 8 – 12 years depending on hardware installed (lower in instances where hardware is installed within the roadway).

Implementation Costs: Refer to Appendix G

2.1.6.2 Station/Platform Adaptive Lighting

Description: Adaptative lighting systems automatically adjusts their light output and operation to provide targeted light levels based on environmental conditions, user schedules or other application specific criteria. Such systems oftentimes can be manually set, over time, in terms of light levels, and in some cases color to provide optimal lighting conditions as set by the system operator. This feature is accomplished by combining controllable luminaries with lighting controls and communication hardware that can understand changes in the environment and adjust the lighting accordingly. Such systems include many different types of products. This may include dimmable luminaries, occupancy sensors, photocontrols, timeclocks, communication panels and wireless communication nodes.

General Usage: In terms of customer safety and perceived safety, this technology can enhance safety at a stop by ensuring that stops are appropriately lit when customers are present and dimming lights otherwise. Additionally, this may provide stations and platforms an appropriate level of lighting depending on environmental factors which can be easily adapted at a smaller scale.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Occasionally deployed at select stations and transit terminals to improve the passenger experience	Uncommon, but could be deployed at select stations and transit terminals to improve the passenger experience	Unlikely to provide significant benefit

Technology Lifespan: 5 – 8 years

Implementation Costs: Refer to Appendix G

2.1.6.3 Platform Boarding Gates (Screen Doors)

Description: Platform screen doors are used at some train, and rapid transit stations to separate the platform from the guideway. These platform screen doors can refer to both full-height and partial-height barriers. Full height platform screen doors are complete barriers between the station floor and ceiling, while the half-height platform screen doors are sometimes referred to as platform edge doors, or automatic platform gates. These gates do not reach the celling and therefore do not create a full barrier.

General Usage: Platform screen doors are primarily used for passenger safety but also provide additional benefits by reducing boarding times and minimizing the possibility of delays due to guideway incursion. Additionally, screen doors can prevent or reduce wind felt by the customers and improve the sound quality of platform announcements as background noise from the tunnels and vehicles that are entering or exiting is reduced.

Maturity: Mature but uncommon in North America

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Could be considered by large transit systems with significant rapid transit infrastructure (i.e., heavy rail, light rail, advanced bus rapid transit).	Unlikely to provide significant benefit for the cost and complexity of implementation.	Unlikely to provide significant benefit for the cost and complexity of implementation.

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
	Not appropriate for most conventional transit applications.	Not appropriate for most conventional transit applications.

Technology Lifespan: 12 – 15 years

Implementation Costs: Refer to Appendix G

2.2 Customer Experience

2.2.1 Fare Collection Systems

The following table summarizes the various technology and systems that provide fare collection solutions and applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Fareboxes	- Enables the collection of various fare media before or after boarding
Smart Cards and Automated Fare Collection Systems	- Enhances fare payment options to customers through card based and account-based systems
Ticket Vending Machines	- Enables customers to purchase fare media through self-serve options
Mobile Ticketing	- Allow customers to purchase and manage fare payments through a mobile application

2.2.1.1 Fareboxes

Description: Fareboxes have long-been a staple in the transit industry. While traditional, or “gravity”/”drop box,” fareboxes have been around for decades, farebox technology continues to evolve. Many transit systems use electronic, or “registering”/”validating” fareboxes that detect and count the fare payments as they are made. It is important to note that these modern fareboxes require back office systems to account for, validate, and manage fare revenue from various fare media.

Such fare collection and polices can reduce boarding times and present the opportunity for greater operational efficiencies. Furthermore, the introduction of newer fare technologies has significantly dropped the proportion of cash fares collected.

FIGURE 13: A COMMON ELECTRONIC FAREBOX INSTALLED FOR TRAINING PURPOSES IN A TRANSIT CENTRE

As fare collection increasingly moves toward cashless and ticketless systems (e.g., Smart Cards, Mobile Payments and Automatic Fare Collection), some transit systems are considering simplifying their farebox systems to eliminate many of the verification and automatic counting features, returning instead to the simple “gravity” farebox to save on maintenance costs.

General Usage: The new farebox technology being installed among many municipalities allow customers to swipe transfer tickets, reducing the possibility that tickets get stuck in the machine. They also give operators greater ability to position the controls, have a brighter, easier to use display and can automatically scan and validate bills. These fareboxes can also tell the operator how much money was deposited into the farebox to pay for the fare. Such features make boarding more efficient and reduce on-going maintenance needs.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
All medium and large transit services have fareboxes. That said, many still rely on mechanical fareboxes, and have made a deliberate decision to reduce cash fares through modern fare collection systems, thus reducing the importance of the farebox.	Most small transit services have fareboxes to collect fares from customers.	While some rural and remote services rely on fareboxes, many rely on operators to collect fares in a pouch.

Technology Lifespan: 10-15 for electronic (registering) farebox, traditional ("gravity") fareboxes last- 20-30 years

Implementation Costs: Refer to Appendix G

2.2.1.2 Smart Cards and Automated Fare Collection Systems

Description: Over the past couple decades, many transit systems have implemented electronic or automated fare collection systems (AFCS). AFCS simplify the payment process for customers. These systems rely on readers installed onboard vehicles and at key transit stops and terminals, and use plastic cards with embedded RFID (radio frequency identification) chips to conduct transactions. A fare processing engine and financial backend is incorporated into the central system. A passenger who "taps" on to a transit vehicle can then step off and board other vehicles within the prescribed transfer rules without paying a second fare or requiring a paper transfer bill.

FIGURE 14: SMART CARD BEING TAPPED ON AN AFCS FARE VALIDATOR

There are two general types of AFCS:

- Card-based systems: older systems used cached (stored) transaction data on-board vehicles, which is then transferred to the central fare processing engine when the vehicle entered the garage. As a result, transaction data and information about transfer validity was stored directly on the card. These card-based systems therefore provide little opportunity for real-time data processing or updates to fare systems (like card reloads or blacklisting).

- Account-based systems: newer systems use an account-based system, where the card references an account each time it is used. Transaction information is transmitted to and from the central system in near real-time. These types of systems pave the way for open payment, including the use of non-traditional media, such as Near Field Communication (NFC)-enabled smart phones and bank-issued credit cards to pay fares. Account-based systems rely heavily on the central system in order to validate fare purchases, transfers, and accounts, and thus require a very reliable communications backbone.

Many AFCS have various customer channels through which individuals can manage their account to add funds/passes and view trips completed. This can include websites, mobile apps, or integration to ticket vending machines.

General Usage: Manual fare collection can be time-consuming, expensive, and hard for transit systems to keep track of. In the long run, out-of-date fare collection methods add higher operational costs. Automatic fare collection provides operators with the tools to eliminate human error associated with manual fare collection. These electronic fare collection technologies collect passenger information, making it easier to keep track of rider trips. Such automated fare collection provides customers with easy and convenient transportation. This means faster, more reliable fare options for transit customers. This can improve the overall transit experience for customers. It can also have a significant benefit of reducing boarding times, resulting in higher service efficiency for busier routes.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Largely deployed, with options such as smartcards and mobile ticketing.	There are some limited deployments of AFCS. However, the emergence of mobile ticketing solutions has decreased demand for AFCS.	There are very limited deployments of AFCS in rural and remote systems due to the cost of implementation.

Technology Lifespan: 5-10 years

Implementation Costs: Refer to Appendix G

See: Appendix I: Case Study- Bracebridge Develops a Transit Technology Plan (Town of Bracebridge)

See: Appendix I:Case Study- Planning for a new Electronic Fare Collection System (Sault St. Marie)

2.2.1.3 Ticket Vending Machines

Description: Ticket vending machines allow users to buy tickets using a self-serve machine with an ATM-like interface where customers can purchase fare media (tickets, fare cards). Such technology is often used in larger systems, because it is a 24/7 service that supports large volumes of sales but comes with a higher capital cost. These costs are increasingly being questioned as the proliferation of cashless and ticketless fare media (such as smart cards and mobile payments) becomes more common. Transit systems, however, must consider the significant equity implications of removing cash payment options entirely.

FIGURE 15: TICKET VENDING MACHINE INSTALLED AT A TRANSIT STATION

General Usage: Ticket vending machines are convenient for customers especially as they offer variety and affordability. These machines offer automated, interactive and dynamic services which allow for simple, fast, and safe transactions. These machines provide a strong and convenient user experience allowing for more autonomy and interactivity. TVM's improve the purchasing process for customers as this process is fully automated and delivers both speed and security.

Maturity: Mature and likely ageing as other alternatives (Smart Cards, Mobile Payments, etc.) increase in prevalence.

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Larger transit services will often implement TVM's at major inter-modal points or hubs with high foot traffic	Seldomly deployed, except in niche applications	Seldomly deployed, except in niche applications

Technology Lifespan: 3-5 years

Implementation Costs: Refer to Appendix G

2.2.1.4 Mobile Ticketing

Description: Mobile ticketing apps have emerged, both as stand-alone fare payment options as well as part of a broader automatic fare collection program. In the former, customers can use a mobile app to purchase a valid fare, and then use the device to validate their fare to the operator when they board the vehicle. The fare is paid either when activated by the customer on the app, or by a fare machine on board the bus. In some cases, vendors are offering mobile ticketing in a 'Fare-as-a-Service' model, with limited upfront cost and higher on-going commissions on fares collected.

As part of a broader program, the mobile app can be connected to a central account which manages and tracks customer preferences, usage, etc.

General Usage: Mobile ticketing apps allow for customers to manage their own accounts completely and independently. This includes one-time ticket purchases or month passes with automatic reload options. Customers can save or change their payment information for faster check-out as well. Transit systems can use such apps to provide real-time data for on route usage that helps make last minute adjustments as well as long term route improvements.

Mobile ticketing allows for reduced boarding time, as scanning a mobile ticket is significantly faster than processing cash payments with on-board fare boxes. This helps overall travel times and dwell times while keeping routes closer to schedule. For transit providers, they are able quickly and easily update fare costs and types which is reflected instantly within the mobile ticketing app, and the use of such apps reduces the need for fewer staff, fewer vending machines and other areas of reduced maintenance costs.

For transit providers, mobile ticketing can reduce boarding times, although an emphasis has to be taken in evaluating the solutions to understand how validation of fares will occur and ensuring that the vendor solution is safeguarded against potential fare evasion.

Maturity: New and improving rapidly

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Most large-scale transit services provide an app or function for customers to utilize mobile ticketing. This can help streamline the process of fare collection, for a larger scale customer base.	Smaller transit services are starting to introduce mobile ticketing, usually as stand-alone systems.	There are limited examples of rural and remote transit services implementing mobile ticketing solutions.

Technology Lifespan: 3-5 years

Implementation Costs: Refer to Appendix G

2.2.2 Customer Information

The following table summarizes the various technology and systems that provide customer information solutions and applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
RTPI and GTFS/GTFS-RT/GTFS-Flex/GOFS	- RTPI includes the provision of various types of real-time information to customers - GTFS and its subsidiary feeds are standards transit providers use to publish data for 3rd-party developers
Trip/Itinerary Planners	- Support customers to plan their trips through transit service provider websites by showing schedule time, fare and route to desired destination
Wayside Next Bus Signage	- Display information related to transit schedule and service within a transit shelter or bus stop
Mobile Apps	- Support customers to plan their trips through mobile applications that show various modes, real time traffic and estimated travel times - Draws data from RTPI and GTFS-RT to provide accurate information to riders

2.2.2.1 RTPI and GTFS/ GTFS-RT/ GTFS-Flex/ GOFS

Description: Real Time Passenger Information (RTPI) provides accurate information on departure and arrival times and service disruptions, allowing customers to plan more efficient trips. Real-time prediction system typically calculates the real-time arrival at upstream stops/stations. Traditionally, the information sent to customers by a Real Time Passenger Information (RTPI) system has been generated by a computer-aided dispatch/automatic vehicle location (CAD/AVL) system.

Many transit agencies provide data feeds to 3rd-party developers, who in turn can use the data to create traveller information tools (including mobile apps, websites, dynamic signs, etc.).

The most common of these data feeds is the General Transit Feed Specification (GTFS) and its subsidiary feeds, GTFS-RT (real-time). The General Transit Feed Specification is an open data format that allows transit systems to provide scheduled (GTFS) service information and real-time (GTFS-RT) updates.

There are also newer standards, GTFS-flex and the General On-demand Feed Specification (GOFS), both with limited implementations, that provide future potential for data feeds specific to on-demand and specialized transit services.

General Usage: Most scheduling system vendors will provide a GTFS feed, and CAD/AVL vendors will provide a GTFS-RT feed. For transit providers, the potential is to use the Real Time Passenger Information to improve customer confidence in the system and the overall customer experience. Providing up-to-date information about certain trip making decision factors such as current arrival time and departure time, allows users to best plan their trips. Such information is usually then displayed on technology such as wayside next bus signage. Alternatively, if there is a case of an unfortunate delay for example, a customer would be able to see such delays and plan accordingly. Providing open data to vendors allows for third parties to create and provide tools that support transit without requiring further investment from the municipality.

Maturity: Mature, with proprietary RTPI feeds decreasing in prevalence as GTFS and GTFS-RT improves in feature availability. GTFS-flex and GOFS are newer standards.

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Most medium and large transit services provide a GTFS feed, but few provide a GTFS-RT feed. Many provide RTPI through proprietary (non-standard) systems. There are no implementations of GTFS-flex.	Many small transit services provide a GTFS feed, but few provide a GTFS-RT feed or have RTPI for customers.	Some rural and remote transit services provide a GTFS feed.

Technology Lifespan: 5-8 years

Implementation Costs: Refer to Appendix G

See: Appendix I: Case Study- Implementing GTFS in Norfolk County without Traditional Transit Technology (Municipality of Norfolk)

2.2.2.2 Trip/Itinerary Planners

Description: Trip planning tools offer customers suggested trip plans based on an address or business name to deliver customers to their destination within their desired drop-off time. Trip planners indicate where bus stops are, route numbers, transfer points and sections of a trip that will require walking or alternate forms of transportation. Some trip planners tell customers the fare that one needs to pay for the trip. They are typically integrated to a transit operator’s website, mobile app, or phone system.

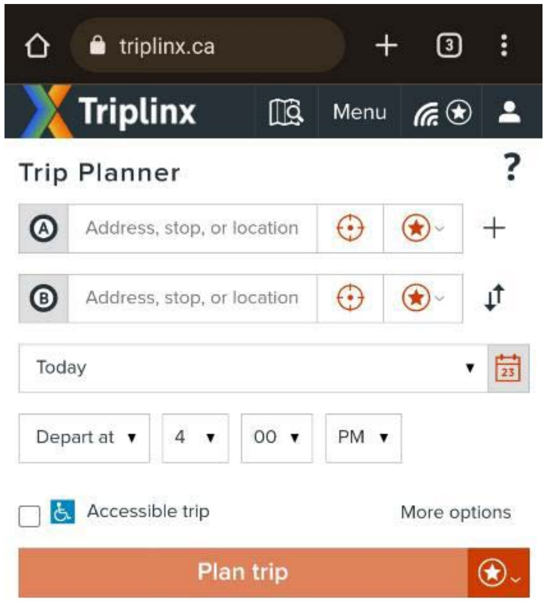

FIGURE 16: SCREENSHOT OF A TRIP PLANNING MOBILE APPLICATION

General Usage: Trip planners support customers on making trip decisions, especially for those who may not be familiar with the transit system. This can help by reducing the load on customer service departments. The use of GTFS makes trip planning possible when using google Maps.

Maturity: Mature, however the value of dedicated trip planners has diminished with the emergence of free third-party tools and mobile applications.

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Usually have their own trip planning tool platform, although the value has diminished with the emergence of Google trip planning and other free third-party tools.	May have proprietary tools. The value has diminished with the emergence of Google trip planning and other free third-party tools.	May have proprietary tools. The value has diminished with the emergence of Google trip planning and other free third-party tools.

Technology Lifespan: 2-5 years

Implementation Costs: Refer to Appendix G

2.2.2.3 Wayside Next Bus Signage

Description: Wayside next-bus signage includes digital media that displays information related to the schedule and service. These signs are typically installed within a transit shelter or on a stop pole. They require an on-site power source as well as a sign controller. These signs allow for effective communication of timely information to customers at bus stops and transit hubs. Wayside signs typically use real-time data generated by CAD/AVL software to tell customers when buses are expected. In some cases, municipalities are able to integrate 3rd party electronic signs with a real-time data feed.

General Usage: This allows for customers to receive updates while waiting for their bus and keep customers informed through signage about arrival times and potential delays. In addition to providing customers upcoming bus departure times, they can also provide additional information such as time, temperature and updates regarding interruptions to the service.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Very commonly deployed by large transit services at bus stops and stations with higher passenger volumes.	Due to the cost, smaller municipalities may choose to install them at main terminals or bus centres instead.	Unlikely to provide significant benefit, as these areas do not have the passenger volumes warrant the investment. Requires supporting electrical and IT infrastructure which may not be readily available.

FIGURE 17: NEXT BUS SIGNAGE INSTALLED INSIDE A TRANSIT SHELTER

Technology Lifespan: 8-12 years

Implementation Costs: Refer to Appendix G

2.2.2.4 Mobile Apps

Description: There has been an increase in transit applications for mobile devices in recent years. Apps can be commissioned by transit systems or, more commonly, created by third-parties based on readily available open data. Mobile apps can help with trip planning, provide real-time updates, current service alerts, understanding fare rules, etc. Customers may use the app before, during, or after their trip. Such apps can also be used as an avenue to provide feedback on service.

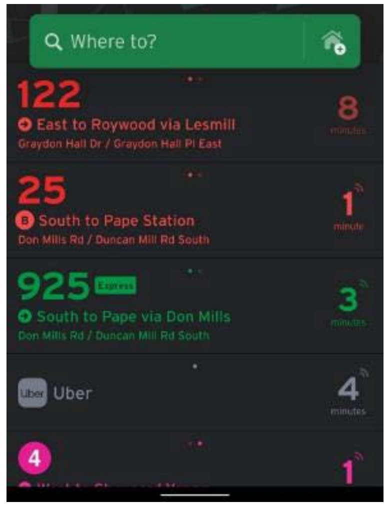

FIGURE 18: A SCREENSHOT OF TRANSIT APP SHOWING HOW SEVERAL TRANSIT SERVICES, INCLUDING UBER RIDE-HAILING ARE INTEGRATED INTO THE PLATFORM.

General Usage: Mobile apps can improve the customer experience as they provide alternative ways for customers to access information and understand the service.

Maturity: Mature, with custom applications for specific transit systems decreasing in prevalence as other third-party applications improve in proliferation and available features.

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Most large systems have numerous apps either commissioned or provided through third-parties. However, commissioned apps are becoming less common due to the proliferation of third-party applications (e.g., Transit, Google Maps, etc.). The lack of standardization among various Apps makes it confusing for riders and can be a barrier to attracting new transit ridership.	Most small municipalities have numerous apps provided through third-parties, although some may have organization-commissioned apps as well. However, commissioned apps are becoming less common due to the proliferation of third-party applications (e.g., Transit, Google Maps, etc.)	Rural and remote transit services are less likely to have their own transit app, although there may be third-party apps if the organization provides open data.

Technology Lifespan: 2-4 years

Implementation Costs: Refer to Appendix G

2.2.3 Mobility-As-A-Service (MAAS)

Technology	General Use
Mobility-As-A-Service (MAAS)	- Provide customers a seamless travel experience through tools and technology that enable customers to plan and pay for multi-modal trips

Description: Mobility as a service (MaaS) is a type of service through a joint digital channel that enables customers to plan, book and pay for multiple types of mobility services. This is enabled by technology that combines transportation services from public and private transportation providers through a unified platform that creates and manages trips, which users can pay for with a single account.

General Usage: MaaS offers a one-stop shop that provides a traveller with all possible mobility alternatives to make a trip from point A to point B. It provides the information that facilitates travel. MaaS approach considers the entire door-to-door journey of all the modes a customer might use for their trip. Using MaaS is most likely done through a mobile app, where customers can plan and book the multi-modal trip and pay for the trip in one integrated fare. As such, this approach needs to be supported by policy and partnerships with their transportation services outside of the municipality. MaaS should be considered in a way that connects regional and supports cross-border movement including inter-city transportation. Transit providers should look to do this in partnership with other services. The potential value of MaaS is highest when more service providers are included. An example of MaaS: customer takes a bikeshare from near their home to the BRT station, ride the BRT and then take a ride-hail to complete the last leg of their trip to their destination.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Limited deployments exist in North America.	Very limited to no deployments.	Very limited to no deployments.

Technology Lifespan: N/A

Implementation Costs: Refer to Appendix G

2.2.4 Customer Service Systems

The following table summarizes the technology and systems that provide safety and security systems applications. Detailed information of each technology is provided in the sections below. While not considered a 'Transit Technology', this section provides some information regarding enterprise-wide telephony and Customer Relationship Management (CRM) systems that many transit providers employ.

Technology	General Use
Phone Systems	- Enable customer service through automated call response or interactive voice response systems that provide callers with information and call options
Customer Relationship Management (CRM)	- Enable efficient customer service through automation of workflow processes and enhanced reporting

2.2.4.1 Phone Systems

Today, while many businesses rely on digital switches to provide reliable voice connectivity for employees with desk phones, the rise of IP-based systems and unified communications, telephone systems are now also providing computing and telephony integration, enabling calling from computers, email alerts with voicemail audio file attachments, and end-user call control. This allows businesses to take advantage of all the benefits that unified communications have to offer. Such systems should have a redundancy or backup plan if they go down.

There are two main types of telephone system architectures: locally hosted and cloud-hosted. With a locally hosted system, all components are installed on site at the customer's location. This can be either a premise-based solution where all equipment is housed in one location (e.g., an office), or a distributed solution where different parts of the system are spread out across multiple locations (e.g., branch offices). A cloud-hosted system is delivered as software as a service (SaaS) over the Internet from a third-party provider's data center.

Most larger call centres also have an Automatic Call Distribution (ACD), Interactive Voice Response (IVR) and call/line recorders integrated to their phone system.

- ACD systems are a key element in providing customers with a consistent experience when calling in for information, or to provide feedback. They also provide insight into agent and system performance through metrics that include such items as average hold time, and average call handling time. ACDs can streamline customer care processes by automatically routing calls to the appropriate agents, whether it be skills based, or language or other possible dimensions.

- Interactive Voice Response (IVR) is an automated phone system feature that interacts with callers and gathers information by giving the customer choices from a menu. It then performs actions based on the answers of the customer through the telephone keypad or voice response. IVR can also be used through integration with CAD/AVL systems to provide a self-serve capability, enabling callers to better plan their journeys by checking on the next vehicle arrivals or schedules for stops. IVRs are also used to notify Para-Transit customers of upcoming reservations and vehicle arrivals.

- Call/line recorders are hardware and software that tap into a phone line (usually multiple lines or channels) and records or monitors calls.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large communities have robust call centres capable of handling customer inquiries and numerous other features.	Small communities may depend more significantly on the phone systems provided universally for all community services, and may have fewer transit-specific applications (like arrival times via IVR).	Rural and remote communities may depend on relatively simple phone systems available throughout the community with limited to no transit-specific features.

Technology Lifespan: 8-12 years

Implementation Costs: Refer to Appendix G

2.2.4.2 Customer Relationship Management (CRM)

Description: Customer Relationship Management (CRM) software is used to manage transit providers' relationship and interactions with all its customers. CRM systems start by collecting customer data such as email, telephone or social media information, and it can store personal details such as a complaint or personal preferences. The CRM organizes such information to give transit providers a complete record of individuals and groups overall to better understand customer relationships over time. Many CRM platforms also connect to other business apps that help transit providers to develop customer relationships.

General Usage: Customer Relationship Management (CRM) helps supports the management of customer interactions and relations. The system tracks reported complaints, inquiries and compliments from customers and supports workflow assignment to ensure customer concerns and related information are managed appropriately. As technology and social media usage grow among customers, CRMs provide a good opportunity to document and investigate customer concerns collected from various formats (e.g., phones, websites, social media). It is important to note that CRM systems handle various personal information of customers. As such, during implementation of CRM systems, it is important for transit providers to meet the Municipal Freedom of Information and Protection of Privacy Act (MFIPPA) obligations related to storing and handling personal information of customers.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large transit systems may have a larger customer base and as a result deal with more complaints/compliments daily. This technology would be appropriate for large transit systems.	Seldom deployed. Customer inquiries are typically managed through a call centre with an internal database (spreadsheets) that keeps track of call logs.	Rural and remote transit services may not deal with as large of a customer base as larger transit systems, and therefore may not depend on such technology, but rather a more manual process.

Technology Lifespan: 8-12 years

Implementation Costs: Refer to Appendix G

2.2.5 Other Customer Experience Technologies

The following table summarizes the various technology and systems that provide additional customer experience solutions and applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Wayside Public Address Systems	- Allow direct and one-way communication of information to customers through announcements
Passenger Wayfinding Technology	- Connect with certain mobile applications through Bluetooth beacons to provide wayfinding information in visual and audible formats
On-board and Wayside WLAN	- Provide internet access on-board vehicles, in stations or at bus shelters to customers
On-board and Wayside Infotainment	- Provide information (e.g., next stop, weather, traffic, etc.) in high-quality digital displays to customers in various formats

2.2.5.1 Wayside Public Address Systems

Description: Wayside public address (PA) systems allow for direct communications to customers and can be used for both emergency and scheduled information. Public Address Systems use a combination of microphone and speakers to make announcements in places such as stations. These systems can be made accessible to those with auditory impairments using digital signage. Similarly, wayside signage should include an accessibility element to ensure that people with visual impairments can obtain information for the signage.

General Usage: Transit systems use wayside public address systems to notify customers of overall service changes, delays and updates as well specific route or trip delays or arrival times. This allows for customers to stay up to date on their trips.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
PA Systems are very common and provide most value in stations and terminals with a large flow of customers.	Small transit services are less likely to find value in implementing a PA system, except at a major terminal or hub where transfers are made.	Unlikely to provide significant benefit, as stops and stations do not have the volume of customers to provide benefit.

Technology Lifespan: 10-15 years

Implementation Costs: Refer to Appendix G

2.2.5.2 Passenger Wayfinding Technology

Description: There is an emergence in passenger wayfinding technology that uses Bluetooth LE (Low Energy) beacons to support navigation within a physical area. The technology requires the customer to have an enabled mobile device and supporting app that allows them to connect with the beacons to receive and listen to information.

General Usage: This technology can provide customers, particularly those with visual or cognitive disabilities, with proximity-based wayfinding information, notification, or obstructions, and guidance to fare payment devices or emergency call boxes and can also help customers who are unfamiliar with the system or specific routes.

Maturity: New

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
There are pilots of the technology being undertaken at limited locations, typically large terminals or stations with complex wayfinding.	There are no implementations for this technology.	There are no implementations for this technology.

Technology Lifespan: 2-5 years

Implementation Costs: Refer to Appendix G

2.2.5.3 On-board and Wayside WLAN

Description: Some transit systems have implemented wireless local access networks (WLAN) for customer's on-board or at stations/stops. Internet is a key enabler of many technologies, including the ones that customers rely on for navigating such services. Public WLAN allows for more equitable access to such apps and other internet-dependant technology, especially for those who may not be able to afford data required for transit service apps or mobile ticketing for example.

General Usage: Public WLAN at stations or stops can provide equitable access to trip planning tools and applications needed prior to boarding vehicles. This allows for customers to stay informed on service updates, changes and can provide additional options for fare collection. Installing fiber along a dedicated transit facility (e.g. rapid transit line) can be been done as a 3rd-party commercial program to generate revenue while introducing WLAN at transit stations.

Maturity: Mature, but decreasing in prevalence

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
While it was once common for large transit systems to provide WLAN on-board and wayside, the proliferation of high-speed cellular data is decreasing the utility of providing this service to customers.	While it was once a common feature to explore in smaller communities to increase ridership, the proliferation of high-speed cellular data is decreasing the utility of providing this service to customers. Unlikely to provide significant benefit.	Not common in rural and remote areas due to the costs and complexity. Unlikely to provide significant benefit.

Technology Lifespan: 4-6 years

Implementation Costs: Refer to Appendix G

2.2.6 On-board and Wayside Infotainment

Description: On-board and wayside infotainment relates to the installation of high-quality digital displays on the vehicle or at key locations. The displays can be configured to provide customers with a vast amount of information in different formats (video, complex graphics, etc.). Most modern infotainment products can combine infotainment (e.g., weather information, traffic information, news) along with travel information (e.g., next stop, estimated travel time).

General Usage: Installing a new digital signage system can help provide customers with improved travel information. Such infotainment attracts more attention compared to traditional signage because of its ability to rotate content, animate and its video capabilities. Additionally, some infotainment can bring in additional advertising revenue. Such technology can be better utilized through targeted content display. This allows for content to be easily changed and triggered depending on the time of day, day of the week, location, etc. providing timely and relevant information.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
More commonly used in key transfer stations and more limited cases of on-board installations due to the cost and limited revenue potential.	Unlikely to provide significant benefit due to the cost and limited revenue potential.	Unlikely to provide significant benefit due to the cost and limited revenue potential.

Technology Lifespan: 4-8 years

Implementation Costs: Refer to Appendix G

2.3 Service Planning

Service planning functions depend on quality data and robust systems to manage, report and validate that data. Within this section, technologies are discussed that support planning and preparing critical information for operations.

2.3.1 Route and Network Planning

The following table summarizes the various technology and systems that provide route and network planning applications. Detailed information of each technology is provided in the sections below.

Technology	General Use
Performance Analysis Reporting Tools	- Integrate available data from different systems to enable analysis of historical trends (e.g., reconciling fares with ridership, on-time performance, etc.)
Geographic Information Systems (GIS)	- Support the planning and modification of transit routes through mapping and analysis of ridership and demographic trends
Integrated Planning Platforms	- Incorporate historical data with geospatial analysis tools to analyze proposed route scenarios and requirements to support transit planning

2.3.2 Performance Analysis Reporting Tools

Description: Historical performance reporting tools allow communities to review historical trends and reconcile important information such as fare collection information with ridership or ticket sales. Tools can range significantly in complexity and sophistication, with the simplest systems built within spreadsheet software to track and report on manually collected data, and the most advanced automatically collecting and integrating datapoints from several technology systems. Reporting tools could be as simple as Microsoft Excel spreadsheets or Access databases, or as complex as SAP Crystal Reports, Clever Devices Ridecheck Plus, or the custom tools developed by transit CAD/AVL vendors.

FIGURE 19: HISTORICAL PERFORMANCE REPORTING TOOL

General Usage: Historical performance reporting is critically important to ensure that communities can appropriately plan and improve their transit services. Transit systems have varying levels of customization available within their specific systems, and generally work to tailor the reporting systems and processes to provide metrics that meet their needs. The level of skill required to customize reports varies depending on the system employed; spreadsheet-based systems are relatively easy to customize with standard software literacy where more complex systems may require experience with data query structures and database languages.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large transit systems frequently deploy integrated reporting tools that combine historical and planned data from several sources. These could include custom-built applications, industry-leading reporting tools, or those provided by transit ITS vendors.	Small municipalities often have limited reporting capacity provided through standard off-the-shelf tools or simple in-house built applications. Smaller transit systems may wish to consider databases in Microsoft Excel or Access which are frequently leveraged with data imported or entered manually from other sources.	These communities have very limited reporting capacity and may only document historical information for simple trend tracking. These communities rarely have sophisticated reporting tools and depend on Microsoft Excel for their reporting needs.

Technology Lifespan: 2-5 years

Implementation Costs: Refer to Appendix G

2.3.2.1 Geographic Information Systems

Description: GIS technologies can allow communities to design and modify transit routes, identify and track infrastructure including bus stop locations and major facilities, and perform geospatial analysis that incorporates local contextual information. GIS are deployed for a wide variety of municipal functions and often find significant applications within transit to support planning and asset management functions. While many transit systems depend on enterprise deployments of GIS software solutions such as Esri's ArcGIS, there are also entirely open-source tools such as Quantum GIS (QGIS).

General usage: Planners often use GIS to identify ridership and demographic trends within the transit service area, plan transit services for existing and new developments, and appropriately locate new transit infrastructure including all manner of assets from simple concrete pads at bus stops to new dedicated transit facilities and right-of-way.

While most small and large transit services likely have in-house capacity or shared municipal services to support GIS analysis, rural and remote communities may have a more limited skillset available to support GIS analysis. The skillset has become commonplace in many relevant college and university programs, and while the technology is mature, it will remain a growing area of expertise for communities across Ontario. Many municipalities have GIS technology, and adding transit (routes, service, stop locations) will assist with asset management and customer information.

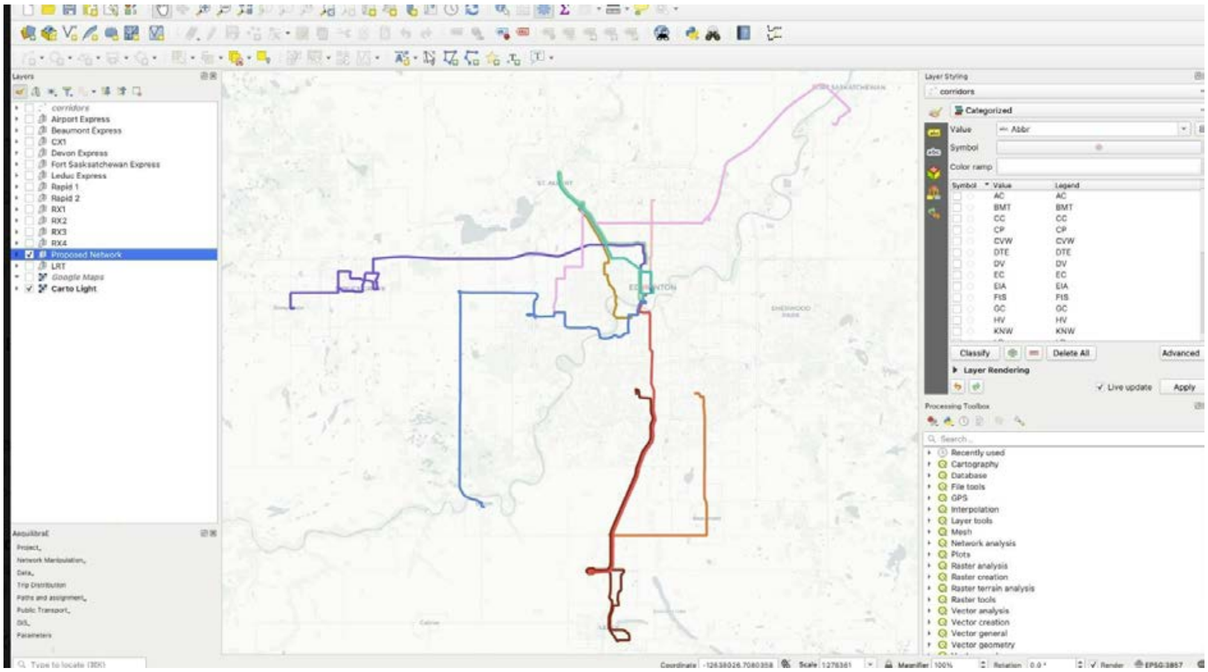

FIGURE 20: A SCREENSHOT OF QGIS, A GEOGRAPHICAL INFORMATION SYSTEMS SOFTWARE

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large transit systems and communities frequently have several staff on hand for managing and maintaining GIS databases. Planning staff often leverage these tools for detailed analysis and communications staff can leverage these tools to develop customer information materials. Most large communities have an enterprise-level GIS solution	Small municipalities often have access to GIS resources, either through internal staff or shared resources from the upper-tier municipality. With the proliferation of open-source GIS tools, small municipalities could more readily adopt desktop GIS for analysis and asset management.	While rural and remote transit services may not have internal capacity to maintain GIS data and produce analysis, most communities leverage a GIS solution for asset management. Transit services could adopt the municipal GIS solution to support transit asset management.

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
including web-GIS platforms.		

Technology Lifespan: 5 years (Most desktop subscriptions are changing to an online subscription basis)

Implementation Costs: Refer to Appendix G

2.3.2.2 Integrated Planning Platforms

Description: These platforms incorporate the sophistication of historical and real-time reporting with live dashboards and geospatial analysis tools. Many of these systems are offered as subscription-based Software-as-a-Service (SaaS) platforms where pricing is done by number of vehicles and leverage open data standards such as General Transit Feed Specification (GTFS) and GTFS-realtime to minimize the need for complex data integrations.

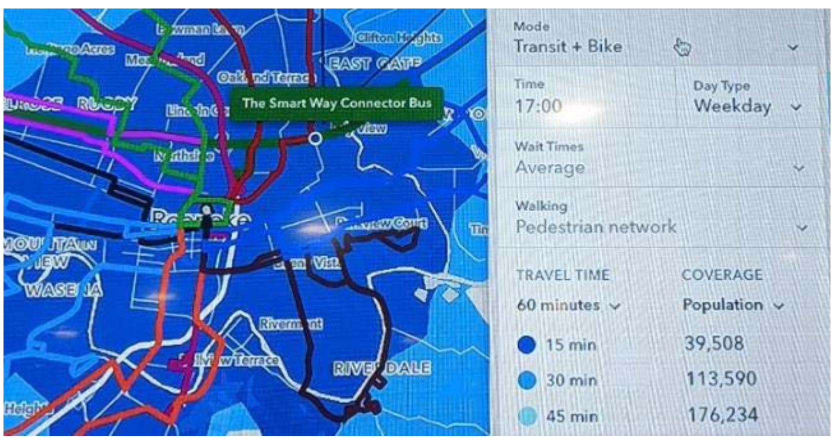

FIGURE 21: AN INTEGRATED PLANNING PLATFORM SHOWING SEVERAL DATA LAYERS WITH MULTIPLE MODES THAT SUPPORT PLANNING EFFORTS

General Function: Planners have historically depended on separate data sources and complex, in-house data integrations to incorporate information into analysis tools such as GIS platforms. These integrated planning platforms allow planners to bypass many of the data transformations that were previously required and can allow for the design and analysis of various scenarios with relatively minimal effort. Some solutions are capable of making data-driven recommendations for scheduling changes while others allow for complex impact assessment based on publicly available demographic data, such as local census information. These platforms help to visually show a service/route proposal in a consistent form. It can also automatically calculate annual service hours and fleet requirements. Due in part to their cost and otherwise in part to their dependence on significant data integration, the platforms are marketed primarily to larger urban metropolitan areas and municipalities that have a robust set of data sources available for integration. They generally have little benefit for smaller communities that may not have these datasets available.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
While relatively new to the industry, large municipalities are increasingly adopting the use of online integrated planning platforms to enhance their analysis. Most large communities have established a relationship and processes with providers, or are in the process of piloting these technologies.	Very few smaller communities have the robust data sources necessary to make the most effective use of these platforms. Additionally, at the time, the subscription-based model tends to be an operational expense that is out of reach for these communities.	These communities are unlikely to derive much benefit from these tools as they are presently marketed to medium and large communities. Additionally, at the time, the subscription-based model tends to be an operational expense that is out of reach for these communities. However, those communities with good data on residents and their travel patterns may still benefit from such technology.

Technology Lifespan: 3-5 years

Implementation Costs: Refer to Appendix G

2.3.3 Transit Scheduling

The following table summarizes the various technology and systems that provide transit scheduling applications. Detailed information is provided in the sections below.

Technology	General Use
Fixed Route Scheduling Software	- Enable the development of fixed-route transit schedules
Runcutting Optimization Software	- Convert transit schedules to create operator shifts (called runs) that operators can work within reasonable constraints - Runcutting software is typically integrated with transit scheduling software
Automatic Passenger Counters (APC)	- Count number of customers boarding and alighting the vehicle to provide ridership and real-time crowding information

2.3.3.1 Fixed Route Scheduling Software

Description: Transit services depend on reliable and fixed schedules to ensure that customers are aware of when to expect transit services, and so that drivers know the paths and the time required to travel along the transit route. Transit schedules can have a significant impact on the perceived performance of transit service, and must be developed accurately and within close tolerances to ensure a reliable experience for customers. Sophisticated solutions exist as both desktop and browser-based solutions.

Additionally, there are also “scheduling-as-a-service” models where a third-party produces transit schedules on behalf of a transit operator. Finally, relatively simple transit services can easily be scheduled manually using conventional spreadsheet software utilizing field data for travel time calculations.

FIGURE 22: A SCREENSHOT OF FIXED ROUTE SCHEDULING SOFTWARE DISPLAYING HOW TRIPS CAN BE BLOCKED INTO VEHICLE-SCHEDULES

General usage: Transit schedule data is critical primarily for customer information and as an an operations aid to ensure that services are operating reliably and consistently. However, as transit services and their supporting technologies become increasingly complex and sophisticated, transit schedule data becomes increasingly critical. Transit schedules frequently become cornerstones of other datasets and systems, including real-time information, fare collection, ridership, schedule adherence monitoring, operator payroll and many others. As a result, large transit systems integrate their transit scheduling solution directly into other downstream systems, including CAD/AVL systems, fare collection systems, workforce management and payroll systems, customer information systems, operator sign in and sign off for payroll purposes and many others.

In smaller communities, transit schedules increase in importance the more technology systems that are deployed. However, even in relatively modest, multi-route systems, it is possible that communities leverage spreadsheet technology to produce the schedules that are then imported into these systems.

Ultimately, communities of all sizes still produce and publish schedules to inform customers and drivers of where and when they can expect a bus to arrive while service is operating. The raw schedules that are produced, either through sophisticated software or through simple spreadsheets, are then converted into public information for customers and guides for operators.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large communities depend on a robust scheduling solution to accurately track and maintain all transit schedules, routing and specific connections. Large transit systems also depend on the scheduling software for downstream customer information, fare collection systems and CAD/AVL systems, among others.	Smaller communities depend on a schedule. However, how that schedule is developed is more variable. Some transit systems simply create schedules manually using spreadsheet tools, and manually import them into other systems. Others use dedicated scheduling platforms. Increasingly, and as staff retire, smaller communities are turning to third-party contractors to produce schedule data on their behalf.	These communities would derive little benefit from a dedicated scheduling platform, unless their services are complex and far-reaching regional services. Even in these instances, such services would likely be scheduled by a third-party contractor, or otherwise built out using conventional spreadsheet tools.

Technology Lifespan: 5-10 years

Implementation Costs: Refer to Appendix G

2.3.3.2 Runcutting Optimization Software

Description: Runcutting is the process by which transit schedules are manipulated into shifts (called runs) that operators can work within reasonable constraints, including those imposed by labour laws and collective bargaining agreements. Transit systems must ensure that service is covered by valid runs while optimizing to minimize various parameters, such as overall cost and the number of operators required.

In all cases, runcutting optimization software is directly integrated with the transit scheduling solution and is not suitable for services that schedule manually.

General usage: Historically, the process involved significant, time-consuming iteration to ensure that all transit service was covered by valid runs. Software solutions have since been developed that allow transit systems to rapidly generate solutions and optimize those solutions based on various parameters. These tools allow large and complex systems to analyse the impact of relatively minor changes to optimization parameters on overall costs, operator requirements, and other characteristics. This provides a greater degree of flexibility for transit systems to evaluate how service impacts may affect overall costs, while also limiting errors of manual runcutting that might inadvertently create invalid runs.

While the runcutting process is a heavily scrutinized and complex optimization activity, the process is not necessary in all instances. Specifically, transit systems that contract service delivery to a third-party frequently are not required to create runs since it is the third-party operator who is responsible for assigning operators to serve the routes appropriately. As a result, runcutting optimization tools are often not required for transit systems that contract transit service.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large communities providing transit service directly (as opposed to those who contract service delivery to a private operator) will depend heavily on runcutting optimization software to ensure that runs are valid according to labour rules while also minimizing costs to deliver service.	These communities are unlikely to derive benefit from this software since they either (a) have relatively simple services that can be runcut manually or (b) they contract service delivery to a third-party, who would be responsible for assigning operators to deliver the service.	These communities are unlikely to derive benefit from this software since they either (a) have relatively simple services that can be runcut manually or (b) they contract service delivery to a third-party, who would be responsible for assigning operators to deliver the service.

Technology Lifespan: 5-10 years

Implementation Costs: Refer to Appendix G

2.3.3.3 Automatic Passenger Counters

Description: Automatic Passenger Counting (APC) systems include on-board and central system technologies that support real-time crowding information and historical ridership trend analysis. On-board technologies include some form of counting system (light-beam or camera) as well as integration with the on-board CAD/AVL system for location and initial data processing. Once vehicles return to the depot, data is uploaded and then processed to ensure that count information is accurate. Generally, algorithms process raw data on the assumption that a vehicle never leaves or returns to the garage with customers on-board, so any discrepancies that violate this assumption are handled through a data cleansing algorithm. The algorithms that process the data are verified by manual counts during the deployment process, and occasionally re-verified to ensure continued accuracy.

Historically, the technology was expensive and reserved for the largest transit systems, and—even then—only a portion of the fleet. However, the technologies and algorithms are growing both more sophisticated and more accessible, and transit services in smaller communities have begun exploring the technology.

FIGURE 23: A SELECTION OF AUTOMATIC PASSENGER COUNTERS (APC)

General usage: APC systems have become invaluable sources of data for many transit systems as they strive to better understand ridership behaviour and detailed trends in demand. Historically, the primary purpose of APC systems was to provide historical ridership data to planners in support of service design and planning activities. However, since the COVID-19 pandemic, customers and operators have grown to depend on real-time ridership information to make travel planning decisions and operational adjustments. Customers have leveraged crowding data to make adjustments to their travel behaviour, and transit systems have begun to leverage crowdsourced information from applications like Transit App to help verify APC accuracy. Supervisors are also finding opportunities to leverage real-time ridership and crowding information to make decisions on service adjustments, such as short-turning and adding vehicles to routes where crowding information warrants a change.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
These services depend on accurate ridership information for many planning functions, while increasingly providing this data to customers in the form of real-time crowding information. While some transit systems may only equip a portion (between 20-50%) of their fleet, with the cost of the technology decreasing in recent years, many are opting to fully equip their vehicles.	Smaller communities may not have the levels of ridership that may necessitate the use of APCs rather than periodic manual counts or farebox data. However, since the technology has decreased in cost in recent years, and fleet sizes are relatively small, these communities are increasingly adopting the technology to support improved data analysis.	Services that equip all fixed-route vehicles with APCs can benefit from such technology in terms of determining where new stops should be located or where existing stops should be moved.

Technology Lifespan: 15 years

Implementation Costs: Refer to Appendix G

2.4 Maintenance

The following table summarizes the various technology and systems that provide maintenance applications. Detailed information is provided in the sections below.

Technology	General Use
Asset Management Software	- Support the management of assets (e.g., fleet and maintenance equipment) by storing a database of information (e.g., age, purchase price, stocking levels, etc.)
Vehicle Monitoring System	- Monitor and collect data on vehicle performance and health to inform maintenance processes
Electric Vehicle Management and Battery Health Monitoring Systems	- Provide data to determine charging strategies by monitoring EV mileage, battery usage

2.4.1 Asset Management Software

Description: Fleet and Facility Maintenance for transit systems is critical for keeping vehicles in working order and ensuring that customers reach their destinations safely. The evolution of asset management software has allowed transit systems to move from manually tracking information to using fully integrated software suites with embedded artificial intelligence (AI). This allows workorder management to be transitioned from being manually initiated to being automated, based on predictive models that consider such inputs as the condition of each vehicle, mileage and failures of components on other similar vehicles as well as time-based maintenance activities.

With the availability of IoT devices and lower-cost, pervasive wireless communications networks, vehicle monitoring can also now be done in real-time, enabling maintenance staff to receive alerts and take action before vehicles break down while in service, thereby reducing the impact on customers. With the explosion of available data, predictive preventative maintenance measures can be put into place so that potential issues can be corrected before they become bigger problems.

General Usage: Over the years, asset management software has evolved from general database applications to industry-specific applications, and from vendor-specific to vendor agnostic applications, enabling the software to work with all types of vehicles – (including electric, diesel and gasoline-powered buses as well as maintenance vehicles) and facilities.

From the perspective of newer technology, such as electric buses, by monitoring real-time vehicle status, battery health and charge levels, as well as charging station status for both fast chargers and slow chargers located at the depot or on route, the systems allow for optimizing vehicle usage between charges, thereby extending service delivery as well as battery life.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Most large systems employ asset management systems to manage: • Fleet Maintenance • Facility Maintenance • Fuel metering/ dispensing • Stock levels • Inform future capital planning • Asset history and tracking by barcode	Smaller systems are less likely to employ a mature asset management system, and may leverage spreadsheet applications to track services and fuel consumption.	Rural and Remote systems are less likely to employ an asset management system, and may leverage spreadsheet applications to track services and fuel consumption.

Technology Lifespan: 10-15 years

Implementation Costs: Refer to Appendix G

2.4.2 Vehicle Monitoring System

Technology	General Use
Vehicle Monitoring System	- Monitor and collect data on vehicle performance and health to inform maintenance processes

Description: Vehicle monitoring systems have been present in most vehicles for years. The systems monitor and collect data regarding vehicle performance and health, including such items as engine diagnostics, fuel levels and tire pressure. These systems initially required a technician to connect equipment to the computer port on the vehicle to check alarm codes and download data.

The systems have evolved into a telematics solution, taking advantage of global positioning system (GPS) and wireless communications technologies, enabling them to track location, speed and direction of travel, and report full technical diagnostics and status back to a central server in real-time. Data is then presented to users in the form of dashboards, apps, emails and alerts.

General Usage: In transit operations, this functionality sometimes leverages systems such as CAD/AVL, with onboard computing linked through Wi-Fi and/or public cellular or other wireless networks. Initially, these systems would log data while the vehicle was out of the garage and connect via Wi-Fi or physical connection to upload data when the vehicle returned at the end of its shift. Today, with the lowering cost of digital communications for IoT devices, more data is pushed from the vehicle in real-time.

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Many, but not all transit systems have some form of vehicle monitoring systems in place. It can vary from vehicle supplier-provided tools, to 3rd party tools that provide more comprehensive monitoring.	Most transit systems have some form of vehicle monitoring systems in place, typically provided by the vehicle supplier.	Most transit systems have some form of vehicle monitoring systems in place, typically provided by the vehicle supplier.

Technology Lifespan: 8-12 years

Implementation Costs: Refer to Appendix G

2.4.3 Electric Vehicle Management and Battery Health Monitoring Systems

Technology	General Use
Electric Vehicle Management and Battery Health Monitoring Systems	- Provide data to determine charging strategies by monitoring EV mileage, battery usage

Description: Electric vehicles require regular charging to ensure continued service and optimal battery life. Depending on the vehicles' ranges, which may range from tens to hundreds of kilometres, charging may have to occur more or less frequently. Route analysis must be conducted to understand energy requirements on each route to develop charging schedules and invest in additional charging infrastructure as needed. Scheduling software with an electrification module is a tool that can enable schedulers to run various scenarios to determine the optimal charging strategy. Typically, municipalities invest in a mix of charging technologies including in-depot chargers and on-street chargers. Technologies such as battery monitoring systems can help municipalities optimize electric vehicle optimization.

Hydrogen Fuel Cell (HFC) propulsion is also an emerging zero emissions vehicle technology that provides a longer range than battery electric vehicles. Although HFC's do not require charging technology like battery electric vehicles, buses fueled by hydrogen do require fueling stations and hydrogen to be transported and stored on-site. Safety systems must also be installed to ensure any leakage can be detected promptly. Due to the challenges in transporting and storing hydrogen, and the increased cost to implement the technology, battery electric buses are the more commonly deployed zero emissions technology in North America.

FIGURE 24 - BATTERY ELECTRIC VEHICLE IN-DEPOT PLUG IN CHARGING STATION (LEFT) AND PANTOGRAPH CHARGING STATION (RIGHT)

General Usage: Systems associated with battery electric vehicles such as charging, battery and vehicle monitoring systems are useful both for supporting the planning, operations and maintenance of electric buses.

Charging technologies involve plug-in and pantograph (overhead) chargers which have varying requirements for installation, operation and maintenance. Where in-depot chargers are deployed, the bus is usually connected to the charging station via a connectorized cable, with chargers located at each parking space, either indoors or out in the yard. High-powered chargers such as pantographs are also deployed in yards of the depots, providing a faster charge for vehicles that are required to run out for a second shift.

With on-street charging, vehicles typically receive a top-up charge for less than 10 minutes to ensure service levels are maintained. To accommodate this efficiently, pantograph chargers are typically utilized for fast charging without requiring the operator to leave the vehicle.

Electric vehicles also have onboard systems that track mileage and state of charge and collect data on other vehicle performance measures such as speed, vehicle load, regenerative breaking, energy consumption and performance issues. These telematic tools can identify the root cause of issues with charging procedures, batteries and other electronic components. Battery Health Monitoring Systems are also important for monitoring the efficiencies of batteries, measuring the degradation of batteries operating on certain heavy-duty routes and seasons. Having this data helps to inform decisions around planning for replacements or utilizing more efficient charging strategies.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Many large transit services are moving towards electrification of fleet. As a result, such larger scale transit systems looking to do so may scale their resources to use such technology.	Smaller transit services in the early stages of electrifying their fleets should consider looking at these newer-to-market tools.	Seldomly deployed as rural and remote transit services may not have electric vehicles due to cost and lack of infrastructure needed.

Technology Lifespan: TBD

Implementation Costs: Refer to Appendix G

2.5 Management and Administration

2.5.1 General Business Applications

Technology	General Use
General Business Applications	- Enable inventory, processing and management of organization wide applications such as human resources, payroll and finance

Description and General Usage: Transit organizations often rely on the following general business applications which are out of the purview of this Toolkit. Many municipalities will often leverage applications that span across multiple departments or teams, including transit. Some examples of general business applications include:

- Human Resource Management
- Payroll Management

- Finance Management

Maturity: Mature

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Universal application of common office applications as well as advanced HR, Payroll and Finance Management applications.	Universal application of common office applications as well as advanced HR, Payroll and Finance Management applications often shared with other community services.	Universal application of common office applications. Some specific HR, Payroll and Finance Management applications in certain circumstances, often shared with other community services.

Technology Lifespan: 5-10 years

Implementation Costs: Refer to Appendix G

2.5.2 Analytics and Business Intelligence Tools

Technology	General Use
Analytics and Business Intelligence Tools	- Provide dashboards used for reporting on key performance indicators such as transit service standards and other organizational metrics

Description: Business Intelligence (BI) tools are a powerful extension of reporting tools that can incorporate historical and (to an increasing degree) real-time or near-real-time data. While BI tools can allow for the creation of dashboards for a wide variety of different datapoints and to support many corporate functions, they are most effective when incorporating large quantities of complex data sources. This allows users to identify historical trends and monitor performance to pre-emptively respond to changes.

FIGURE 25: ANALYTICS DASHBOARDS SHOWING STATS FOR AN ON-DEMAND SERVICE.

General Usage: Dashboards are updated periodically and can be made available to a wide variety of users, including the general public. They are often used to communicate key performance metrics easily and without significant data literacy skills to make them generally accessible to a wider audience. Often, performance dashboards are generated to support board or council reporting, but they are increasingly being utilized to investigate trends in operations at a more granular level for route and system planning.

Maturity: Improving

Appropriateness/Scalability:

Medium and Large Transit Services	Small Transit Services	Rural & Remote Transit Services
Large communities frequently have higher requirements for reporting and accountability to their overseeing government agencies or municipalities. Additionally, BI tools provide significant analytical capacity that allows large transit systems to readily digest and assess large and complex data from many different sources.	BI tools are seldomly deployed in small communities exclusively for transit usage. In very limited cases, BI tools may be used across the municipality, but transit is usually a data provider rather than a data consumer of these tools in such applications.	BI tools are unlikely to be scalable for the smallest and most remote of communities, due to their cost and complexity.

Technology Lifespan: 5-10 years

Implementation Costs: Refer to Appendix G

3 LIFECYCLE: PLANNING

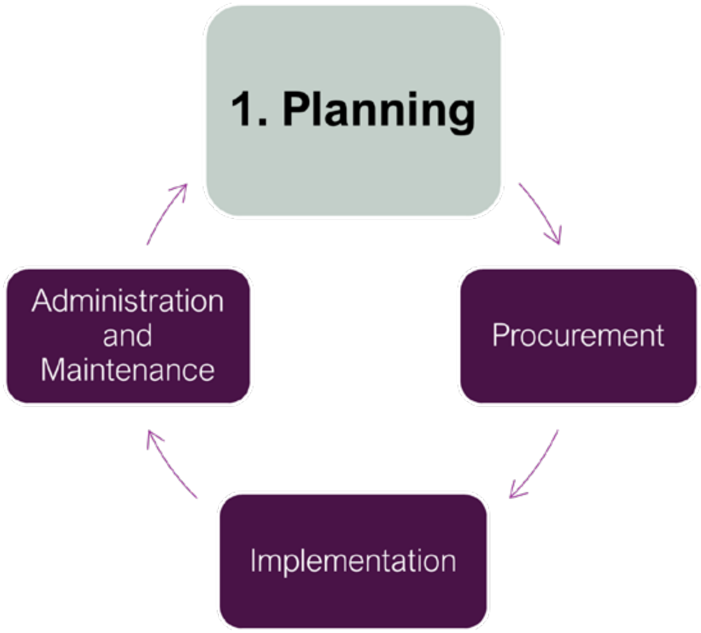

FIGURE 26: THE PLANNING STAGE IN THE CONTEXT OF THE TRANSIT TECHNOLOGY LIFECYCLE

As introduced in Section 1.3, the Transit Technology Lifecycle is a cyclical process comprised of four distinct stages.

The first stage of the lifecycle is "Planning", in which organizations evaluate their needs, weigh potential options, and ultimately make plans for the right technology or technologies to address those needs. Planning includes the following key components which are explored further in this section:

- **Needs Assessment**: working across the organization to understand and define the business needs and objectives;
- **Alternatives/Feasibility Analysis**: identifying potential options and analyzing one or more to determine the best course of action; and
- **Project Planning**: establishing a project and resources to successfully procure and implement the desired technology (or suite of technologies).

3.1 Needs Assessment

Performing a needs assessment will help you look at challenges facing the transit system or review unmet goals and define a set of needs. Simply put, a needs assessment involves collecting information on the challenges that one or more individuals face in some aspect of their duties.

Stakeholder input and "buy-in" during the assessment is essential to avoid conflict or shifting priorities later. When the results of the assessment have been documented, they will be used to explore alternatives and select the alternative that best meets the needs.

3.1.1 Meeting with Staff to Collect their Needs

Gathering needs is typically accomplished by meeting with all stakeholders/organizations that are involved in one or more related business processes to discuss their roles and experiences. In the case where there is an existing system that would be replaced, include direct users of that system, as well as users and administrators of adjacent systems.

Ensure you meet with all staff that are involved with the process, either directly or in supporting processes, to ensure that their needs are captured.

For example, in the case of daily operations management and dispatch, stakeholders include:

- Dispatchers/Controllers
- Operators
- Supervisors
- Marketing
- Customer Service
- Incident investigators
- IT System administration, infrastructure management, desktop support, service desk
- Training department

Adjacent Systems could include:

- Fixed Route Scheduling system
- Stops database/management
- Operator sign-up/workforce management system
- Asset Management system
- Maintenance/work-order
- Yard management
- Trip planners

- Management reporting
- Security/CCTV systems

3.1.2 Documenting the Needs

Exploratory discussions with stakeholders are used to uncover issues they currently experience. The discussions should focus on business issues, not technical features of the system. Discussions typically begin by asking the stakeholder to tell you about what they do, what they use to complete their tasks and what issues or problems they experience. It is important to also document what it would mean to them if the problem was resolved. Remember, at this stage, you are not attempting to solve problems, but rather to identify the stakeholder's role, their business issues and the benefits that will be realized if the issue could be resolved.

Focus on business or process issues, not the wish list of technical features of a future system.

Needs statements are sometimes referred to as problem statements, and form the basis of documenting needs. They are developed based on the point of view of the user. These statements should be concise and actionable statements that identify the user, the problem that is experienced by that user, and the impact or benefit of resolving the problem.

It is often helpful to engage a group of similar users in an exercise to provide input. Stakeholders could be asked to think about what they need and why. Several frameworks could be used for involving them, but it is often helpful to provide a group of people with "sticky notes" and ask them to fill in the blanks of a statement

A *<role>* needs to *<issue to be resolved>*, because *<benefit that would be experienced>*.

Examples of needs statements are:

- An operator, needs to locate their vehicle at the depot quickly, at the beginning of their shift, because they only have 15 minutes to start the vehicle, complete the pre-trip inspection and leave the depot if they are to meet the schedule.; or

- A mechanic, needs to locate vehicles quickly at the depot, because there is limited time to reposition, repair and/or inspect vehicles before they are required back in service.

Once several needs statements have been developed, they can be grouped or clustered based on similarity, providing potential use cases, against which to develop specifications.

Needs can also be grouped into two primary categories – Functional and Non-functional. Functional needs focus on the role that the system is to perform, while non-functional needs may include such items as cost, hardware colour, or support service levels.

Develop clear, concise statements focused on business problems, and what it would mean to specific users if the problems could be solved.

Answer the questions: Who needs what? Why?

3.1.3 Importance of Traceability

Transit technology projects can take months or even years to procure and implement. As such, it is important to document the origin of needs, so that specifications can be developed, proposal solutions can be assessed, and value can be communicated to the stakeholders.

Section 5.1.4 of this Toolkit introduces the concept of a traceability matrix that allows organizations to ensure that the original requirements of the system are carried through and validated through testing and commissioning. By ensuring this continuity of thought, the organization can ensure that the original needs that were defined by users are adequately met by the new or upgraded system.

3.2 Alternatives Feasibility Analysis

With needs identified and documented, an alternatives feasibility analysis is undertaken for comparing projects or determining which alternative to pursue. The analysis works by first defining alternatives, then identifying, measuring, and valuing the benefits and costs of each.

Alternatives may include the comparison of multiple available technologies, the ability of the transit system to support one technology over another, or one versus multiple suppliers, or even single, fully-featured and integrated systems vs disparate stand-alone systems, and may also include deployment approaches, such as full deployment, partial deployment, or staged deployments. Alternatives can be identified through research, peer interviews and brainstorming sessions with key stakeholders or subject-matter experts.

The alternatives are then scored against whether, or how well they deliver against each individual identified need. Scoring can be undertaken by one person, and reviewed with the stakeholder team, but is often less controversial when scoring is undertaken as a team activity.

A consistent approach should be used for quantifying the benefits and costs associated with each alternative.

Stakeholder input and consensus is critical to the overall viability of the selected alternative.

Scoring can be binary (quantifying 1 if meets needs, or 0 if it does not). Scores would then be tallied, with the highest scoring alternative becoming the preferred approach. Several variations can be applied to the scoring methodology, but scoring must be applied consistently across all dimensions and alternatives. Scoring of each dimension (need) could be against a scale of 0-5, 0-3, or 0-10, with several options for visualization of the analysis from tabular tallying of the total score, to spider diagrams or other visualizations

TABLE 4: SAMPLE OF AN OPTIONS ANALYSIS SCORING SHEET, WHERE THE SCORE OF ZERO TO FIVE IS ATTRIBUTED TO FOUR ALTERNATIVES RELATIVE TO THE FUNCTIONAL AND NON-FUNCTIONAL NEEDS IDENTIFIED. IN THIS CASE, THE PREFERRED ALTERNATIVE WOULD BE THAT WITH THE HIGHEST SCORE

Need	Score (0 - 5) Alternative #1	Score (0 - 5) Alternative #2	Score (0 - 5) Alternative #3	Score (0 - 5) Alternative #4
Functional Need 1	3	4	3	5
Functional Need 2	0	3	4	5
Functional Need 3	2	3	4	5
Non-functional Need 1	5	5	5	5
Non-functional Need 2	3	4	5	4
Non-functional Need 3	1	3	3	2
Total Score	**14**	**22**	**24**	**26**

Typical factors for evaluation would include all identified needs:

- Operational functional needs, and
- Non-functional needs, such as:
  - Adherence to budget
  - Impacts on schedule
  - Regulatory issues
  - Corporate preferences
  - Level of risk

3.3 Turning Plans into Projects

Once organizations have established a need and determined the preferred alternative at a high level, the next step is to formally establish a project. This includes defining budget requirements, timelines, and establishing a project team to advance the initiative forward.

It should be noted that different organizations have different requirements and expectations around project planning and approvals. As such, be sure to spend time working with your senior leadership to understand the specific elements of relevance to your project.

3.3.1 Budget Planning

Technology procurements and implementations are typically paid from organizations' capital budgets. Once a system is in place, on-going support and warranties are covered through operating budgets.

Technology costs can vary dramatically according to many factors. The key factors include:

- **Scope and complexity** – which system or systems are sought; what integrations are required;

- **Size** – how big is the implementation and if vehicles are involved how big is the fleet;

- **Customization** – is the application being sought readily available off-the-shelf, or will it need to be custom built? Are the requirements general to the industry or unique to the transit system?

Different models can be researched for cost estimating. The one thing they have in common is that cost estimates at an early stage should be presented with appropriate buffers or contingencies to reflect a lack of certainty. After procurement is complete, and as you move forward with your project, you will be able to provide increasingly more confident estimates.

Cost estimates at an early stage should be presented with appropriate buffers or contingencies to reflect a lack of certainty.

Developing budgets for technology projects can be challenging, especially for organizations with limited previous experience. It is important to follow good budgeting principles when estimating the type and level of resources required for a project to meet its objectives and resist the urge to 'back-in' predetermined values. This can occur when organizations are unable to determine the actual required effort because of a lack of understanding. Alternatively, estimates are sometimes inflated to reach a known value or to serve as a protection against uncertainty in the project, which may better be addressed by considering contingencies.

To support organizations with preliminary budgeting, Appendix G: Budgeting Tables is provided for different technologies. You can use these to support your research, but we suggest you take additional steps to get a sense of how much budget your specific initiative may take. This can include:

- **Vendor discussions** – you can speak with vendors informally at trade shows or hosted demos and they are usually willing to provide early estimates. Remember to speak to multiple vendors to get a clear picture of what the implementation could cost, and recognize that when they see a formal procurement document with specific details and commitments their numbers will almost certainly change.
- **Peer discussions** – ask peer agencies of a similar size about their costs and lessons learned.
- **Metrolinx Transit Procurement Initiative** – Metrolinx has established contracts with vendors, including for technology implementations, that can be leveraged by Ontario agencies. Agencies can connect with the Metrolinx TPI to obtain additional information and more detailed cost estimates for internal planning. Agencies will need to work with Metrolinx to scope the project and develop the requirements. While the joint procurements can be more complex and time consuming to set-up and require some compromise in terms of requirements, joint procurements can help to obtain better pricing from vendors.

3.3.2 Project Financing

Alongside budget planning, organizations should consider how projects will be paid for. Some of the mechanisms more commonly seen in the Ontario market are:

- **Municipal/transit operator budgets** – this includes projects paid from the general coffers of the organization that are funded by local taxpayers;

- **Gas Tax funding** – transit systems have considerable flexibility to use their annual allocations of Gas Tax funding toward operating and/or capital expenditures. The main focus of the program is on expenditures which help systems to grow their ridership;

- **Federal, provincial, and other grants** – studies and technology projects may be funded through different grant programs from the Federal or Provincial governments. Some recent examples include the Federal government's Rural Transit Solutions Fund and the Investing in Canada Infrastructure Program, the Innovative Solutions Canada Fund, Ontario's Community Transportation Grant Program and the FCM's Green Municipal Fund. The best way to be plugged in and aware of these opportunities is to be a member ofthe Ontario Public Transit Association (OPTA) and the Canadian Urban Transit Association (CUTA) and participate in the regional working groups, or to contact the Ontario Ministry of Transportation.

There are other mechanisms for funding projects that some organizations explore, for example financing (e.g., electrification projects through the Canada Infrastructure Bank), and public-private partnerships (e.g., advertising or exclusive rights for micro-mobility projects), however these are more niche in nature.

Early discussions with the finance department or leadership will ensure that funding for the project is in place to move forward without delays.

3.3.3 Timeline Planning

In addition to budget planning, your organization will likely require you to provide an estimate of timelines for the project.

See: Appendix I: Case Study- On-Demand funding support for Mohawk Council of Akwesasne

Procurement timelines vary dramatically by organization – we recommend you reach out to your procurement department to support with the estimate.

Once a vendor is on board, they will provide a detailed scheduled with concrete timelines for delivery. For the sake of project planning, the following table provides a high-level estimate of how long typically technology implementations can take (from once a vendor contract is in place to when the system is fully commissioned). Variations do, of course, exist by technology, but overall timelines are largely driven by whether the technology includes remote hardware installations (e.g., on vehicles, garages, facilities, terminals) or if the technology is predominantly a software tool.

TABLE 5: SUMMARY OF THE TYPICAL TIMELINES FOR IMPLEMENTATION OF VARIOUS TECHNOLOGIES, BASED ON WHETHER THEY REQUIRE VEHICLE INSTALLATIONS. THIS IS DIVIDED BASED ON THE SAME COMMUNITY TYPES DESCRIBED IN SECTION 0

Typical Implementation Timelines	Large	Small	Rural and Remote
Without vehicle installations	6 months - 2 years	3 months – 1 year	3 months – 1 year
With vehicle installations	2-4 years	1-2 years	< 1 year

3.3.4 Project Teams

There are two key project team resources that should be established early in the project definition.

- The **Project Manager** is responsible for advancing the project forward, and ensuring anyone involved in the project understands their individual roles and commitments. For many smaller or rural communities, this may be the head of the transit system. In other circumstances a departmental manager may serve best as project manager. For larger technology projects, especially those that will have large impacts on operations, additional staff may need to be hired or new job assignments made.

- The **Project Sponsor** is responsible for ensuring the project is adequately resourced, supported, and advocated for. In short, they are responsible that the Project Manager is equipped to be successful. Typically this person would be more senior to the Project Manager and well-positioned within the organization to influence priorities. In a small organization, the manager and sponsor may be the same person.

As the project develops, other roles and responsibilities will be filled. Different departments (in particular, the IT department) will need representation and the Project Manager would work to identify the specific individuals for each role.

3.3.5 Project Management Plans

For larger and more complex projects, organizations can consider developing Project Management Plans. These often include different elements, for example:

- Change management plan
- Stakeholder engagement plan
- Risk management plan
- Quality assurance plan
- Process improvement plan
- Schedule baseline
- Cost baseline
- Work Breakdown Structure

Formal project management training is encouraged for individuals reaching the point where a formal Project Management Plan is required or would be strongly beneficial.

See: Appendix I: Case Study- Bracebridge Develops a Transit Technology Plan (Town of Bracebridge)

4 LIFECYCLE: PROCUREMENT

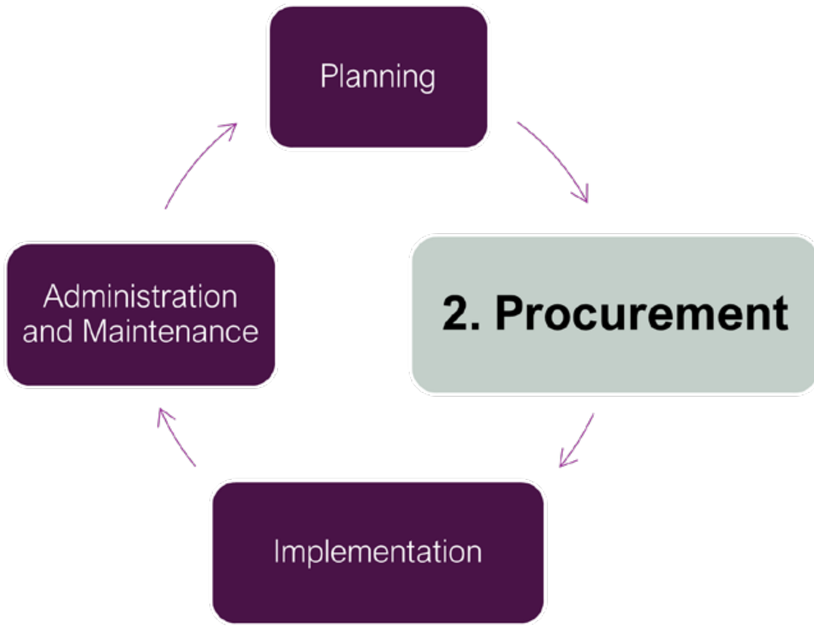

FIGURE 27: THE PROCUREMENT STAGE IN THE CONTEXT OF THE TRANSIT TECHNOLOGY LIFECYCLE

The second stage of the lifecycle is “Procurement”, in which organizations act on the decisions made during the planning stage and begin the processes and steps to procure the selected technology or technologies. Procurement of technologies typically consist of the following steps:

- **Establish Procurement Strategy:** Determine what type of procurement to pursue based on the transit system’s understanding of needs, knowledge of available technology and pricing.
- **Develop the Procurement Materials:** Draft the various components of a procurement document and ensure functional requirements and evaluation criteria are clearly defined.
- **Procurement Stage:** Publish the procurement documents, notify vendors, hold vendor meetings (if required), answer questions from vendors and issue amendments as appropriate.
- **Evaluation Stage:** Evaluate the submitted proposals using the developed criteria, shortlist vendors (if applicable), host vendor demonstrations and hold vendor interviews and select a vendor to award a contract.

- **Contract Negotiations:** Work with selected vendor to agree on pricing, contract agreements including terms and conditions, project schedule and milestones.

4.1 Establish Procurement Strategy

Once the organization has defined the business needs and decided on the technology "project" as outlined in Section 3, the next step is to establish a procurement strategy on how to purchase the technology. At this point, it is important to meet with the organization's procurement team or representative to discuss options and decide what is best for the organization. If the project includes funding from a Federal or Provincial program, the funding agreements for those programs may outline certain conditions or requirements for any procurements (e.g., must be open and competitive). These agreements, as well as guidelines which accompany them, may also specify eligible expenditures.

There are various types of procurement that an organization can choose from. The following describes the various procurement types.

Request for Proposal (RFP): An RFP is a detailed procurement document that seeks to obtain technical proposals from vendors and suppliers on their holistic approaches to complete the scope of services required by an organization. Submitted proposals are quantitatively and qualitatively evaluated on the quality of responses, vendor's previous experience, project approach, ability to meet the project requirements and pricing among other elements. The highest scoring proposal is then awarded the project.

RFPs are well-suited for most transit technology procurements because they are structured to support the procurement of complex and evolving technologies with varying business processes.

Request for Quotation (RFQ): An RFQ is issued by organizations when they have a thorough understanding and have made decisions on the type of technology and services required. An RFQ focuses on gathering detailed pricing information from vendors and suppliers on products and services that will meet the organization's needs for the lowest possible price.

Tender: Invitations to tender is a type of procurement strategy utilized in large projects (typically construction) and involves specifying detailed and rigid requirements that bidders must meet. These involve requirements of the work that vendors must complete as well as the type of qualifications that vendors must have.

Two-stage Request for Qualifications/Request for Proposals (RFQ/RFP): A two-stage procurement strategy enables an organization to evaluate vendors and suppliers on both the technical aspects of their proposals as well as the pricing. While there can be multiple variations of a two-stage procurement, the common technology procurement process involves inviting vendors to submit their qualifications and experience in the first stage and requiring a short-list to then submit a technical and pricing proposal in the second stage.

Joint Procurement: Some smaller and medium-sized transit systems may benefit from undertaking joint procurements with other transit providers. This can be through Metrolinx Transit Procurement Initiative (TPI), or directly between transit providers. For the TPI, local transit providers would need to work with Metrolinx to scope the project and develop the requirements. While the procurement may be complex, time consuming to set-up, and require some compromise in terms of requirements, it can help to obtain better pricing from vendors.

Once a procurement strategy has been established, the next step is to involve a legal representative and understand what form of draft standard contract terms and references are required with the procurement documents to prepare for release. In the meantime, the project team can begin to develop the supporting documents that detail the technology specifications and documents.

4.2 Developing an RFP

Most transit technology procurements involve complex technical requirements and re-engineering business processes in an industry that is continually changing its technology landscape. As such issuing an RFP is often the best approach to obtain proposals on the best approaches to solving the technology needs of an organization while encouraging competitive pricing among vendors.

It is important to develop RFPs that are concise and clearly communicate what the community needs. It is recommended that transit providers focus on the functional needs and use cases to drive requirements rather than take requirements listed in other sample RFPs.

Typically, an RFP is developed with the following structure:

- Organization background and purpose of the RFP (organizational needs and business objectives)
- Scope of work

- Functional use cases and detailed functional requirements
- Required system integrations
- Performance requirements
- Implementation and testing requirements
- Training requirements
- Technical submission requirements (e.g., asking for a description of technology offerings and how requirements will be met, past deployments, references, approach to deliver scope of work, project timelines, etc.)
- Pricing (sometimes required as a separate submission)
- Evaluation criteria
- Submission timelines
- Terms and Conditions

Developing an RFP builds on the technology requirements defined as part of the needs assessment described in Section 3.1 as well as the drafting of other supporting documents and evaluation criteria. The specification of functional requirements is the most critical component of RFP Development (see Section 3.1.2 on examples of how to turn needs into functional requirements). Turning identified business needs into specific functional use cases and requirements will be an iterative process that requires the involvement of business owners and users to refine and finalize.

It is important to note that while sample RFPs (see Appendix H: Sample RFP Library) of other communities are a valuable resource to reference, transit providers should focus on clearly defining and evaluating proposals against the functional needs the technology must meet rather than depending on the technical specifications of other RFPs to drive the procurement requirements.

Another key component of an RFP is the development of the evaluation criteria. Examples of evaluation criteria that can be used to assess respondents on various elements of their proposal and presentations include:

- Completeness of solution in meeting the specifications
- Integration capabilities
- Ease of use
- Price
- Service level agreement and vendor support services
- Training and user resources
- Vendor performance (captured via reference checks)

- **Providing a clear evaluation and scoring criteria helps vendors and suppliers tailor their responses.**

Developing a scoring matrix with weights for each criterion is an industry best practice to conduct evaluations. Having these criteria established prior to RFP publication will help to ensure a fair and consistent evaluation process once proposals are received. Given that functional requirements are core to the RFP, assigning a higher weight to the vendor's technical proficiency and ability to meet functional requirements can help to minimize the risk of poor vendor performance.

Assigning a higher weight to the vendor's technical proficiency and ability to meet functional requirements can help to minimize the risk of poor vendor performance

4.3 Procurement Stage

4.3.1 Issue RFP and Notify Vendors

Once the RFP documents are completed, the agency is ready to publish the procurement. The documents should be available on the organization's website and through other bidding sites such as *MERX*, *Biddingo*, and *Bids and Tenders* to ensure maximum reach. It is also important to notify various vendors in the market of the RFP to encourage proposal submissions. Transit providers can consider issuing a notice through transit trade magazines such as *Mass Transit*, *Passenger Transport*, and *Transit Talent*. Furthermore, transit providers can notify vendors directly upon issuing an RFP.

Pre-proposal meetings are highly recommended for transit technology projects that will require the deployment of hardware. A date and location should be determined by the transit provider and stated in a request for proposals (RFP) package for a Pre-Proposal Meeting. The Pre-Proposal Meeting should consist of providing an overview of the key technical features of the system specifications. The transit provider should have staff or a consultant who can address any technical questions that the transit provider chooses to answer during the pre-proposal meeting (as opposed to those questions deferred to addressing through a follow-up addendum). Further, the procurement staff can provide an overview of proposal submission requirements.

4.3.2 Review Technical Questions by Proposers

The RFP should include a cut-off date for written questions. Procurement staff or a consultant will develop written responses to all written questions, which will be distributed by the transit provider to all firms that received the RFP.

4.3.3 Prepare Addendums

The transit provider may develop and issue addenda to the RFP, based on the questions, results of the Pre-Proposal Meeting discussions, or other changes that may require an update. An addendum modifies one or more of the requirements or procedures, and/or might change the submission deadline. It is typical for interested vendors to ask several questions during the question period. As such, multiple addenda may be released to answer questions that come in throughout the question period. Providing answers on a rolling basis can help vendors better responses in a timely manner. It is also best practice to provide responses that are clear and directly answer vendor questions. Having detailed information on the scope and if possible, the budget, reduces the vendor’s perception of risk and encourages vendors to provide lower pricing.

Being as clear and direct as possible when answering questions will encourage vendors to submit concise proposal responses, lower their perception of risk and encourage vendors to provide lower pricing.

Informal interaction with vendors is not permitted during the procurement process. Vendors must be directed to submit all questions online or to the procurement manager and be advised that answers will be made available through addenda. All questions and corresponding answers should be included in the addenda for transparency and distributed to all vendors. The addenda should be distributed to all known potential respondents. If an addendum of significant impact is issued only a brief time before the proposal submission deadline, the transit provider should assess whether or not to extend the deadline. While the delay is never welcome to the issuing transit provider, it may in some cases be preferable to the risk of certain potential respondents concluding they would not have time for an adequate response.

4.4 Evaluation Stage

4.4.1 Evaluation of Submitted Proposals

The evaluation process will culminate in an award decision and Notice to Proceed (NTP) requiring a thorough technical analysis of each proposal. The organization should establish an Evaluation Committee which could consist of representatives from key stakeholder departments including business users as well as administration and support users. This committee should be established *prior* to the release of the RFP, and include representatives from the various business units that will be involved in using or supporting the technology. The results of the evaluations will be in the form of scoring each proposal based on the technical evaluation criteria. A “Requirements Compliance Matrix” (a copy of the specifications in a spreadsheet form with a requirement per row) will be used to thoroughly assess how proposers comply, do not comply or comply with modification to each requirement.

Utilizing a robust evaluation method with multiple weighted criteria is key to holistically and objectively evaluating vendor proposals on their technology capabilities, experience, and pricing.

Along with the technical proposal, each price proposal must be assessed as well. This cost assessment will focus on the reasonableness of the quoted prices and identify any errors or inconsistencies. Using information on price proposals from similar projects can help to determine the reasonableness of bid prices. A sample RFP Evaluation Template can be found in Appendix B: Sample RFP Evaluation Template.

When scoring proposals, a best practice is to have multiple members of the evaluation team score all elements of the proposal and take the average of multiple scores for each criterion to ensure consistency and reduce subjectivity.

Once the proposals are reviewed and final scores are calculated, the transit provider can select vendors in the competitive range to create a shortlist or choose to keep all vendors in the competitive range for interviews. It is recommended that any vendors who have not been eliminated take part in an oral selection interview or product demonstration (either virtual or in-person).

4.4.2 Vendor Interviews and Factory Demonstrations

For larger technology projects, it is recommended that the transit provider conduct either on-site or virtual interviews and demonstrations to evaluate vendors. Interviews and demonstrations help transit providers further evaluate shortlisted vendors to select one vendor to award. This provides the benefit of staff seeing the technology first-hand and gauging the fit for the organization in a more practical and visual way. It also provides an opportunity for staff to ask specific questions of the vendors, including lessons learned from implementing these technologies elsewhere and opportunities and techniques that help ensure the success of the implementation of their systems.

Vendor interviews and factory demonstrations provide staff with an opportunity to evaluate the technology firsthand and ask specific questions to vendors.

Vendor interviews consist of the transit provider's proposal evaluation team/committee developing and asking specific questions of each vendor, based upon proposal evaluations conducted by the evaluation committee members. The transit provider or consultant should develop a consistent agenda for the interviews and compile a list of clarification questions that shall be asked of each interviewee based on the proposal evaluations conducted by the members of the proposal evaluation team.

Alternatively, product demonstrations can be requested of shortlisted vendors to demonstrate their technology. Product demonstrations may be done virtually or onsite, depending on the technology procured. It is best practice for a transit provider to provide an agenda of items to be shown in the demonstrations. Product demonstrations provide an opportunity for the transit provider to see what the technology interface and/or hardware look like and enable agencies to better evaluate how well the vendor's solution meets requirements and assess the ease of use.

4.4.3 Vendor selection

A final selection of the vendor should be made based on the highest scores assigned from proposal evaluation and interviews or factory demonstrations. Once selected, the vendor should be notified, and the contract negotiations can begin.

4.5 Contract Negotiations

Upon evaluation and selection, the transit provider can enter into contract negotiations with the selected vendor. Consult with your legal and procurement departments on the typical structure and approach. Some of the elements to be confirmed through the negotiation include:

- Any adjustments to requirements based on compliance responses from vendors;
- Payment milestones;
- Uncertainties related to the vendor's submission (get it in writing);
- Confirming quantities of parts and units, which may have changed in the procurement period;

- Exceptions or adjustments to contract language put forward by vendor;
- Updated/baseline schedule based on a confirmed award date.

It is extremely important that the transit provider have a draft agreement in place prior to initiating contract negotiations to protect the transit provider's interests. If a draft agreement is not in place, the selected vendor may come in with an agreement that favours the vendor, rather than the transit provider.

Finding the right balance between minimizing risk to the agency and providing vendors with reasonable payment timelines is key to successful contract negotiations.

Payment milestones are critical to the success of the project as well. When negotiating payment milestones, it is important to minimize the risk to the transit provider by ensuring work is completed at a satisfactory level before payment, while also ensuring the vendor gets paid at reasonable intervals. The experience of vendors and successful deployments confirmed through reference checks as well as elements of uncertainty should inform the negotiations. If necessary, separate payment milestones for systems to be delivered by third-party vendors should be established to ensure that any delays due to issues with third-party vendors are minimized.

See: Appendix I: Case Study-Deploying CAD/AVL Through the Metrolinx Transit Procurement Initiative (TPI) (City of Timmins)

5 LIFECYCLE: IMPLEMENTATION

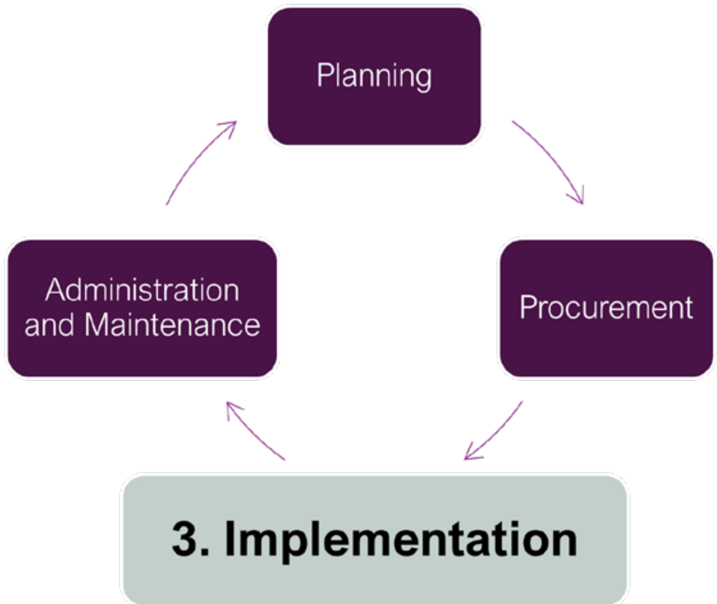

FIGURE 28: THE IMPLEMENTATION STAGE IN THE CONTEXT OF THE TRANSIT TECHNOLOGY LIFECYCLE

5.1 Typical Technology Implementation Process

With requirements developed and a vendor contract in place, the next stage is implementation. Project implementation is the process of taking the procured solution, configuring it to meet the previously defined requirements, implementing and then operationalizing the solution. Successful implementations are a cooperative effort between the transit provider and the successful vendor, or between the contractor and the internal multi-disciplinary team. This process can be broken into different stages, including:

1. System Design
2. Business Process Re-engineering
3. Integration
4. Verification
5. Testing
6. Deployment
7. Validation
8. Training

5.1.1 System Design

System design is typically completed first at a high-level to identify the software modules and hardware products that will deliver the broad functionality; then secondly at a detailed level to include all configuration and customizations and integrations required. With completion of the detailed design, the system hardware components, network infrastructure, and software applications and integrations can be planned.

Design is typically led by the vendor and reviewed with the transit provider to ensure agreement before deployment.

Design is typically led by the vendor and reviewed with the transit provider to ensure agreement before deployment. Design reviews confirm how software and hardware are combined, configured and utilized in the proposed solution. Review sessions often involve the vendor providing system diagrams and component details, and walking through each requirement, identifying how the design delivers it. Transit provider representatives participate in the design reviews to ensure that proposed designs meet their needs with minimal disruption or modification to business processes and workflows.

5.1.2 Business Process Re-engineering

In parallel with the system design phase, as the functionality and operations of the new system becomes clear, it is a worthwhile exercise to engage with user departments to document existing business processes. This is typically accomplished by gathering key resources from each department to brainstorm the business processes that touch or are touched by the new system.

Agencies can maximize value derived from systems by undertaking a fulsome review of business processes.

With a list of business processes, convene sessions with all participants in each process, and document it in a flow-chart, covering all steps and decisions, as well as the actor or person that completes each step. Ask how the process begins, then have the team describe what tasks and decisions are made to complete the process.

With existing processes documented, reviewed and agreed to by your stakeholder departments, it is time to re-imagine or re-engineer the process to take advantage of new functionality of the new system, or its integration with existing transit systems. For instance, in an existing process, street supervisors may have to be deployed to route vehicles around an accident or route blockage. With tools provided in a CAD/AVL system implementation, controllers or dispatchers may be able to insert detours into routes and automatically distribute those route changes to all appropriate vehicles from the control room, eliminating or reducing the requirement to deploy people to the site to locally manage service.

Business processes are usually documented in flow charts or process maps, in accordance with BPMN (Business Process Model and Notation). This can be accomplished with Microsoft VISIO, or BPMN-specific modellers, such as Camunda. More information can be found on tools and approaches to modelling business processes at http://bpmn.org.

The following is a sample business process map.

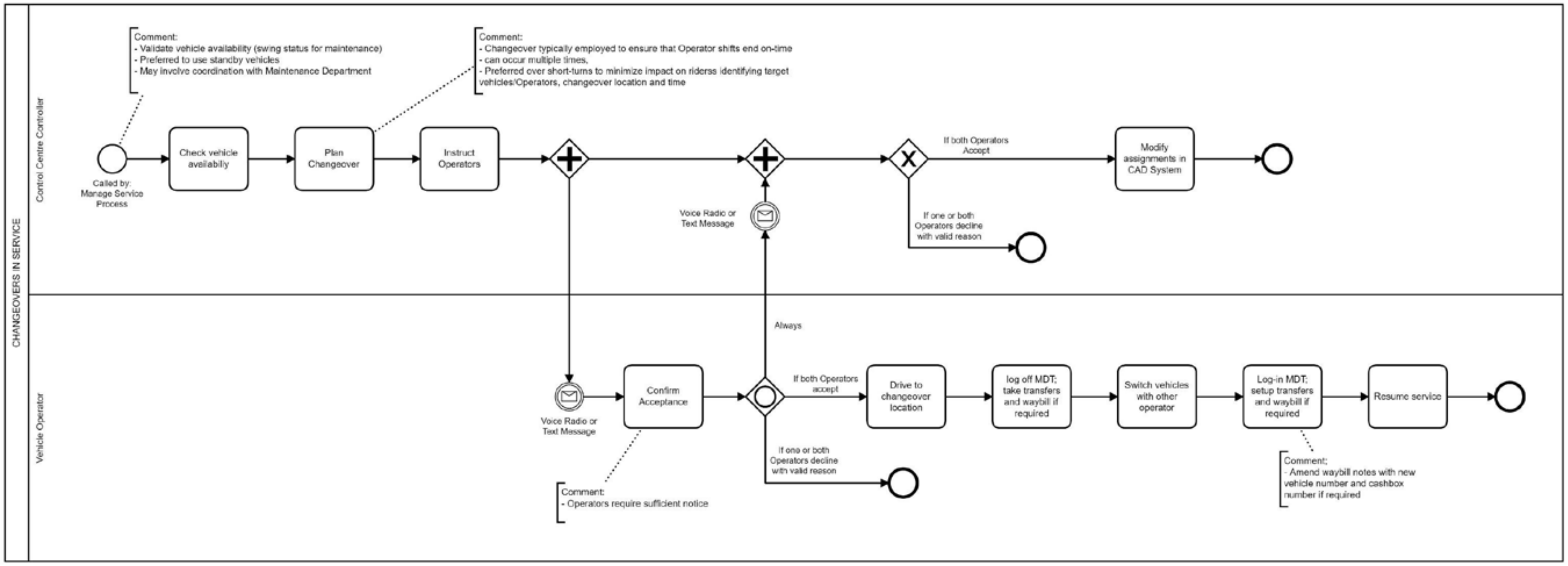

FIGURE 29: A SAMPLE OF A BPMN-FORMATTED BUSINESS PROCESS MAP INDICATING HOW DIFFERENT ACTIVITIES, SUBPROCESSES AND BRANCHES INTERACT ACROSS WORK STREAMS

5.1.3 Integration

Integration is the process to combine new hardware and software into a cohesive solution, as well as to properly ‘connect’ the new system with existing systems and applications as required to enable the smooth flow of data between them.

Upstream systems that feed data into a new CAD/AVL system, for instance, may include the scheduling, workforce management, and asset management systems; while downstream systems receiving information from the new CAD/AVL system may include reporting, workorder management, incident management and payroll systems.

As part of the procurement, vendors may be required to provide an Application Programming Interface (API), which can be used to more effectively integrate to external systems. This can help in the future should one of the systems require a change or upgrade.

Leverage your organization’s IT resources to support integration efforts.

Best practices are to include the organization’s IT resources to work with the vendor, throughout the implementation phase, ensuring that any integrations are compliant with the organization’s IT policies and practices. In some cases, the organization’s IT developers will take on development within existing IT systems, to meet standard API requirements, leaving the vendor to perform required development on their applications.

5.1.4 Verification

Verification is the process of evaluating the systems meeting requirements and design. It answers the question, “Was the system built right?” Verification results in ‘accepting’ the products from the development team.

Verification plans are typically documented within a traceability matrix. Larger projects, sometimes require a verification plan, but most operate with documenting verification of requirements within the matrix.

The traceability matrix is a key tool that helps to ensure requirements are met, and at which stage, verification is performed (Factory Acceptance, Installation, Mini-Fleet, or System Acceptance). It does not specify how requirements will be verified, as the methods and procedures employed are documented within test plans.

The traceability matrix is a key tool that helps to ensure requirements are met.

Traceability matrices are usually in the form of a spreadsheet or workbook with one row dedicated to each requirement in the contract with the vendor. They consist of columns organized in groups, capturing:

- Requirement
  - Paragraph Number
  - Requirement Text
- Proposal response
  - Proposed Compliance Status
  - Proposed Modified Requirement Text
- Requirements Review
  - Proposal Reference (Section and Page Number)
  - Discussion Notes
  - Compliance Status as of Requirements Review
  - Final Requirement as of Requirements Review
- Verification Details
  - Phase
  - Component Type (Subsystem)
  - Verification Stage (Contract, FAT, IT, MFT, SAT, BIT)

5.1.5 Testing

Testing may be done by the system developer or an independent third-party, in conjunction with the transit provider.

Tests are performed according to formal test plans to determine if requirements are met. Testing usually occurs in various stages:

1. **Factory Acceptance Testing (FAT)** is conducted on individual system components prior to them being transported to the site.

2. **Installation Testing (IT)** is conducted to make sure delivered components work according to design and that the site meets design requirements as well.

3. **Mini-fleet (MFT)** is a proof of concept that involves installing the system and components on a selected few vehicles or locations, verifying expected operation of the system in live conditions prior to rolling out to the entire fleet.

4 **System Acceptance Testing (SAT)** is conducted on the entire integrated system (that is all hardware and software components) as a point-in-time test that validates all expected functionality.

5 **Burn-in testing (BIT) is** the process of exercising/burning-in/breaking-in a system. This is typically initiated after a successful SAT, and involves the system being used in a live or simulated operating environment.

Agencies should insist on receiving a test plan or procedures in advance of testing.

Agencies should insist on receiving a test plan or procedures in advance of testing. The test procedures should identify what specific tests will be completed along with anticipated results and will be used to deem the tests a success or failure. Depending on the severity of the failure, vendors may be required to develop a recovery plan that includes re-testing completely, partially, or advancing on to the next stage.

Agencies can minimize the risk of failure by asking vendors to confirm in advance of testing that they have undertaken adequate pre-testing.

5.1.6 Deployment

Deployment is the initiation of operation of the system in its intended environment. Deployment requires consideration of scheduling, resource availability, training, and coordination among stakeholders. System users should receive adequate training prior to deployment (refer to Section 5.1.8).

System users should receive adequate training prior to deployment.

In many cases, a new technology system is used offline in parallel to the current system. For example, a transit system adopting computer-aided scheduling and dispatch software may continue to use its normally scheduling and dispatch processes while also using the new system. This allows for bugs in the software and data and process shortcomings to be addressed.

5.1.7 Validation

Validation is an assessment of the operational system. It evaluates the system in reference to the project's goals and objectives. It determines if the system is meeting its intended purpose and the needs of the stakeholders. All stakeholders should be involved in the validation process as it determines if needs are being met by the new system. It is important to complete the validation process quickly as stakeholder understanding and perception of the system and needs may change after a short period of operation.

5.1.8 Training

Training transit staff to properly use the new technology is critically important. Spend time thinking about who needs to be trained and on what.

Vendors will typically provide a library of generic training on the use of their products, introducing users to the features and functions of the new system. These training modules may have to be bundled or even modified, to meet the specific transit provider's requirements, as they may have been developed for other agencies, or using industry-generic nomenclature for job titles or user functions.

Typically training will cover:

- Users of the system
- IT administrators, and
- Hardware support (if applicable).

The first step is to develop a training plan. The plan needs to consider the people being trained (operators, mechanics/technicians, supervisors, investigators, security, management, customer service, etc.), as well as the types of training (classroom, on-the-job training, self-directed computer-based) that are best suited to each group. The training plan is often developed by the vendor but should include input from the transit provider.

Vendors typically provide train-the-trainer sessions, ensuring that the transit provider training department is armed with the necessary materials to train larger volumes of operators and maintenance personnel. They may also provide direct-to-learner training for supervisors and maintenance personnel, as well as customer service, and/or reporting teams.

The transit provider may wish to consider developing customized training providing guidance on re-engineered business processes that were developed to leverage new system functionality and improve operational efficiency.

5.1.9 Phased Implementations

A common method of managing the implementation of large, complex systems is phased implementation. Phased implementation may make additional sense in rural communities due to the lack of experience with technology. Coordinated cross-regional systems may also benefit from incremental implementation.

Each phase should result in an operationally useful system. It is impractical to consider a phase complete when it has made no impact or provides no useful function to the system. Do not ignore necessary components for phased developments (If B requires A to provide a function, then A needs to be in place or implemented in tandem with B).

5.2 Project Management Duties and Responsibilities

The project manager is responsible to manage all aspects of the project including managing vendors, budgets, scheduling, risk, communicating progress, and escalating any issues for direction from a steering committee or project sponsor.

On large complex projects, the project manager is responsible to develop and implement the formal project plans identified in Section 3.3.5.

5.2.1 Project Schedules

One of the most critical tools with which to manage a project is a schedule. Smaller projects might use spreadsheets, such as Excel, or online subscription services, such as Smartsheets, Monday.com, or Celoxis, while larger, more extensive projects tend to leverage industry-leading enterprise applications such as Microsoft Project, or Primavera.

A schedule consists of a series of tasks, linked together in a manner that reflects their dependencies and expected effort or duration. Resources are then assigned to each task, and they are plotted on a linear calendar usually in the format of a Gantt chart. As the project progresses, project managers update each task to show its progress in the form of percent (%) completion. In a properly developed schedule, the application will identify critical path items, enabling your project manager to focus efforts on the most critical tasks that can easily result in project delays if not completed on time.

In larger, more complex projects, the project manager should hold weekly progress meetings, using reporting from the schedule tool to focus on critical path tasks, as well as two, or three-week look-ahead reports that identify all tasks underway during that short period.

Vendors should provide a schedule and update it at least once per month.

Whatever your project, insist that your vendor provide a schedule and update it at least once per month. The schedule should contain clearly defined tasks, the responsible party for each task, deadlines and deliverables, clearly laying out what is expected of you as the procuring party. It should further provide time for all review cycles, providing you with enough time to circulate reports and/or configurations to the appropriate stakeholders to gather comments.

5.2.2 Action Item Log

Transit technology projects often use Action Item Logs to track and manage requests or actions that arise. These logs are typically in the form of a matrix or spreadsheet, tracking the date assigned, due date, task/action description, and assigned resource to undertake the action.

Action Item Logs are effective for tracking and managing requests or actions that arise through the course of implementation.

An Action Item Log template can be found in Appendix C: Sample Project Action Item Log Template.

Beyond completion of the tasks identified in the project plan, in many cases, additional effort is required to investigate and clear issues that may be causing delays. This could require IT staff to provide details of integration with an adjacent system, or even coordination of staff for a particular period to focus on project activities.

5.2.3 Risk Assessment Framework

Risks are present throughout every project, be it technical, administrative, environmental, etc. As a result, most technology projects benefit from having a formal risk management plan or process.

A key output of the risk assessment process is a risk register. The risk register documents foreseen risks, potential impacts, associated mitigation plans, and people responsible for taking appropriate actions. A sample risk register can be found in Appendix D: Sample Risk Register Template.

Assessing risks typically consists of an evaluation of the likelihood, impact, and response time for an event.

- Likelihood can be measured as a probability per unit of time. For example, the likelihood that our telecommunications will go out on a given day is .01%.
- The Impact of the occurrence of events can vary in magnitude and scope and have financial and nonfinancial consequences.
- Not all events require immediate response or resolution. Having extra time may change the nature of the event and its remedy.

Effective risk assessment helps transit systems prioritize actions. Many potentially adverse events, especially those with very low probability or those with relatively minor impacts, should not be included in a risk management plan.

Mitigation plans should be made to describe the processes that will follow and the responsibility of individuals and organizations if an adverse event were to occur. For coordinated efforts, it is recommended that agreements be in place.

6 LIFECYCLE: ADMINISTRATION AND MAINTENANCE

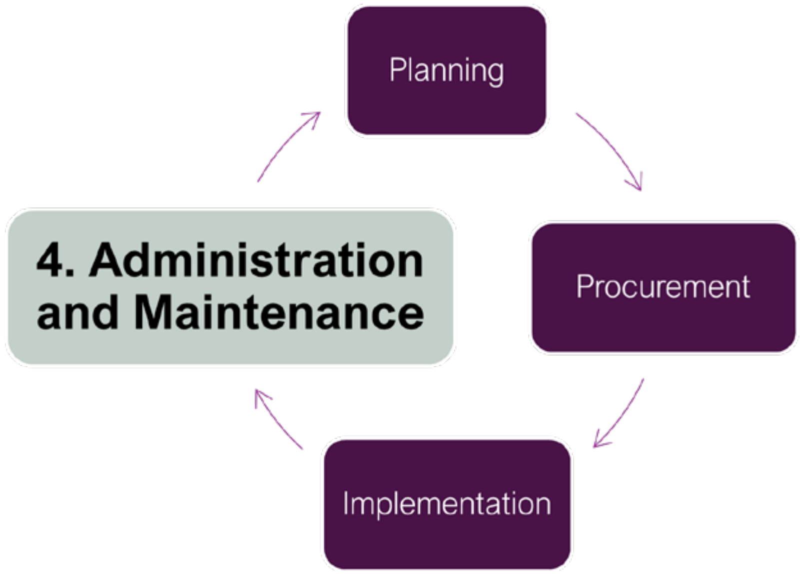

FIGURE 30: THE ADMINISTRATION AND MAINTENANCE STAGE IN THE CONTEXT OF THE TRANSIT TECHNOLOGY LIFECYCLE

After a system has been deployed and accepted, it moves into the operation and maintenance phase of the project lifecycle. IT plays a primary role in supporting and maintaining the systems. This involves ensuring newly implemented technologies are utilized well, providing ongoing system support and overseeing continued improvement of systems. This section details the following aspects of Administration and Maintenance once the implementation is successfully completed:

- Maximizing Technology Investments
- System Monitoring, Vendor Support, Warranties and Upgrades
- Continual Improvement and Replacements
- Typical Support Roles and Responsibilities

6.1 Maximizing Technology Investments

In addition to robust planning of user needs and staff training during deployment, measures must be in place to ensure that the technology is used to its full potential to maximize a transit provider's investment into the system. These include the following:

Identify Superusers: Superusers are staff who know the system particularly well and can train or support their peers to troubleshoot common errors and use new features.

Superusers are typically the most excited when a new feature or option is available; they are the individuals whose curiosity drives them to explore the technology in their downtime.

Update Business Process: Business process re-engineering is an iterative process with new technologies. Although processes are reviewed and updated during implementation, tweaks may need to be made once technology is operational to ensure the business needs are met efficiently. This is particularly important to ensure that newly added features of a system are utilized to enhance efficiencies. Draw in superusers to help inform on-going business process reviews, leveraging their knowledge of untapped features.

Document Procedures and Processes: Ensure updates to Standard Operating Procedures (SOP) for operating (business users) and troubleshooting/maintaining (IT) the systems. If major updates are made or if documents did not exist before, developing these documents ensure procedures and processes are formalized.

Develop Job Aids: Job aids are developed by staff (typically superusers) to support the transition to new technologies by providing user tips on how to use helpful features of the system (such as reporting). Developing and updating job aids can help new users as well provide additional support to existing users on how to use new features or updated processes.

Provide Refresher Training: While training during deployment is key, providing refreshing training for staff is equally important. The frequency of training depends on system complexity and the needs of your users.

Adjust On-Boarding for New Hires: Give thought to what changes should be made to on-board processes and new user training. Leverage the training materials and job aids created, and encourage new staff to connect with superusers as they uncover questions about systems *after* they have been thoroughly trained.

Ensure Access to Key Documents: Ensure key information such as warranties, instruction manuals and safety manuals (if applicable) are available in accessible formats to staff. These documents should be easy to find and new updates from vendors should be filed as they become available.

The technology lifecycle does not end after implementation. To ensure technology is used to its full potential, key measures such as identifying super users, documenting processes and providing refresher training, among others should be taken.

6.2 System Monitoring, Vendor Support and Warranties

System monitoring, support and maintenance involves troubleshooting, developing workarounds, and investigating the root cause of system issues. IT involvement will be heavy at the early stages after deployment to troubleshoot issues and should become routine thereafter. Routine maintenance involves installing software updates, ensuring security measures are in place, performing preventative maintenance and working with vendors to resolve any identified software bugs or recurring issues.

New technology implementations come with warranties and typically includes direct vendor support for any issues that may come up in the early days of deployment. Assigning a dedicated IT administrator(s) to each system is key to ensuring there is a knowledgeable representative from the transit provider side to provide system support internally and liaise with vendors to resolve issues. When a new system is implemented, the IT administrator should work with vendors to understand the process for monitoring the system, detect errors and report and resolve issues. IT administrators and business unit managers should keep track of warranties and ensure issues covered under warranties are resolved in a timely manner.

Assigning an IT administrator(s) for each system is a best practice that ensures there is dedicated staff that can liaise with. Assigning an IT administrator(s) for each system is a best practice that ensures there is dedicated staff that can liaise with vendors and be experts in detecting and resolving system errors.

Once the system is in operation and initial issues have been resolved, system support can become more routine. Best practices for ongoing system support include the following:

Implementing a helpdesk for users to submit tickets: An IT helpdesk is a helpful tool to not only report issues but to also keep track of data on the type of issues, frequency, time to resolve and notes on the resolution.

Managing and Reporting Data: The system should be configured to easily access valuable transit data and use it in analysis and decision making. Data formats and security measures should be in place to ensure accessibility and privacy. General system information should also be collected and analyzed on a regular basis and particularly during unplanned disruptions. Data on the cause, restoration and performance of the system should be collected as well as the downtime and time to repair.

Implementing tools and processes for staff to submit tickets can help track recurring system issues and support root cause investigations that can inform future technology decisions such as technology upgrades and additional training

Develop processes for ticket handling: When a transit provider has multiple systems or a large system with many users, the volume of tickets can quickly rise. As such, processes should be developed and documented for prioritization of tickets, communication with customers during support and documenting resolutions and results of any root cause investigations performed.

Formalize commitment by establishing KPIs and targets: To ensure systems are being maintained effectively, Key Performance Indicators (KPIs) and associated targets for helpdesk support should be developed and monitored. KPIs should be established to measure level of service in helpdesk support and customer satisfaction. KPIs and targets are particularly important to establish for cloud-hosted and software-as-a-service solutions and are typically worked directly into the vendor contracts.

Include KPIs and performance targets in your contracts for cloud-hosted and software-as-a-service solutions, as well as broader vendor support requirements

6.3 Continual Improvement, Upgrades and Replacements

6.3.1 Continual Improvement

The challenges of lifecycle management include planning for continued improvement while also managing current systems, ensuring compatibility between new and old technologies, and dealing with the ever-changing landscape of IT/ITS. As such, IT's role goes beyond providing day to day system monitoring and troubleshooting support. Providing continual improvement involves collaboration between IT and business departments to identify gaps and inefficiencies in existing business processes and technology.

IT's role goes beyond system monitoring and support. It includes working with business units to continually assess technology needs, improve processes and identify new solutions.

Best practices to support continued improvement of technology include creating an inventory of existing systems and technologies, developing a roadmap for future needs, establishing governance procedures to manage change, and allocating resources appropriately. The responsibilities for these activities should be undertaken between IT and respective business partners. IT can support this by planning for periodic (e.g., quarterly) reviews of systems to assess how well they meet needs and investigate any overarching issues.

Where a gap is identified, IT's role can be extended to support business units to investigate potential solutions, and help evaluate their value to the organization. A cost-efficient solution is to upgrade a system that is emerging or mature in the market. Upgrading existing systems to the latest version available can be a straightforward and cost-efficient project (compared to system replacement) that can address a transit system's changing needs.

6.3.2 System Upgrades and Replacements

The more robust a transit provider's maintenance of systems is, the longer the system will meet the transit provider's needs. However, eventually, all systems will need to be replaced or retired. This may be due to increasing frequency of failures due to age (reaching end of lifespan), high operating and maintenance costs, changing needs, or unsupportable obsolete technology.

Vendors may also offer version upgrades which can extend the life of a system. The upgrades typically involve upgrading the system software but leaving hardware unchanged.

As with other assets, systems and technologies have defined lifespans, beyond which point, vendors withdraw support, rendering the technology obsolete and adding risk to transit operations. Typical lifespans for the various systems and technologies found in transit systems are presented in the Appendix F: Typical ITS Technology Lifespans.

Proper monitoring and continual improvement can help to prolong the lifespan of systems.

If the replacement of a system nearing its lifespan has not already been planned, the process cycle is complete, and a new planning phase begins. A gap analysis of the legacy system versus capabilities needed should be conducted to inform the needs analysis.

6.4 Typical Support Roles and Responsibilities

As transit systems grow and become more reliant on ITS technologies, it is critical to have qualified resources to consult with business departments, manage the systems, and interface with various end users to provide support and training.

System Administrators are typically responsible for the overall system, updates and patches, as well as coordination of maintenance and monitoring of performance. As systems age, the System Administrator is a key contributor to all system lifecycle stages.

IT system administrator(s) are key to maximizing investment in technologies. Key responsibilities of IT system administrator(s) include providing implementation support, maintenance and continual improvements of all technologies.

The Administrative aspect of a technology's lifecycle requires dedicated IT resources to support the maintenance of the technology once implemented. To support transit providers in this regard, a sample Information Technology (IT) Administrator job description has been presented in Appendix E: Sample IT Administrator Job Description.

The key qualifications and responsibilities have been gathered and consolidated from existing roles of various municipalities identified in the Case Study Report as well as industry requirements to support several transit technologies. The sample job description outlines the main duties that will effectively support the operation and maintenance of ITS technologies such as CAD/AVL systems, fareboxes, passenger announcements, and on-board communication systems.

Key responsibilities of IT system administrator(s) include supporting implementation, upgrades and replacements of systems, monitoring and troubleshooting systems to minimize disruption and performing root cause analysis.

7 CASE STUDIES

Left Turn Right Turn has developed ten (10) technology-focused case studies to help expand awareness of existing and emerging innovative transit technologies that can be implemented in Ontario. The case studies have been derived from interviews with a range of small, rural, and Indigenous communities to gauge their use and experience in deploying various technologies. A variety of technology vendors were also issued invitations to interview with the intent of increasing the knowledge base in terms of feasibility in smaller locales, cost, vendor innovation, and how vendor product information is disseminated.

Two interview guides were developed to lead discussions (one for municipalities and one used for vendor interviews). Questions and points of discussion within the interview guides were designed to further the overall understanding of the opportunities, gaps, challenges, successes, and lessons learned of technology deployment and capacity.

The ten (10) case studies are included in Appendix I: Detailed Case Studies.

7.1 Summary of the Case Studies

As the case studies were developed, three predominate themes emerged from the discussions with different interviewees:

- Operational technologies
- Fare collection and customer experience technologies, and
- Specialized integrations.

The case studies have been categorized into these trends (although some may overlap) based on their topic to better guide the reader. The table below outlines the interview participants, topics explored, year of implementation, and thematic categories. The table is organized by thematic category and year of implementation, with the most recent implementation being prioritized.

TABLE 6: SUMMARY OF THE CASE STUDIES PRESENTED IN THIS TOOLKIT

Topics	Implemented	Interviewee	Theme
Implementing a Trunked Radio System for Transit Operations	2021	Thunder Bay	**Operations Technology**
Deploying CAD/AVL through the Metrolinx Transit Procurement Initiative (TPI)[2] (City of Sault Ste. Marie)	2021	Sault Ste. Marie	**Operations Technology**
Deploying CAD/AVL Through the Metrolinx Transit Procurement Initiative (TPI) (City of Timmins)	2018	Vendor: CONSAT	**Operations Technology**
Operating an Integrated Transit Technology Suite	2016	Bracebridge	**Operations Technology**
Planning for a new Electronic Fare Collection system	Upcoming	Sault Ste. Marie	**Fare Collection and Customer Experience**
Implementing GTFS without Traditional Transit Technology	N/A	Norfolk County	**Fare Collection and Customer Experience**
Developing a Transit Technology Plan	2021	Bracebridge	**Specialized Integrations**
Deploying an Integrated Specialized and Conventional On-Demand Technology (Milton Transit)	2021	Vendor: Spare Labs	**Specialized Integrations**
Planning the Transition of Specialized Transit Technology Systems	2018	Thunder Bay	**Specialized Integrations**
On-Demand funding support for Mohawk Council of Akwesasne	N/A	Vendor: Pantonium	**N/A**[3]

7.2 Summary of Case Study Learnings

The interviews showcased the implementation of technology in smaller jurisdictions can have a significant impact on transit and/or staff efficiency and effectiveness. It may enable the automation of work, relieve a shortage of staffing resources, improve ridership, or provide ease and convenience to residents. However, the implementation of technology can also have operational and financial implications.

[2] Additional details about the Metrolinx Transit Procurement Initiative can be found online: https://www.metrolinx.com/en/projectsandprograms/tpi/tpi.aspx

[3] This case study is thematically adjacent. While contextually similar to the Specialized Integrations theme with respect to On-demand service, there is currently no formal transit service offered in the community. The case study's focus is on the experience of seeking funding support and opportunities.

The following table provides a summary of the case study findings, focusing on the following questions:

The summarized information focuses on the following questions:

- To what extent is the technology being deployed in Ontario today?
- What lessons can be learned for Ontario communities and transit systems?
- What additional considerations may apply to rural, northern, and Indigenous communities?
- Who are the current technology vendors, and are there any Ontario-based vendors?
- How much might the technology cost to implement (including direct costs and any associated infrastructure or operations upgrades)?
- How much lead time might it take (from request for proposal/quotation to deployment)?

The summary groups the case studies through their thematic lens of operational technologies, fare collection and customer experience technologies, and specialized integrations. By grouping the findings, we can expand and abridge on information, to better inform the summary questions.

7.2.1 Theme Findings – Operational Technologies

Case Study Communities	Cities of Sault Ste. Marie, Thunder Bay, Timmins; Town of Bracebridge
Technologies Deployed	Integrated Transit ITS Suites, CAD/AVL Systems, Closed-circuit Radio System
To what extent is the technology being deployed in Ontario today?	• Closed-circuit radio systems are being used by many transit systems. • ITS Suites vary by transit system. Larger transit systems tend to procure technology as needed, having a variety of vendors. • Several municipalities across Ontario have taken part in the **Metrolinx Transit Procurement Initiative**: o Belleville, Cornwall, Kawartha Lakes, Kingston, Milton, North Bay, Orangeville, Orillia, Sarnia, Sault Saint Marie, Simcoe County, St Thomas, Stratford, Sudbury, Temiskaming Shores, Thunder Bay, Timmins
What lessons can be learned for Ontario communities and transit systems?	• The AODA requirement to have next stop announcements was a key driver for technology implementation. • Integrated Technology Suites are provided by a single vendor. This may leave gaps in support and functionality that the vendor's technology does not naturally cover. However, in dealing with a single vendor, procurement and new modules are often streamlined. • Operators and staff require time to adjust to new systems. • The integrated technology suites may provide residents access to online services and portals. While these can reduce the number of calls to the municipality regarding delays and schedules, certain demographic groups do not tend to access and/or understand the online components.
What additional considerations may apply to rural, northern,	• Working with Indigenous communities to ensure Indigenous languages are available for stop announcements is key to success. • Having a small fleet size leads to a significant per vehicle cost to deploy systems like CAD/AVL.

Case Study Communities	Cities of Sault Ste. Marie, Thunder Bay, Timmins; Town of Bracebridge
and Indigenous communities?	• Utilizing the data collected from this technology to inform planning is a key benefit that all transit systems should consider. For small transit systems with limited resources, data analytics modules that provide automated reporting can be leveraged. • Closed-circuit radio systems require a dedicated staff member to monitor from the control console. • Integrated Transit Suites provide a cloud-based system that relies on cellular connectivity between on-board systems and vendor-hosted servers. Therefore, the municipality itself does not need infrastructure to store technology and the online portals provide reporting tools for monitoring and analysing service performance and ridership. • Collaborating with peer transit providers is prudent when using a single vendor for determining gaps/solutions. • New technology, such as the closed-line radio system, can increase job duties and responsibilities for certain positions thus increasing the need for expertise and increasing training requirements.
Who are the current technology vendors, and are there any Ontario-based vendors?	• CAD/AVL Systems: Clever Devices, CONSAT, ETA Transit Systems, INIT, Strategic Mapping Inc, TripSpark Technologies • Closed-circuit Radio System: Bell FleetNet, Harris Radio, PowerTrunk, Tait Communications • Integrated Transit ITS Suites: Modeshift, TransitFare & Systems (Ontario-based)
How much might the technology cost to implement (including direct costs and any associated	• The initial capital investment for a new CAD/AVL system with a fleet size of 25 buses cost $10-25k per bus. o This initial cost per bus increases as the transit fleet size is lowered. For example, it would cost a smaller transit provider $25k per bus for a system with a fleet size of 4 buses. o Data analysis module/add-on costs vary; basic reporting capabilities may cost $500/month.

Case Study Communities	Cities of Sault Ste. Marie, Thunder Bay, Timmins; Town of Bracebridge
infrastructure or operations upgrades)?	• Integrated Transit ITS Suites vary in price, subject to the technology included.
How much lead time might it take?	• CAD/AVL implementation varies, generally from three to six months.[4] • Integrated Transit ITS Suites, vary based on the type of technologies included in the suite.

[4] This timeframe is derived from the observed deployment time of the Cities of Timmins and Sault Ste. Marie via Metrolinx Transit Procurement Initiative (3 months and 6 months, respectively). Deployment of other systems, outside of Metrolinx's program, may require additional lead time to account for requirement and specification gathering, testing, and training.

7.2.2 Theme Findings – Fare Collection and Customer Experience Technologies

Case Study Communities	City of Sault Ste. Marie; Town of Bracebridge; Norfolk County
Technologies Deployed	Integrated electronic fare collection systems, GTFS customer information
To what extent is the technology being deployed in Ontario today?	• GTFS information is used broadly across the transit industry. It allows transit systems to publish their transit data in a format that can be used to provide real-time information and updates, greatly increasing service planning and customer experience. • Integrated electronic fare collection systems are being used across Ontario, particularly in large metropolitan areas where electronic systems can facilitate regional integration. • Electronic fare collection is becoming more popular, especially considering COVID-19, as a replacement for physical fare.
What lessons can be learned for Ontario communities and transit systems?	• Using GTFS data to visualize data and estimate arrival times and vehicle positions can reduce time-consuming daily tasks of dispatch staff, such as phone inquiries for bus arrival times. Similarly, these estimated arrival times and vehicles positions provide an added perception of reliability for transit users as they can more accurately estimate bus arrival time. • The initial integration of a new fare collection system is estimated to have service delays caused by the public being introduced to, and learning how to use, a new fare payment system. These delays are expected to be temporary.
What additional considerations may apply to rural, northern, and Indigenous communities?	• Smaller agencies may have more difficulties in recuperating the capital and operating costs associated with integrated electronic fare collection systems, as the amount of fare collected tends to be lower than larger communities due to lower ridership numbers. • Fare collection systems can provide a primary source for ridership and revenue data. However, smaller communities may have difficulties processing this information with fewer staff and/or expertise. • Electronic fare systems may pose difficulties for residents in smaller rural, remote, northern, and Indigenous communities who are cash reliant rather than relying on debit or credit cards.

Case Study Communities	City of Sault Ste. Marie; Town of Bracebridge; Norfolk County
	Even if tickets may be purchased with cash at specific locations or kiosks, unless there is a cash box on the bus, it can provide an equity barrier to riding transit. • While GTFS is used broadly, particularly by larger transit systems, it does require analysis tools to be used, analyzed and visualized effectively - particularly for real-time displays. This may require additional costs and training.
Who are the current technology vendors, and are there any Ontario-based vendors?	• Fare Collection: Cubic Fare Collection, ETA Transit Systems, GFI Genfare, INIT, NEC, TransitFare & Systems (Ontario-based), TripSpark • GTFS Services: AddTransit, Google, Hastus/Giro, IBI Group, Moovit, Optibus, RouteMatch by TripSpark, Trapeze Group, Trillium Solutions • GTFS Visualization Tools: Esri ArcGIS Pro, Esri ArcOnline, Transit Vis, TransitFlow, Traze by Veridict
How much might the technology cost to implement (including direct costs and any associated infrastructure or operations upgrades)?	• Integrated electronic fare collection system pricing varies. Smaller communities can expect initial capital costs of approximately $15-30k per bus (based on a fleet size of 28 conventional buses) which does not include the first year of support. o On-going annual fees vary, with some based on number of buses, others on ridership. • GTFS data synthesis is available at no charge with certain providers, excluding analysis and visualization.[5]

[5] As above, Google provides the synthesis at no charge if schedules, routes, and other transit agency information is provided. However, additional analysis of GTFS data, including visualization, may require other software provided by various vendors at various costs.

Case Study Communities	City of Sault Ste. Marie; Town of Bracebridge; Norfolk County
How much lead time might it take?	• For Fare Collections Systems, transit providers can expect that the period between issuing the Request for Quotation and the technology deployment is approximately 12 months.[6]

[6] The approximate deployment time varies by agency resources and fleet size. The 12-month estimate is derived from the experience of Sault Ste. Marie Transit, who has procured and is currently deploying new fare collection technology. This is exclusive of the time required to gather agency-specific specifications.

7.2.3 Theme Findings – Specialized Integrations

Case Study Communities	**City of Thunder Bay; Town of Milton**
Technologies Deployed	Integrating specialized with on-demand
To what extent is the technology being deployed in Ontario today?	• The prevalence of conventional transit systems' adoption of on-demand services is a key driver of the integration of on-demand technology with specialized services. • Ontario currently provides the highest number of on-demand/same-day trips in the nation according to the 2019 CUTA statistics (302,679 trips /766,891 Canada wide). CUTA defines on-demand trips as trips delivered the same day as they are requested. Currently, many of these on-demand trips are delivered through a partnered taxi service. • The integration of specialized transit with on-demand services is being planned and or implemented by several transit systems across Ontario with the following objectives: o To ensure all customers, regardless of ability, have access to the same services. o To provide specialized customers with alternative methods to conveniently book trips on their own and at any time. o To support the seamless integration of specialized customers into a municipality's family of services.
What lessons can be learned for Ontario communities and transit systems?	• Although the concept of on-demand is something that specialized transit systems have been striving for many years, the long-standing specialized transit policies and the car centered built environment have posed challenges to successfully meet the objectives of integrating specialized transit with on-demand services. • The changes in eligibility requirements in the AODA from the past five years have been a key driver to the significant changes in eligibility and customer policies in Ontario. While the AODA stipulates that all transit service providers must provide equal access of services to both specialized and non- specialized customers, there is little guidance on how to implement and integrate services.

Case Study Communities	**City of Thunder Bay; Town of Milton**
	• To be compliant with the AODA, transit providers providing on-demand services as part of its conventional service must provide the same option to its specialized customers. This can be used as an opportunity to lighten the load on specialized fleets to on-demand vehicles where possible. On-demand integration can also be leveraged to connect specialized customers to conventional transit. Ontario is home to many communities with varying fare policies and transit infrastructure. While on-demand services can be used to connect specialized transit customers across regions, transit providers must ensure consistent customer and fare policies, accessible infrastructure and travel training are in place to successfully provide interregional travel.
What additional considerations may apply to rural, northern, and Indigenous communities?	• Having conventional transit is not a prerequisite to integrate on-demand with specialized transit. Small communities like the Town of Halton Hills where public transit does not exist are adapting on-demand services to provide better mobility options to all residents, including specialized customers. • To successfully integrate on-demand services with specialized transit, specialized transit providers must work with operations, infrastructure, planning and eligibility departments to determine appropriate customer policies and service parameters, and make necessary infrastructure upgrades. • Rural, northern and Indigenous geographies with limited transit systems have been built for cars. On-demand services pose a risk of adding more cars to the network, however if planned correctly, on-demand can be leveraged to connect customers to other cities through multi-modal trip connections to transit hubs. • Having the right transit infrastructure like accessible bus shelters, customer education and communication is key for successful adaptation.
Who are the current technology vendors,	• There are several on-demand vendors that provide specialized/paratransit integration. • The following lists On-demand system vendors (headquarters noted in parentheses):

Case Study Communities	City of Thunder Bay; Town of Milton
and are there any Ontario-based vendors?	o RideCo (Waterloo) o Pantonium (Toronto) o Spare labs (Vancouver) o Via On-Demand (New York) o Routematch by TripSpark (Demand) (Atlanta) o Blaise Transit (Quebec) o DemandTrans (Chicago) o Moovit (San Francisco) o The Routing Company (Cambridge, MA)
How much might the technology cost to implement (including direct costs and any associated infrastructure or operations upgrades)?	• An annual platform fee of $15k is the base-level price and includes all components of the technology implementation and operation (e.g., hosting the server, annual upgrades, maintenance, training). • The annual fee depends on the number of vehicles in the municipality's fleet. For a fleet size ranging from 5-20 vehicles, this cost typically varies from $350-$400 per vehicle per month.
How much lead time might it take?	• Once an on-demand system is implemented (typically three months), specialized integration can take place in a few months. However, the lead time to ensure customer policies, customer communications, travel training and other considerations are in place can take six months to one year. • If the specialized integration involves integration with a family of services (where specialized customers are dropped off at an on-street bus shelter or transit terminal to connect to other conventional services), the lead time can be longer. • Factors that influence lead time for integrating into a family of services can include determination of service design parameters and policies (e.g., what distance should trips be

Case Study Communities	**City of Thunder Bay; Town of Milton**
	integrated? How many transfers should be involved? How should transfer points be selected?) and capital work to ensure transit infrastructure (bus shelters, terminals, etc.). are accessible and support seamless integration of multimodal trips. The planning and implementation of these elements can take over a year.

APPENDIX A: TRANSIT TECHNOLOGY GLOSSARY

The following table is presented as a glossary of key terms and acronyms utilized in this toolkit.

TABLE 7: TRANSIT TECHNOLOGY GLOSSARY

Term/Technology	Acronym	Definition
Account-based Fare System	N/A	A fare system in which customers register their personal information, fare media, and preferences to track their usage patterns. These systems depend on connection to the central account system for verifying fare payment.
Application Programming Interface	API	A computer code that allows two separate software to communicate and work in tandem.
Automatic Fare Collection	AFC	An integrated and automated ticketing system for transit networks.
Automatic Passenger Count	APC	Systems that track the boarding and alightings of customers at each stop, noting time, location, and direction of each passenger.
Automatic Stop Annunciation	ASA	Integrated audio system that provides relevant announcements to customers in transit platforms and vehicles.
Autonomous Vehicle	AV	A self-driving vehicle that does not require a driver/operator. There are six levels of automation (Level 0 to Level 5) to define the extent of a driver's involvement on the vehicle's operations and its degree of autonomy.
Bid Selection	N/A	Bid selection refers to the bidding process of selecting shifts based on seniority.
Big Data	N/A	Large datasets that include information on travel patterns and analytics to inform analyses and decision making.
Card-based Fare System	N/A	A fare payment system in which smart cards and smart card readers are utilized to process fares and store information on its transactions. These systems depend on the balance or products stored locally on the card for verifying fare payment.
Closed Payment (closed-loop) System	N/A	A transit fare payment system in which fare media is only valid for a particular transit system.

Term/Technology	Acronym	Definition
Computer Aided Dispatch / Automatic Vehicle Location	CAD/AVL	Systems that facilitate dispatch and tracking of vehicle locations using the real time positioning of each vehicle. This information is then relayed back to a central location.
Cost-Benefit Analysis	N/A	Compares and reflects the societal costs and benefits in monetary terms for proposed projects, technologies, and policies. Calculates net benefits and losses based on economic fluctuations.
Electric Vehicle	EV	A vehicle that is propelled by electricity, usually stored on-board in the form of a battery or other alternative fuels such as hydrogen fuel cells.
Geographic Information System	GIS	System to store, capture, visualize, and analyze spatial and aspatial data.
General Transit Feed Specification	GTFS	Compilation of transit data used primarily for integrating with travel planners such as Google Maps and other third-party transit information tools.
Geofencing	N/A	A digital barrier that fences off where a vehicle (like an automated vehicle, e-scooter, or drone) can operate.
Graphical User Interface	GUI	The front-end that a user sees and interacts with in a software system.
Intelligent Transportation Systems	ITS	The integration of technology to improve or enhance a transportation system.
Internet of Things	IoT	A large network of connected devices that utilize sensors and processors to collect, communicate, transfer, and share data. Virtually anyone or anything can be connected to the IoT.
Key Performance Indicators	KPI	Selected quantifiable measures used to evaluate the productivity and efficiency of a technology, program, policy, service, etc.
LiDAR	N/A	A survey method using light detection, sensors and ranging to detect targets and to measure the distance to them.
Mobile Data Terminal	MDT	A computerized device mounted in vehicles to receive information and facilitate communication with a central dispatch/control system.
Mobility-as-a-Service	MaaS	A system that integrates planning, booking, and paying for multiple modes of transit services into one platform.

Term/Technology	Acronym	Definition
Open Payment (open-loop) System	N/A	A transit fare payment system in which third party media payments (e.g., bank cards and mobile devices) are permitted as fare media.
Open Source	N/A	Publicly accessible information/data that can be modified and used by virtually anyone.
Software-as-a-Service	SaaS	Software and applications that can be delivered and accessed online.
Specialized Transit	N/A	Specialized Transit is the common parlance for Paratransit in Ontario.
Stored Value Fare Card	N/A	A prepaid fare card loaded with a specific value.
Transit Signal Priority	TSP	Systems that alter the timing of traffic signals according to the detection of incoming transit vehicles to enhance service performance.
Transportation Network Company	TNC	Ride share companies that provide on demand transit services through web/mobile apps

APPENDIX B: SAMPLE RFP EVALUATION TEMPLATE

The following is a sample evaluation template that can be adapted to score a technology RFP.

Scoring Guidelines:

- Poor : 0-49
- Marginal: 50-69
- Good: 70-89
- Very Good: 90-100

Company:				
Evaluator:				
EVALUATION CRITERIA	**Weight**	**Score**	**Total**	**Comments**
1. Completeness of Solution - Case Management	**20%**		0.0	
a) Case (or ticket) Management function				
2. Completeness of Solution - Customer Interaction	**20%**		0.0	
a) Contact Management function to manage customer and partner profiles				
b) Customer Login function to track communications				
c) Email Campaign function				
d) Monitor and capture interactions from social media				
e) Chatbot function				
3. Completeness of Solution - Reporting and Administration	**5%**		0.0	
a) User Management function to manage access and permissions				
b) Reporting function				
4. Completeness of Solution - Knowledge Center	**5%**		0.0	
a) Knowledge Center function to aid in responses				
5. Service level agreement and vendor support services	**15%**		0.0	
6. Implementation process and timeline	**10%**		0.0	
7. Integration and Data Migration Capabilities	**15%**		0.0	

a) Integration with Client Website				
b) Integration with Outlook Email				
c) Integration with Phone Systems				
d) Integration with proprietary systems				
8. Training and User Resources	**10%**		0.0	
TOTAL WEIGHTED SCORE	**100%**		**0.0**	

APPENDIX C: SAMPLE PROJECT ACTION ITEM LOG TEMPLATE

The following is a sample structure for a project action item log, used for tracking requests and actions during the implementation phase. In many cases, vendors may use a spreadsheet application to house the log. Guidance is provided in the first row to indicate how the template is intended to be completed and subsequently updated.

ID	Date Added	Target Date	Action Item / Description	Priority	Owner	Status	Updates / Comments
1	*Insert Date*	*Insert Date*	*Insert text description of the action item*	*High / Med / Low*	*Initials of individual responsible*	*Open / Paused / For Review / Closed*	***2022-07-20**: Insert text description of updates and comments.* ***2022-07-21**: Add the date in bold when new comments are added*
2							
3							
4							
5							
6							
7							
8							
9							
…			*Add additional rows as required*				

APPENDIX D: SAMPLE RISK REGISTER TEMPLATE

A key output of the risk assessment process described in Section 5.2.3 is a risk register. The risk register documents foreseen risks, potential impacts, associated mitigation plans, and people responsible for taking appropriate actions. The following sample risk register can be tailored for technology implementations.

Project Name:
Date Updated:
Updated By:

Risk Number	**Risk Name**	**Effect/Description**	**Probability** (Very Low, Low, Medium, High, Very High)	**Severity** (Very Low, Low, Medium, High, Very High)	**Management Strategy** (Mitigation)	**Comments**
Example	*Employee Safety*	• *Employees becoming injured on the job* • *Operational impact, reputation risk, long term disability payments, worker shortages*	*Very Low*	*Low*	• *Maintain health and safety training and policies in line with Municipality/Agency standards (Workplace Safety Insurance Board, etc.)*	
1		·				
2		·			·	
3		·			·	

APPENDIX E: SAMPLE IT ADMINISTRATOR JOB DESCRIPTION

The following is a sample job description for an IT or System Administrator. Transit providers can use this sample to get a sense of the type of responsibilities that may be given to such a position, but should adapt this to the IT environment and context of their jurisdiction.

IT ADMINISTRATOR
JOB DESCRIPTION:
This position is responsible for providing technical support, maintenance and design for Intelligent Transportation Systems (ITS) and Information Technology (IT) infrastructure for various transit technologies such as CAD/AVL systems, fareboxes, passenger announcements, and on-board communication systems. Additional responsibilities may include assistance with data collection, technology inventory management, and statistical and systems analysis.
DUTIES AND RESPONSIBILITIES:
• Work with systems support staff to ensure servers, storage and network equipment are operating optimally. • Conduct regular monitoring and inspection of all transit customer-facing systems including fareboxes and fare card reader systems, CAD/AVL and onboard signage or announcement systems (ITS), manifest tablets, customer-facing advertisement and/or public information systems to ensure consistent performance. • Coordinate onsite review and conduct acceptance testing of all ITS technologies installations. • Coordinate the work of maintenance of real-time information systems and conducts field checks of equipment/ electronic signs. • Troubleshoot issues related to the operating system, server, storage, network, and cloud (where applicable). • Work with internal teams and external support vendors to resolve incidents, fulfill requests, implement changes, and conduct maintenance activities. • Respond to escalated service requests for any reloading and diagnoses, repair, maintenance or replacement of components/ programming of all electronic registering fareboxes and ITS equipment to maintain data integrity and on-time customer service. • Manage, implement, and support the design of computing infrastructure plans, disaster and recovery plans, develop training tools and maintain documentation for standard infrastructure operating procedures, processes, and design (e.g., create and maintain network and server data flow diagrams).

- Administer Windows and Linux/Unix servers on Hyper-V, VMware and Oracle Virtual environment.
- Oversee identity and access management, including administration of Active Directory.
- Maintain an inventory, database and accurate record of repair of transit technology assets. Where available, develop and maintain a computerized asset management system for transit on-road assets. Collect annual reports on asset conditions and usage and provide recommendation for replacements or upgrade for budget preparations by management.
- Assist with data collection, calibration & validation of on-time performance data, passenger surveys and field investigations to support service planning. Prepares and submits reports regarding operational or equipment performance issues upon request.
- Provide technical requirements and input to request for purchase (RFP) and tenders. Establish guidelines for installation, configuration and management of host computer operating software and hardware products.
- Assess, plan and monitor the availability of and capacity of infrastructure to make recommendations based on feasibility and projected growth.
- Develop and control project and program timing, budgets, expenditures, and governmental reporting requirements.
- Conduct research on innovative technologies, new technology development, and industry trends to evaluate new services and identify opportunity for improvement.
- Implement and maintain security systems related to firewalls, networking devices, and virtual private network (VPN). Recommend, maintain, and implement security policies and procedures to ensure security of infrastructure and sensitive data. Conduct annual security audits to ensure regular compliance.
- Conduct ongoing performance monitoring of and reporting of IT infrastructure and applications.

SUGGESTED EXPERIENCE AND QUALIFICATIONS:

- Graduate of a three-year program at a recognized educational institution in Computer Science or Information Technology, with particular emphasis on system administration or an equivalent combination of education, training, and experience in a complex IT environment.
- Certifications recognized include Microsoft Certified Solutions Expert (MCSE), Red Hat Certified System Administrator, CompTIA Server+ and VMware Certified Professional, or similar role-based certifications or experience are deemed equivalent.
- Minimum five (5) years' experience in system administration and support of Windows Enterprise Server; Microsoft Exchange; Microsoft SCOM, SCCM; VoIP, routers, and switches; Windows 10, Defender and Office 365. Other directly related experience in

server installations and demonstrated skills working in a virtual environment using Hyper-V and VMWare are considered.

- Knowledge and proficiency in Intelligent Transportation System (ITS) programs including CAD/AVL, transit scheduling software and associated payroll components.
- Proficiency in the analysis, troubleshooting and use of fareboxes, ITS systems and various data reporting modules or equivalent.
- In-depth knowledge of industry best practices covering computer and network security, Active Directory design, group policies and Exchange.
- Excellent research, analytical, and problem-solving skills.
- Excellent written and verbal communication skills and ability to work effectively in a team independently.

APPENDIX F: TYPICAL ITS TECHNOLOGY LIFESPANS

The following is a summary of the typical lifespan of the ITS technologies described in Section 0. Lifespan refers to how long a municipality can expect to get value from operating the system.

Transit providers can use this table to evaluate the remaining useful life in their current technologies, plan for their replacement, and prepare capital budgeting forecasts (in conjunction with Appendix G: Budgeting Tables.)

TABLE 8: SUMMARY OF TYPICAL TECHNOLOGY LIFESPANS

System/Technology	Typical Lifespan (Years)
Fully featured Fixed Route CAD/AVL Suites	8-12
On-board announcement system	8-12
On-board emergency alarm	8-12
Transit Signal Priority	8-15
Data and Voice Communication	5-15
Performance Monitoring Application	8-12
Control Centre Video Monitoring	5-8
Closed Circuit Television (CCTV) Systems	5-12
Precision Curbside Alignment System	TBD
Wayside Emergency Call Boxes	12-15
Wayside public address systems	10-15
Geographic Information Systems	5
Station/Platform Adaptive Lighting	5-8
AVL-only solutions	2-6
Ticket Vending Machines	3-5
Platform Boarding Gates (Screen Doors)	12-15
Farebox Systems running CAD/AVL applications	5-10
Fareboxes	10-15 electronic (registering) 20-30 gravity (dropbox)
Smart Cards an Automated Fare Collection Systems	5-10
On-board fare collection with fare media validators	5-10

System/Technology	Typical Lifespan (Years)
On-board and wayside infotainment	4-8
On-board farebox (legacy)	10-12
On-board self-serve ticket machines	3-5
On-board and wayside WLAN	4-6
Off-board fare collection with fare media validators	5-10
Real-time Information System (with alerts)	5-8
Operations Management Software, including Bid/signup management, Workforce Management, Operator check-in applications at kiosks	5-10
Yard Management Systems	3-8
Fixed Route Scheduling Software	5-10
Historical Performance Reporting Tools	2-5
Paratransit scheduling software, including client management, booking/reservations, scheduling, CAD, AVL, Operations Management	4-8
On-Demand Scheduling Software (e.g., for microtransit)	TBD
On-board Surveillance Systems	5-8
Runcutting Optimization Software	5-10
Wayside Surveillance Systems	5-8
Wayside next bus signage	8-12
MaaS and other evolving Mobile Apps	N/A
Trip planners	2-5
RTPI and GTFS/GTFS-RT	5-8
Mobile ticketing back-office functionality	5-10
Mobile ticketing	3-5
Mobile Apps	2-4
Phone systems (customer care ACD)	10-15
Call/Line Recorders	10-15
Interactive Voice Response (IVR) Systems	10-15
Land-mobile radio	15-20

System/Technology	Typical Lifespan (Years)
Automatic Passenger Counter (APC) Sensors	10-15
Automatic Passenger Counter processing system	15
Automated Vehicle Announcements (AVA)	8-12
Vehicle Component Monitoring (VCM)/Automatic Vehicle Monitoring (AVM) Systems	8-12
On-board routers	10-15
Customer Relationship Management (CRM)	8-12
Passenger wayfinding technology	2-5
Integrated planning platforms	3-5
Route/Network Planning tools to restructure routes and networks	2-5
Asset Management Systems	10-15
Electric vehicle and battery health monitoring systems	TBD
BI and Data Warehouses/Databases	5-10

APPENDIX G: BUDGETING TABLES

Developing budgets for technology projects can be challenging, especially for transit systems with limited previous experience in the area. It is important to follow good budgeting principles when estimating the type and level of resources required for a project to meet its objectives and resist the urge to 'back-in' predetermined values. This can occur when organizations are unable to determine the actual required effort because of lack of understanding. Alternatively, estimates are sometimes inflated to reach a known value or to serve as a protection against uncertainty in the project, which may better be addressed by considering contingencies.

To support transit systems with preliminary budgeting, this appendix provides high level budget ranges for different technologies. You can use these to support your research, but we suggest additional steps in Section 3.3.1 to get a sense of how much budget your specific initiative may take.

Operating Performance and Schedule Adherence Monitoring Technology (CAD/AVL)	Cost Range/Structure
Performance Monitoring Application	$200k-$500k Central Software (including monitoring, schedule adherence, incident management, detour management, driver attendance, and communications control)
Control Centre Video Monitoring (Video Wall)	$2k-$5k per flat screen monitor, plus video management system/application
On-board Announcement System	$4k-$8k per vehicle, plus $20k-$40k central application
On-board Emergency Alarm	$400-$1000 per vehicle, plus $2k-$4k per vehicle integration with Communications link (radio or cellular)
Transit Signal Priority	$1500-$4k per vehicle, plus $30k per intersection (wayside), plus $30k-$40k centralized application
WLAN Infrastructure (Garage and Onboard to upload and download data)	$500-1500 per vehicle, plus $3k-$5k per access point within garage, plus network and electrical infrastructure

Operator Management and Support Software	Cost Range/Structure
Bid/Signup management	$20k-$75k add-on to fixed route scheduling software
Workforce Management (HR ERP system or Payroll)	n/a
Operator Check-in kiosks	$5,000-10,000 per kiosk, plus application software
Operator Performance Module (g-force monitoring)	$500-1000 per vehicle (hardware), plus Vehicle Component Monitoring System

Yard Management Systems	Cost Range/Structure
Vehicle Tags	$150-250 per vehicle
Wayside sensors, switches	$10k - $200k per garage (plus electrical infrastructure)
Central Software	$40k-$100k
Integration (with Scheduling and CAD/AVL)	$15k-$30k
Integration (with Maintenance)	$15k-$30k

Demand Responsive Transit Software	Cost Range/Structure
Specialized Booking/Reservations/Scheduling	$100k-$300k central application, plus $2k-$5k per vehicle (hardware)
On-demand Booking and Scheduling	Pricing models vary dramatically. They may include some element of up-front implementation cost or be fully license-based. The pricing is also closely linked to whether the organization is procuring service provision of the on-demand service, or only software.

Safety and Security Systems	Cost Range/Structure
CCTV	$2000-4000 per camera, plus network, storage, and integration. Monitoring application included.
Wayside Emergency Call Boxes	$1500-$3000 per call box, plus network (Ethernet/Fibre, cellular, or POTs)
Integration - CCTV/ECB	$15k-$25k integration module
Onboard CCTV (with onboard NVR)	$1000-2000 per camera, plus $5-10k per NVR, plus $5k-$25k playback/streaming application, plus wireless network usage for streaming
Integration - Onboard CCTV/CAD/AVL (time/location stamping)	$500-$1000 per vehicle

Additional Operations Technologies	Cost Range/Structure
Station/Platform adaptive lighting	$10K-$20K per platform
Platform Boarding gates (screen doors)	$2M-$5M per station

Customer Experience (Fare Collection)	Cost Range/Structure
Fareboxes (Registering)	$20-30k per vehicle, plus $20-40k wayside probe, plus $75-150k central software
Smart Cards and Automated Fare Collection Systems	$3-5k per validator, plus $50-150k central software; $5-$8 per card
Ticket Vending Machines	$25k-$50k each, plus network, plus credit/debit transaction
Mobile Ticketing	$20-50k website, plus Automated Fare Collection System

Customer Information	Cost Range/Structure
RTPI (Real-time Passenger Information) (arrival prediction, information dissemination control, integration to CAD/AVL & Scheduling)	$65k-$225k central application
GTFS/GTFS-RT (General Transit Feed Specification)	$20-40k one-time integration (with Google)
Trip Planners	$50-150k (requires GTFS or scheduling system)
Wayside Next Bus Signage	$5K-$15k per sign plus network
Mobile Apps	$50-100k (if developed in-house)

Customer Service Systems	Cost Range/Structure
Phone Systems (including IVR and Call Centre ACD)	$150-250 per phone (non-recurring), plus $15-$20 per month per phone (recurring)
IVR Integration with CAD/AVL, and Para-Trans scheduling	$50k-$150k
Customer Relationship Management	$25-$50 per month per user

Other Customer Experience Technologies	Cost Range/Structure
Wayside Public Address Systems	$25-35k per bus platform (amp, speakers, wiring) plus $30-50k per control centre headend
Passenger Wayfinding Technology	$1500-2500 per stop, plus $25k-$50k application and integration
On-board and Wayside WLAN (for customer use)	$2-3k per vehicle, plus $10k-$15k per platform, plus $25-35k headend, plus Network, plus usage
On-board and Wayside Infotainment	$3-5k per vehicle + $50-150k for content management system (as add-on to CAD/AVL)

Service Planning – Route and Networking Planning	Cost Range/Structure
Performance Reporting tools	Some applications moving to an annual subscription by user
Georgraphic Information Systems	$20-$65k
Integrated planning Platforms	$5-$15K Annual subscription based on users and fleet size.

Service Planning – Transit Scheduling	Cost Range/Structure
Fixed Route Scheduling Software	$75k-$200k
Runcutting Optimization Software	$25k-$75k
Automatic Passenger Counters	$3k-$5k per door, plus $20k-$45k central application

Maintenance	Cost Range/Structure
Asset Management Software	$50k-250k software
Vehicle Component Monitoring System	$100k - $200k software, plus $2k-$4k per bus hardware
Electric vehicle management and battery health monitoring systems	Unknown

Management and Administration	Cost Range/Structure
General Business Applications (Microsoft Office 365, etc.)	$200 - $1000 per user per year
Analytics and Business Intelligence Tools	Technology: SQL Server/Storage/ETL/BI $50k-$300k Startup Consulting $200k-$300k

APPENDIX H: SAMPLE RFP LIBRARY

A library of sample Request for Proposals (RFP) has been curated for various transit technologies. These RFPs have been gathered from small to medium sized transit systems to use as reference for developing functional and technical specifications.

The library contains sample RFPs for the various transit technologies including the following:

- CAD/AVL System (including APCs, real-time passenger information and announcements)
- System for Real Time Arrival Alerts and Accessible Wayfinding
- Fare Collections and Mobile Ticketing System
- On-demand/Microtransit System
- Scheduling System
- MaaS and Multi-modal Trip Planning System
- Battery Electric Buses and Charging Infrastructure
- Data Management and Analytics Software

The sample RFPs have been packaged in a ZIP file. You can email mto.smart.mobility@ontario.ca to request a copy. The list of documents included has been indexed below.

These RFPs are intended to be used as guidance for procurement. Transit providers are recommended to develop their own specifications based on specific needs and use cases.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
1	Bay Area Transportation Authority (BATA)	N/A	City	Unknown	Fixed Route CAD/AVL and Route Planning ITS	- Cloud-based or browser-based SQL server communications system to schedule driver assignments, trip schedules, automatic trip status updates, GPS vehicle location, and route navigation. - Automated tablets or mobile data terminal (MDT) working with a cloud-based server through an information transfer system (e.g. modem, radio, etc).
2	City of Medicine Hat	4	Small	16	Supply & Implementation of Transit Technologies & Management Software for CAD/AVL and/or Electronic Fare Management Systems	- Installation of CAD/AVL with MDT - Automated fare collection system with contactless payment options (e.g. digital ticketing, QR codes/smart card, etc.)

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
3	Southern Teton Area Rapid Transit (START)		Rural	30	Intelligent Transportation Systems (ITS) - CAD/AVL/APC and Mobile Ticketing - Electronic Fare System	- CAD/AVL to work in tandem with an onboard TSP hardware. - Software for scheduling and dispatching. - Electronic mobile ticketing. - GTFS feed and algorithm implementation.
4	Mountain Rides Transportation Authority (MRTA)	N/A	Small	26	Intelligent Transportation System for Fixed Route	An intelligent transportation system (ITS) that includes CAD/AVL, digital voice annunciation sysem (DVAS), mobile data terminal (MDT), APC, real time passenger info via signage/web and mobile apps.
5	Napa Valley Transportation Authority (NVTA)	N/A	City	Unknown	Automated Demand-Response Dispatch Software System	- Open "client-server" architecture. - MDT systems integrated with CAD/AVL systems for on-demand service.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
6	Regional Municipality of Wood Buffalo	4	Rural	57 conventional fleets 10 specialized fleets	Transit Scheduling and Dispatch Software System, Automated Passenger Counters and On-Demand App	- Transit app - Dispatch system for conventional and specialized fleets. - Proposed scheduling software to use GIS to map and contain functionalities.
7	City of Fredricton	N/A	Small	28	Automated Vehicle Location (AVL)/Fleet Management System	- System to be compatible with a wide range of legacy interfaces (including low emission vehicles). - Ability to send real time data.
8	City of Barrie	4	City	48	Automatic Vehicle Location (AVL) and Associated Web-based Software RFP	Upgrading current AVL system and associated web-based software.
9	City of North Bay	5	City	21	Dynamic Dispatching System Pilot Program	Seeking a cloud-based booking system that can be easily integrated and compatible with

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
						existing city systems and IS standards
10	Sound Transit	N/A	Small	Unknown	Real Time Arrival Alerts and Accessible Wayfinding	- Solution that enables passengers to travel from the station entrance to the platform and correctly identify and board the train of their choosing. - Solution should alert passengers that they have reached their destination stop and help navigate them to the exit.
11	City of North Bay	5	City	21	Transit Electronic Fare Management System	- Electronic, QR code, bar code, or "tap card" system using smart cards or mobile payments. - Enables multi-ride tickets to be electronically processed.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
12	City of Brandon	5	City	17	Automatic Fare Collection System	Exploring options to replace existing fareboxes.
13	Sault Ste Marie Transit	4	City	28	Fare Collection System	Planning for a new electronic fare collection system to replace aging fareboxes.
14	Eastern Upper Peninsula Transportation Authority	N/A	Rural	3 local vehicles and passenger ferries	Ferry Fare Collection System	- Replacing existing fare system with a cloud-based, hosted mobile ticketing solution. - Includes customer mobile app, validating mobile app (for staff to validate tickets), and a back-office system (hosted environment or as a SaaS).

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
15	VIA Metropolitan Transit	N/A	City	Unknown	Smart Cards	Contactless smart cards with microprocessor to function with an automated fare collection system.
16	Halifax Regional Municipality/Halifax Transit	3	Small	387	Mobile Ticketing Solution (MTS)	System to enable passengers to purchase electronic tickets/passes through a mobile application
17	Town of Okotoks	N/A	Small	4	On-Demand Transit Services	- On-Demand booking/scheduling/dispatching software - Automated customer service phone line - On-Road Monitoring and Scheduling Management - Two-way vehicle communication equipment
18	Town of Milton	4	Small	27	On-Demand Microtransit Solution	- Microtransit solution under a Software-As-a-Service (SaaS) model - Scheduling/dispatching/optimizing/online

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
						booking functions - Onboard technology supports (e.g. mobile data units with cellular capability)
19	City of Airdrie	4	Small	13	On-Demand Transit Services	solution that provides all aspects of the OnDemand Service such as the software application/platform, vehicles, drivers, and other potential elements.
20	Bay Area Transportation Authority (BATA)	N/A	City	Unknown	Paratransit/Micro-transit CAD/AVL and Scheduling ITS	- Paratransit/micro-transit CAD/AVL, scheduling software and hardware for paratransit/micro-transit fleet. - Cloud based system, SQL server, or agency-based server for on-demand, demand-response, and scheduled para-transit service. - Compatible with tablets or MDTs and

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
						must work with CAD/AVL.
21	Municipality of Chatham-Kent	N/A (106k)	Small	16 vehicles (owned, operated, and maintained by InTouch Connections, Voyago & Citilinx)	Demand-Responsive Transit Software Platform	- Software-as-a-service (SaaS) platform to operate demand-responsive public tranist service. - Platform will facilitate trip requests by the rider (app/web portal), operator (table-based app), specialized transit trips, and mix of conventional and specialized transit using same vehicles. - Capture, store, and report data.
22	Municipality of Leamington	5	Rural	2	On Demand Transit Service Pilot Program	- Software solution for on demand transit. - Integration of Google maps or esri gis for real time position of bus.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
						- GPS track to monitor bus mileage.
23	City of Hamilton	2	City	267	Demand-Responsive Transit Pilot	Software/technology platform to support the routing and dispatching of demand-response service.
24	City of Saskatoon - Saskatoon Transit	3	City	125	On Demand Service	On-demand under SaaS model.
25	Region of Waterloo	2	City	290	Software and related Technology and Services for On-Demand Transit Service Delivery	- On-demand transit solution under a SaaS model. - Software solution should be able to trip book, dispatch, share, route, and integrate with fixed route to facilitate connectivity. - Support mobile and app fare payments, or integration with future payment platforms.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
26	C-Tran	N/A	City	Unknown	Microtransit Technology Platform	- Implementation of MaaS software for an on-demand microtransit service, including solution for automated scheduling, dispatching, and booking. - Solution can integrate real time operations technology based on demand.
27	Town of Oakville/Oakville Transit	3	City	101	Conventional Fixed Route Transit Scheduling and Driver Management System	A driver management system to integrate with route transit scheduling and payroll systems.
28	Lane Transit District (LTD)	N/A	City	Unknown	Multimodal Trip Planner	Software solution providing access to various modes of transit (e.g. fixed route, on demand transit, first/last mile connections, etc.) into one singular platform.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
29	Chattanooga Area Regional Transportation Authority (CARTA)	N/A (73k)	City	105	Mobility as a Service (MaaS)	- Microtranist solution under Phase 1 of a mobility-as-a-service (MaaS) model/program. - Integrated web/mobile/app-based service to support the planning, booking, dispatching, and payment of microtranist.
30	Capital MTA	N/A	City	315	Electric Buses and Chargers	Detailed specifications for 40ft and 60ft ebuses and supporting charging infrastructure.
31	Eastern Contra Costa Transit Authority (ECCTA)	N/A	City	Unknown	Charging Station Installation	Specifications for installation of 2 electric bus chargers.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
32	City of Guelph	3	City	102	Electric Bus Charging System and Associated Electrical Upgrades at Guelph Transit's Watson Road Facility	Consulting services for ebus charging system and facility upgrades.
33	City of Lethbridge	4	City	48	Transportation Data Management and Analysis Software	- Software that can store, organize, and analyze various transportation data collected about the City. - Data collected includes but not litmited to: bicycle counts, vehicle movements, traffic signal warrants, shortcutting studies, etc.

Number	Agency/Municipality	CUTA Group Number	Size (ex. Small/Rural, City)	Fleet Size	Technology	Technology Description
34	City of Barrie	4	City	48	Transit Planning Analytics Software	Cloud based Transit Planning Software that can provide reports on summaries, graphs, and maps based on data collected from APCs and AVLs.
35	Brampton Transit	2	City	450	Replacement of On-board Cameras and Video Recorders on Brampton Transit Buses	- Replacement and installation of on-board security cameras and video recorders with the capability to also record audio in vehicle fleets. - Support wireless downloads of recordings.

APPENDIX I: DETAILED CASE STUDIES

Case Study: Implementing a Trunked Radio System for Transit Operations

Thunder Bay Transit has conducted a replacement of their conventional radio system due to its posed difficulty in providing clear communication between dispatchers and drivers. The City of Thunder Bay adopted a trunked radio system for emergency and transit services which has significantly improved the efficiency of dispatch management.

COMMUNITY:	City of Thunder Bay
POPULATION:	107,909
TRANSIT SERVICE PROVIDER:	Thunder Bay Transit
TYPE OF SERVICE:	Local, in-house service
CONVENTIONAL BUSES:	48
SPECIALIZED VEHICLES:	26
ANNUAL SERVICE HOURS:	146,817
COMMUNITY TECHNOLOGY STATUS:	Modern
RADIO SYSTEM TECHNOLOGY PROVIDER:	Not provided

Thunder Bay Transit is operated by the City of Thunder Bay and provides urban-centric local connections to the community, from the County Fair Plaza to Lakehead University, to Fort William First Nation Business Park. Service is provided 7 days a week across 17 routes, with a fleet of 48 low-floor and accessible buses and 26 specialized vehicles.

Technology Profile: Trunked Radio System

A trunked radio system provides independent, dedicated channel(s) of communication from buses to a dispatch console. When an operator pushes the “talk” button, the system will automatically connect them to dispatch, placing them in a separate, unused communication channel. Dedicated communication channels allows drivers to correspond with dispatch directly, without interference from other users on the line. This varies from a conventional radio system where every radio uses the same line to connect to dispatch. This creates radio “chatter” as every operator can hear every other user. This creates situations where an operator needing assistance may have to wait for on-going conversations to be over before they can access dispatch. Therefore, trunked radio systems provide a more manageable system as concurrent radio “chatter” is diminished and dispatch can more easily respond to individual drivers. Trunked radio systems are the preferred solution of transit systems in general, particularly in mid-sized and larger transit systems with more simultaneous radio users at any given time.

Year Implemented: 2021	**Stage of Lifecycle:** The technology has been planned, procured, and implemented. It is now in the administration and maintenance stage.	**Set-up Timeline Before Deployment:** Not available – the system was implemented as the final stage of city's corporate radio system upgrade

Purpose of Implementation: Replacement

Prior to the transition to the trunked radio system, Thunder Bay Transit operated using a conventional system. Conventional radio systems have a single line, that anyone can access at any time, often simultaneously, resulting in constant radio chatter. This can become difficult for drivers and dispatch to communicate with one another effectively.

Thunder Bay Transit (TBT) is a department within the corporation of the City of Thunder Bay. However, it has the autonomy to identify and address internal needs based on peer and industry review. TBT recognized that their current conventional radio system was not working efficiently, nor was it the standard of the transit industry (trunked radio systems are the standard for mid-sized and larger transit systems).

Before TBT had the chance to procure a new system, the City of Thunder Bay replaced their conventional radio system with a trunked system across the corporation. They began by first replacing the systems of emergency services (fire, EMS, and police), and eventually expanded to include Thunder Bay Transit (while it is one trunked radio system, each individual service uses unique dedicated channels so there is no overlap between transit and police, for example). This was a corporation-led implementation which corresponded with Thunder Bay Transit's internal need for a more efficient communications system.

Organizational Impacts

In terms of technology complexity, the conventional and trunked radio systems are operated in a similar fashion – both have dispatchers waiting to respond to operators – so organizational impacts are more negligible than if they were implementing new technology. Further, Thunder Bay Transit was the last department within the city corporation to transition to the new trunked radio system. This provided TBT with insight into the implementation process, as well as lessons learned from other departments who deployed earlier. Notwithstanding, TBT experienced the following impact:

- Organizations using trunked radio systems require a stationary console from where dispatch must respond to operators (as opposed to their conventional system where they had mobile radios). This requires a dedicated staff member being stationed at the console.

As a staff member is required to always manage the console directly, this system increases staff requirements.

Implementation Considerations

Implementing new technology may have considerations beyond organizational impacts. Thunder Bay Transit identified an implementation consideration pertaining to staff familiarity and comfort.

- Operators require time to adjust to the new system (i.e., operators can only communicate directly with dispatch, or select operators may require time to adjust to the absence of radio chatter).

Realized Benefits

Thunder Bay Transit experienced operational advantages after switching to a trunked radio system from a conventional one. Benefits identified included:

- Easier management for both operators and dispatch as the trunked radio system automatically connects the operator to dispatch on an unused frequency when the talk button is pushed. This provides the operator with an immediate and direct line of communication to dispatch whereas in the previous system they would have had to wait until other radio chatter was over before being able to speak. Similarly, dispatch now have multiple direct lines for one-on-one communication and can focus more readily on a task-by-task basis.
- Thunder Bay Transit noted that communication efficiency improved after changing radio systems. The experience of other transit providers in North America has indicated a similar, albeit marginal, improvement.
- Increased driver safety. While radio chatter may have been minorly distracting, similar to the first bullet, a one-on-one communication line allows for dispatch to respond more promptly if an operator reports a situation.
- The provision of an archived audio log. These archived logs allow for the storage and retrieval of quality field recordings that can be analyzed. This is useful to analyze the performance of dispatch, or if an operator is assailed or encounter another problem while driving.

Lessons Learned

A trunked radio system requires a dedicated dispatch employee. Therefore, this type of new technology does not automatically relieve staff and/or expertise requirements – sometimes it increases. Similarly, new technology can increase job duties and responsibilities for certain positions, making these positions more difficult to fill.

Case Study: Deploying CAD/AVL through the Metrolinx Transit Procurement Program

Sault Ste. Marie Transit's aging CAD/AVL system required replacement to ensure continued reliability of service. The community participated in the Metrolinx Transit Procurement Initiative to procure a new solution from CONSAT.

COMMUNITY:	City of Sault Ste Marie
POPULATION:	73,300
TRANSIT SERVICE PROVIDER:	Sault Ste. Marie Transit
TYPE OF SERVICE:	Local, in-house service
CONVENTIONAL BUSES:	28
SPECIALIZED VEHICLES:	11
ANNUAL SERVICE HOURS:	81,799
COMMUNITY TECHNOLOGY STATUS:	Modern and continually improving
CAD/AVL TECHNOLOGY PROVIDER:	CONSAT

Sault Ste. Marie Transit is operated by the City of Sault Ste. Marie and provides urban connections within the city. Service is provided 7 days a week. They have 8 conventional routes, with on-demand service provided on weekend evenings.

Technology Profile: Computer-aided dispatch / automatic vehicle locations systems

CAD/AVL (Computer-Aided Dispatch / Automatic Vehicle Location) collects real-time location data from buses and identifies whether they are running early or late, how far they have travelled, if they are stopping at the correct stop points, schedule adherence, breakdowns, emergencies, and AODA compliance (the AODA requires all transit vehicles must verbally announce approaching bus stops). All this information can be used by back-office staff and dispatchers to improve performance, understand ridership trends, and provide more accurate information to transit users and council. This data can also be synchronized to in-vehicle peripherals for the drivers and customers (head signs, stop annunciation) as well as passenger information systems (websites and apps).

Year Implemented: 2021	**Stage of Lifecycle:** The technology has been planned, procured, and implemented. It is now in the administration and maintenance stage.	**Set-up Timeline Before Deployment:** 6 months

Purpose of Implementation: Replacement

Sault Ste. Marie Transit had a CAD/AVL system prior to procuring this new system. The old CAD/AVL system was approximately 20 years old and did not provide as many features or collect as wide of a variety of data. In September 2021, through the Metrolinx Transit Procurement Initiative, Sault Ste. Marie fully launched a new replacement system on all buses, provided by CONSAT.

Organizational Impacts

CAD/AVL is an organizationally impactful technology. CAD/AVL allows organizations to comply with AODA requirements (stop annunciation) while simultaneously collecting ridership data, recording and reporting on bus logistics, and providing real-time location information for customers. These various components affect a multitude of staff members, from maintenance and customer service to IT services, operators, and management. The following are organizational impacts experienced by Sault Ste. Marie:

- Technology Ownership: Sault Ste. Marie Transit is the owner of the CAD/AVL technology and thus is responsible for the associated maintenance, updates, and cost (as opposed to other technology that may be owned by the city as a corporation and maintained and administered by their internal IT department, for example).

Implementation Considerations

As CAD/AVL is an organizationally impactful technology, it has facets to consider when implementing that relate to service development and data management:

- Data management: Data collected via the CAD/AVL technology is managed internally by Sault Ste. Marie staff. From this preliminary data collected, Sault Ste. Marie staff process and synthesize it into more useable information to inform service development, ridership density, network expansion, and Council recommendations. An alternative to internal data management is having CONSAT (Sault Ste. Marie's CAD/AVL provider), or another third-party vendor, collect the preliminary data.
- Data analysis: The CAD/AVL system provides a large amount of data (outlined under Realized Benefits, below). However, upon receipt, this preliminary data is considered "raw" – it does not immediately display a significant amount of information. To produce relevant information, the data must be manually synthesized by staff, which requires time and knowledge, or be synthesized by the provider (or other third-party vendor), which requires additional costs.

Realized Benefits

As mentioned in the technology profile, CAD/AVL systems have many benefits, both for transit providers and customers. Select benefits of the new, upgraded system, realized by Sault Ste. Marie Transit, include:

- Automated ridership counting and data (APCs)
- Stop utilization data
- Ensured AODA compliance
- Bus and route monitoring
- Bus logistics
- Passenger-facing real-time location information
- Detailed reporting on maintenance data and driver behaviours

Comparatively, the original CAD/AVL system would have had very limited functionality. At 20 years old, the system would have been extremely dated, in both capacity, processing efficiency, and user-friendliness nor would it have had any of the previously mentioned benefits, except for ridership data (notwithstanding software upgrades over time).

Lessons Learned

With a new CAD/AVL system, the biggest challenge is change management and proper training so staff have a high comfort level upon system deployment. Lessons learned from Sault Ste. Marie:

- Staff Buy-In:
    - Is integral to the successful implementation of new technology but takes time.
    - For Sault Ste. Marie, some staff are still not adapted to the new system and require constant reminders to undertake specific tasks. For most organizations, staff resistance stems from new processes that result in the deployment of new technology. Staff who have been used to a particular process for many years are hesitant to change their day to day and many don't see the benefits to be worth the effort required to learn new processes.
- Training:
    - Similarly essential for successful deployment and continued use.
    - For Sault Ste. Marie Transit, staff were trained to support implementation, but training to use the new technology will be on-going for the foreseeable future.[7] Notwithstanding, there are some general best training practices from larger transit

[7] Frequency and type of training needed vary by the technology (complexity), by the organization (some operators may take longer to adjust to the new technology/staff may not have adequate expertise upon initial deployment), and by the vendor (some vendors provide enhanced training sessions and resources).

providers that can apply to smaller ones, such as Sault Ste. Marie in deploying CAD/AVL technology and other technologies. These include:
    - Requiring complete training materials as part of the procurement process
    - Adding supplemental training as a requirement within support contracts
    - Master User" and "Train-the-Trainer" training materials
- Engagement:
  - It is important to engage all relevant staff from the start, before deployment.
  - CAD/AVL technology affects operators, dispatch, support staff, maintenance, and management. Therefore, they are the most important to engage for input prior to releasing an RFP for new technology.
  - Sault Ste. Marie Transit found that the best approach is to engage very early on, although that does not always adequately address concerns and difficulties staff may have in transitioning to the new technology.
  - Having a champion within each department to help answer training related questions and garner buy-in from fellow staff are successful strategies other transit providers have used.
  - If certain staff members cannot be targeted for specific engagement, transit providers should prioritize engaging operators and other employees that interact with the technology daily.

The implementation was quick, but the speed of execution imposed difficulties. Lessons learned include:

- Plan realistic timelines. For Sault Ste. Marie Transit, timelines were tight, and the back-end setup and data input were a much longer process than anticipated. The CAD/AVL deployment was planned for a three-month timeline (similar to the City of Timmins' CAD/AVL deployment). However, SSM had to extend the deadline by three months due to service challenges encountered at the time.

- Anticipate difficulties in installation. Sault Ste. Marie Transit encountered a set-back when older buses began to experience mechanical problems and could no longer function, while their spare buses were being outfitted with the new technology. This resulted in very limited spare availability in the event of bus failings on-street. They have since replaced older vehicles with 14 new buses.

Case Study: Bracebridge Develops a Transit Technology Plan

Due to the new launch of the Town of Bracebridge's conventional and specialized transit service, the town retained the consulting services from Left Turn Right Turn to develop a strategic 5-year Business Plan. This Plan helped identify and design an implementation roadmap for improvements and changes (i.e., transit technology deployment) for developing transit service. While many of the anticipated outcomes of the plan have been delayed due to the pandemic, it has been vital in securing support from council, buy-in from other departments, and budget allocation.

COMMUNITY:	Town of Bracebridge
POPULATION:	17,305 (6,500 within the transit service area)
TRANSIT SERVICE PROVIDER:	Bracebridge Transit – Ride the Wave
TRANSIT SERVICE PROVIDER:	Local, in-house service
CONVENTIONAL BUSES:	1
SPECIALIZED VEHICLES:	1
ANNUAL SERVICE HOURS:	3,290
COMMUNITY TECHNOLOGY STATUS:	Improving
TECHNOLOGY PLAN VENDOR:	Not applicable

The Town of Bracebridge launched conventional transit services in August 2016 with Bracebridge Mobility specialized service launching in January of the following year. The community is served by a conventional fixed-route service that operates in a continuous loop on a one-hour cycle, as well as a demand-responsive specialized service for qualifying customers.

Technology Lifecyle: Planning for Strategic Technology Deployment

In late 2020, the Town of Bracebridge recognized a need to strategically plan for improvements and changes to its young transit service. With operating contracts expiring for both Bracebridge Transit and Bracebridge Mobility in 2021, the town partnered with consulting firm Left Turn Right Turn to produce a strategic 5-year Business Plan, within which was an integrated transit technology plan that was firmly tied to the goals and objectives of the town.

By first reflecting on the successes and challenges of Bracebridge Transit and Bracebridge Mobility since launch, town staff identified strategic goals and objectives for the following five years. Based on these strategic objectives, the plan built up a comprehensive set of recommendations starting from broader transit network improvements down to the enabling technologies that would assist the town in delivering on the commitments made within the plan.

One of the key recommendations included procuring a booking and scheduling solution for Bracebridge Mobility that would be capable of on-demand booking and scheduling to support implementing future on-demand service to augment the conventional fixed-route service. This technology was selected because it closely aligned with key strategic goals including enhancing transit productivity, improving access to transit service for the broader community, enabling transit to respond to demand, improving access to transit service for priority residents and communities, and improving operational understanding. This technology would then be supported by deploying a Bracebridge Mobility booking website and an integrated mobile application to support customer requests.

A significant deliverable as part of this assignment was a roadmap guiding the implementation of various service changes and technologies over the five-year plan. In addition to the demand responsive booking and dispatch software, other recommended transit technologies include a modern fare collection system that can support additional forms of fare media, and a fixed-route CAD/AVL system that can enhance on-time performance and provide real-time communication with drivers and operators. These proposed technology changes aim to improve transit operations and service quality. The Town of Bracebridge has since taken concrete steps with their existing technology vendor to explore developing and deploying these technologies in order to advance their strategic goals.

Year Implemented: 2021	**Stage of Lifecycle:** The technology has been planned, procured, and implemented. It is now in the administration and maintenance stage.	**Set-up Timeline Before Deployment:** 4 months to complete the plan

Purpose of Implementation: Identifying New Technologies

The development of the strategic plan was predicated on a council request to review the service and find ways to innovate and improve transit within the community. While this tends to direct many communities to identify cost-saving measures, the town took this as an opportunity to identify ways that the community could be better served by transit, even if that service required additional strategic investments.

By identifying strategic transit goals within the community, technology recommendations could be prioritized based on their impact. The supporting technology investments could then be justified on the basis that they contributed to community goals and the overall improvement of transit service.

Organizational Impacts

Through the development of the strategic plan and the implementation roadmap, the town was able to reengage with several key stakeholders and realize organizational benefits that service providers can offer:

- Service providers have technology expertise and an understanding of industry best practices, as well as contextually appropriate solutions that may be applied to unique municipalities. By engaging with the contracted service provider through the strategic planning process, the town was able to identify key technology challenges and recommendations were made to improve staff training and communications through new policies and procedures.

It is important to note that no significant changes to the organization were required beyond periodic engagement with consultants over the course of the engagement.

Implementation Considerations

The Town of Bracebridge developed a strategic transit technology plan, which has both similar and different considerations than implementing specific technology.

- Strategic plans must engage with staff during the development stage of the process, or buy-in may be slow. Low buy-in can result in a longer implementation timeline.
- Staff from within the overseeing department (Public Works) as well as planning ans parks and recreation were able to reengage with transit department staff and see benefits to various service and technology enhancements proposed through the plan as contributing to their own strategic goals.

Realized Benefits

The preparation of a strategic plan provided the town with the following benefits:

- Town staff were able to identify key metrics and interim goals that would trigger advances in implementation, such as the appropriate staging of various technology features based on customer reception and capacity.
- Town staff were able to prepare funding estimates based on the technology procurement and ongoing licensing costs presented in the strategic plan.

Lessons Learned

The Town of Bracebridge recognized that an overarching strategic plan which incorporated supporting technologies was more beneficial than their prior dependence on scanning peers for their experiences. This is because technologies and decisions made by peers had slightly different nuances or strategic objectives guiding them, which may not be directly applicable to the scope of their service. The strategic plan allowed staff to consider the impact that they wanted transit to have on the community and allowed for the selection of appropriate, right-sized technologies to fit within that plan.

Additionally, and somewhat unique to the town's plan, town staff appreciated that the implementation plan was defined primarily by staging gates rather than concrete dates. This approach allowed the town to experiment with some of the more innovative service and technology changes, monitor their impact and then decide to proceed to subsequent phases of the plan.

Case Study: Deploying an Integrated Specialized and Conventional On-Demand Technology

In accordance with Milton Transit's 2020 Accessibility plan, the town has identified the need to develop and implement a centralized reservation process and same-day booking features for their specialized transit services. As a result, Milton Transit conducted a replacement of the current specialized transit scheduling and booking system with a new on-demand platform to address this need.

COMMUNITY:	Town of Milton
POPULATION:	126,355
TRANSIT SERVICE PROVIDER:	Milton Transit
TYPE OF SERVICE:	Local, in-house service
CONVENTIONAL BUSES:	20 (2021)
SPECIALIZED VEHICLES:	6 (2021)
ANNUAL SERVICE HOURS:	50,031 (Conventional vehicle hours) N/A (specialized vehicle hours)
COMMUNITY TECHNOLOGY STATUS:	Modern
ON-DEMAND TECHNOLOGY VENDOR:	Spare Labs

Milton Transit operates within the Town of Milton and provides conventional and access+ (specialized) transit service on weekdays and Saturdays. Milton Transit OnDemand is a responsive transit service that was launched in March 2021 to enable customers to connect their trips with other Milton Transit bus routes or GO Transit services through a free mobile application. To use the Milton access+ program, users are required to submit an application that determines the users' eligibility for using the specialized service. Once approved, specialized customers can book a trip by phone or the Milton Transit OnDemand app.

Technology Profile: specialized on-demand booking and scheduling software

Milton Transit procured a dynamic booking and scheduling software that introduced an on-demand platform for its conventional and specialized transit services. Traditionally, Milton Transit's specialized transit service (Access+) required the booking of trips one day in advance limiting the flexibility of users. The procurement of this new technology platform allowed for trips to be scheduled and dispatched in real-time at greater efficiency due to the co-mingling of transit modes. Co-mingling can involve sharing fleet, operator shifts and/or sharing of trips between different services (e.g., specialized and on-demand). This strategy promotes multi-modal trips, dynamic trip scheduling and provides more convenient booking options for all customers. The technology procurement enabled Milton's specialized customers to plan and book their desired trips through their mobile phone at any time, with additional features in the Milton OnDemand app to add customers or request accessibility features. The technology also provides drivers with live updates on upcoming trips along with navigational instruction.

Year Implemented: 2021	**Stage of Lifecycle:** The technology has been planned, procured, and implemented. It is now in the administration and maintenance stage.	**Set-up Timeline Before Deployment:** 6 months

Purpose of Implementation: Replacement

As part of Milton Transit's 2020 Accessibility plan, the municipality was looking to initiate the replacement of the current specialized transit scheduling/booking software to a new system that provides transit customers with more convenient booking options.

The Milton Transit OnDemand platform was launched in two phases, with a timeline from contract award date in January 2021 to launch in May 2021. The technology platform began with the integration with Milton Transit's existing specialized services (Access+) in early May 2021 and was followed by the launch of their new on-demand services a month later. The modified specialized service was launched within two zones; a central urban zone that allowed travel within and to/from the rural zone; and a rural zone that only allows travel to/from the urban zone. Features included a rider mobile application that enabled on-demand specialized trip booking and scheduling, call center support, specialized staff and operator training, and other accessible features planned to be implemented such as an eligibility management tool (Engage).

Organizational Impacts

Milton Transit experienced several organizational impacts as a result of the integration of the specialized on-demand software through a co-mingled service. This platform enabled the servicing of multi-modal trips by integrating conventional and specialized vehicles in the same fleet to be used for both their Access+ and On-Demand services. Some impacts and considerations include:

- Having an adequate number of staff and resources present to execute the project plan and adhere to the desired timeline (e.g., to create new standard operating procedures for the system).
- Change management and training to support staff to embrace the new technology and processes.

Implementation Considerations

Other considerations for Milton Transit relate to service design and development, as well as changes to select customer-facing processes:

- Changes to service design and configuration (i.e., planning for service parameters such as service area and hours, vehicle size, and other navigation constraints).

- Internal and customer-facing process changes to use the on-demand system to book and schedule specialized trips. For example, the software provides an automated process to schedule and dispatch dynamic trips and provides customers increased options and flexibility in time frame and mode (i.e., mobile phone) to request trips. This changed the customer booking process and day to day specialized trip scheduling process.

Realized Benefits

Milton Transit experienced operational advantages after replacing its specialized transit scheduling/booking software. Select benefits include:

- Increased convenience for customers to book trips (i.e., app, web, in addition to phone).
- Improved rider communication and experience through the real-time app (i.e., rider notifications).
- Increased service area coverage and improved mobility to/from different fixed routes.
- Increased customers per vehicle hours (PPVH).
- Increased job satisfaction and productivity as result of automating dynamic scheduling and dispatching processes.
- Anticipated reduction in costs to operate a fixed-route service and procure additional vehicles.
- Enhanced data collection (e.g., ridership reporting).

Lessons Learned

Change management remains a challenge during the implementation stage that is often overlooked. As the technology impacts the organizational structure and shifts roles, staff and operators need time to adequately train and become accustomed to the new technology. This can include communicating the purpose and benefits of adopting the new technology with operating staff and dispatchers in advance and providing an opportunity to ask questions and understand the change. For public users, providing informational resources and instructions to help them manage and use the new technology (e.g., how to use the app) as well as provide options to call in and book trips can minimize the pressure on staff capacity to respond to future inquiries. These strategies can help manage resistance and provide clarification early on. Staff should be engaged during the requirement gathering and process re-engineering stages, while customers should be engaged a few months before and during the initial launch of the new technology.

Receiving council buy-in was also one of the key challenges faced. To encourage buy-in, staff presented simulations to demonstrate the potential benefits of the technology to help build confidence. For example, simulations can be used to show how the introduction of a co-mingling service can reduce operational costs through increased load and efficiency of shared vehicles and improve quality of service (i.e., reduced wait times) for specialized customers.

Case Study: Deploying CAD/AVL Through the Metrolinx Transit Procurement Initiative (TPI)

As a result of a change in legislation in the Accessibility for Ontarians with Disabilities (AODA), Ontario transportation service providers were required to implement automated audible and visual announcements for call-out stops. Timmins Transit participated in the Metrolinx Transit Procurement Initiative to procure a new CAD/AVL solution from CONSAT.

COMMUNITY:	City of Timmins
POPULATION:	41,788
TRANSIT SERVICE PROVIDER:	Timmins Transit
TYPE OF SERVICE:	Local and regional, in-house service
CONVENTIONAL BUSES:	23 (2022)
SPECIALIZED VEHICLES:	6
ANNUAL SERVICE HOURS:	47,358 (2019 conventional vehicle hours) 5,149 (2018 specialized vehicle hours)
COMMUNITY TECHNOLOGY STATUS:	Improving
CAD/AVL TECHNOLOGY VENDOR:	CONSAT

Timmins Transit is operated by the City of Timmins and serves the communities of Gold Centre, Schumacher, Porcupine and South Porcupine in Northern Ontario. It runs 7 days a week on 13 routes, with a fleet of 23 low-floor and accessible buses. A specialized door-to-door transit service, Timmins Handy Transit, is offered for persons with mobility constraints.

Technology Profile: Computer Aided Dispatch & Automatic Vehicle Location systems

CONSAT was Timmins Transit's first implementation of a CAD/AVL system. Timmins procured a CAD/AVL system with additional features such as automatic next-stop announcements, at-stop displays, automatic passenger counters, fleet management, data management system, customer applications and web display. Additional features of the CAD/AVL system include the ability to track and analyze performance data such as on-time performance, ridership counts and passenger information.

Year Implemented: 2018	**Stage of Lifecycle:** The technology has been planned, procured, and implemented. It is now in the administration and maintenance stage.	**Set-up Timeline Before Deployment:** Approx. 3 months.

Purpose of Implementation: New Technology

The driving force of the technology deployment in Timmins is a result of a change in legislation in the Accessibility for Ontarians with Disabilities Act (AODA). In 2017, the AODA required municipalities to have automated audible and visual announcements for call-out stops. To help support Ontario municipalities in procuring the Intelligent Transportation System (ITS) to be in compliance, Metrolinx launched a joint procurement program: Metrolinx Transit Procurement Initiative (TPI). This program enables municipalities to procure additional ITS subsystems that serve to improve the overall operating efficiencies of the service. As a result, Timmins Transit procured a CAD/AVL system to modernize operations beyond stop announcements.

Organizational Impacts

The deployment of new technology has significant organizational impacts. Timmins Transit experienced the following organizational impacts:

- The need to develop new operational processes to support the dispatching and communications functions of the CAD/AVL technology.
- Change management and training to support staff to embrace the new technology and processes. Training would typically be provided to operators, supervisors and dispatchers.

Implementation Considerations

As the main purpose of implementation is driven by provincial legislation, stakeholder buy-in was not difficult to obtain. Beyond the implementation considerations of CAD/AVL's data management and data analysis requirements, CONSAT provided the following consideration:

- The need for additional project support from the vendor to provide knowledge on the technical requirements of the system. Timmins leveraged vendor expertise and utilized their support to convert existing schedules to a format required by CAD/AVL.

Realized Benefits

The procured technology provides automated scheduling support, dispatching and fleet maintenance that can help offload tasks and support limited manpower. Some other benefits include:

- A broadened source of data generated from the ITS technology such as on-time performance, real-time data, and vehicle locations can help directly inform service planning and operation decisions.
- Data analysis module that provides data analysis functions and standard reports to support data-driven decision making.
- Fleet management modules that provide automatic maintenance checks of vehicles to highlight vehicle faults and allow staff to take preventative measures to save on operational costs.
- A web-based transit tracker that allows customers to see real-time information such as bus arrival times, wait times and vehicle capacity.

Lessons Learned

A common challenge experienced by small, rural and Indigenous communities in procuring new technology is that the RFPs developed are inappropriately scoped in terms of scale, cost, vehicle requirements, technology requirements, and/or implementation timelines. As a result, the RFPs do not properly reflect the business needs of the municipality or organization. This is a common practice of smaller transit providers that develop RFP documents based on templates used by larger transit providers.

To procure a technology that is well-suited and sustainable in the long-term, transit providers should focus the intent of the document on their service objectives, strategic goals and how the vendor can help achieve them. An alternative solution employed by the City of Timmins and other Ontario transit providers is leveraging a joint procurement such as the Metrolinx Transit Procurement Initiative. This was an effective solution because it gives smaller transit providers an opportunity to learn and share technical knowledge and gain purchasing power, which is typically challenging when doing an independent procurement.

Case Study: Operating an Integrated Transit Technology Suite in Bracebridge

In 2017, the Accessibility for Ontarians with Disabilities (AODA) announced that all Ontario transportation providers were required to implement automated audible and visual announcements for call-out stops. As a result, the Town of Bracebridge procured an integrated transit technology suite that featured AODA-compliant stop annunciation and LED displays to meet this need.

COMMUNITY:	Town of Bracebridge
POPULATION:	17,305 (6,500 within the transit service area)
TRANSIT SERVICE PROVIDER:	Bracebridge Transit - Ride the Wave
TYPE OF SERVICE:	Local, in-house service
CONVENTIONAL BUSES:	1
SPECIALIZED VEHICLES:	1
ANNUAL SERVICE HOURS:	3,290
COMMUNITY TECHNOLOGY STATUS:	Improving
ITS SUITE TECHNOLOGY VENDOR	TransitFare

The Town of Bracebridge launched conventional transit services in August 2016 with Bracebridge Mobility specialized service launching in January of the following year. The community is served by a conventional fixed-route service that operates in a continuous loop on a one-hour cycle, as well as a demand-responsive specialized service for qualifying customers.

Technology Profile: Integrated Fare Collection and Vehicle Location System

Since launching the service in August of 2016, the Town of Bracebridge has leveraged an integrated transit technology suite for fare collection, automatic vehicle location, AODA-compliant stop annunciation features, and real-time customer information. The solution is completely integrated within a cloud-based service that relies on cellular connectivity between the on-board GPS systems and vendor-hosted servers.

Within the single on-board setup, drivers can monitor their trip progress and schedule adherence and record and accept fares in cash or via smart card. Further, the system automatically announces next stop information on an audio PA as well as a dot-matrix LED display. All configuration of the on-board system is available from the central browser-based interface that allows the solution to operate entirely on the cloud.[8]

[8] Select vendors offer cloud-based services rather than requiring on-site servers. Cloud-based solutions are discussed in the “Administration and Maintenance” section of the Toolkit.

Back-office system functionality includes fare policy management and smart card management, vehicle tracking, schedule creation, real-time information portal management, ridership and performance reporting, and many other administrative tools.

Year Implemented: 2016	**Stage of Lifecycle:** The technology has been planned, procured, and implemented. It is now in the administration and maintenance stage.	**Set-up Timeline Before Deployment:** Unknown – the system was procured by previous staff

Purpose of Implementation: New Technology

The solution was procured after town staff investigated various products used at other similarly-sized, geographically-appropriate peer transit providers. The system was selected for its user-friendly portal (easily navigable for staff) and advanced reporting features. This ensured that the service met the minimum requirements for the AODA while also providing important revenue collection and reporting functions.

Since the first implementation in August 2016, the town has worked with Transitfare to secure progressive system upgrades, including enhancements to the smart card-based fare collection system, new reports, and is presently investigating integrating a booking platform to support Bracebridge Mobility and future on-demand transit services.

Organizational Impacts

Bracebridge Transit noted the following organizational impact:

- To mitigate staff requirements for customer service and pass sales, Bracebridge Transit has leveraged existing town facilities (library and community centres) and their front-desk personnel to minimize additional transit customer service staff.

Implementation Considerations

Through utilizing the technology over the past six years, Bracebridge Transit noted these considerations:

- On-board technology is used to varying degrees of accuracy by contracted operators. Some operators neglect to appropriately log in to their trips, or sign into a trip in the wrong direction. This negatively impacts on-time performance reporting and real-time information for customers.
- Staff noted that support from the vendor has been challenging but have reached out to peers across Ontario who are using the same technology in order to collaborate and find solutions. This municipal outreach led to round-table discussions which resulted in an ad-

hoc working group to discuss system needs and challenges. At times, this group has been able to advocate to the vendor for improvements to the technology.

Realized Benefits

By deploying an integrated suite of technologies, the Town of Bracebridge has been able to realize several benefits common to larger municipalities, at a significantly reduced cost.

- Staff have become more comfortable with using the reporting tools available through the browser portal for monitoring and analysing service performance and ridership information. This has become an invaluable tool when addressing councillors and other departments as transit strives to meet community and sustainability goals.
- Staff believe that the smart card system has significantly reduced the amount of cash management, and many customers easily adapted to the technology when introduced early in the service launch.
- Expanding on a single technology with an existing vendor contract tends to be significantly less effort than going to a new procurement, so long as the vendor is willing to negotiate a fair price for additional modules or functionality.
- Deploying the real-time information portal resulted in reduced calls to the town regarding delays and schedules. However, certain demographic groups who utilize the transit service do not have access to, or an understanding of, the online portal. Therefore, staff continued to provide a phone in service for transit users and continue to receive calls. As the municipality explores more ways to expand access to these groups, they have worked with the service provider to ensure the technology is as user-friendly as possible.

Lessons Learned

While the technology has been a successful component to the transit services in Bracebridge, the town has nonetheless learned that there are benefits and challenges with a single integrated suite of transit technologies. On one hand, being entirely dependent on a single vendor may leave gaps in support or functionality. The town has managed to navigate around these challenges by working with peer transit providers with the same suite of technologies and negotiating through that group for improvements and bug-fixes. On the other hand, by leveraging a single vendor and being willing to work within the limitations of the existing technology, the town was able to streamline the procurement of new modules and is presently exploring enhancements to support Bracebridge Mobility and future on-demand transit services.

Case Study: Implementing GTFS in Norfolk County without Traditional Transit Technology

Ride Norfolk Transit has adopted the General Transit Feed Specification (GTFS) common data format to define their public transportation schedules and associated geographic information to enhance online trip planning tools and customer service support.

COMMUNITY:	Norfolk County
POPULATION:	65,000
TRANSIT SERVICE PROVIDER:	Ride Norfolk Transit
TYPE OF SERVICE:	Local and regional, in-house service
CONVENTIONAL BUSES:	Unavailable[9]
SPECIALIZED VEHICLES:	Unavailable[10]
ANNUAL SERVICE HOURS:	4,759
COMMUNITY TECHNOLOGY STATUS:	Improving
GTFS TECHNOLOGY PROVIDER:	Not provided

Ride Norfolk Transit is operated by Norfolk County and provides connections to Simcoe, Brantford, Delhi, Windham Centre, Waterford, Wash, St. Williams, Port Rowan, Courland, Tillsonburg, Langton, Greens Corner, Bill's Corner, Port Dover, Port Ryerse, Turkey Point, and Vittoria, in Southern Ontario. Service is provided from Monday to Friday, year-round. There is no weekend or holiday service. They have daily "In-Town" service within Simcoe as well as daily service to Brantford. Other communities are serviced on different days of the week.

Technology Profile: General transit feed specification (GTFS)

General Transit Feed Specification (GTFS) is a common data format for defining public transportation schedules with associated geographic information. GTFS "feeds" allow public transit providers like Ride Norfolk to publish their transit data. This includes scheduling, fare, and geographic transit information that can be visualized and analyzed through specific tools. Further, GTFS allows for a real-time component that facilitates arrival predictions, vehicle positions, and service advisories. This real-time component can be publicly disseminated, typically through a website or app, to allow residents to know where the next bus is, and its estimated arrival time.

Ride Norfolk Transit uses the data to visualize transit routing and information on their website, using the ArcOnline tool. They do not use the GTFS real-time component.

[9] Norfolk County does have a fleet of vehicles. However, the fleet numbers reported in this document are derived from CUTA reports. The most recent report provided by CUTA does not provide fleet numbers for Norfolk County.

[10] As noted above, the fleet numbers are unavailable; CUTA has not yet collected this data.

Year Implemented: Ongoing	Stage of Lifecycle: The technology has been planned and implemented. It is now in the administration and maintenance stage.	Set-up Timeline Before Deployment: Not applicable – GTFS data can be produced and synthesized quickly if the right tools are administered.

Purpose of Implementation: New Technology

GTFS is a unique dataset that has many ways of being used, with the right tools, such as mapping systems. Ride Norfolk sought to mitigate the internal resources required for resident trip planning by providing residents with greater options and improved ease of use, as well as to reduce phone calls received from residents.

Prior to the GTFS visuals on the website, residents had to rely on the information provided at the bus stop or call the County. Ride Norfolk was responding to an internal desire to increase productivity and customer satisfaction by minimizing the need for calls on the part of riders, thereby reducing the volume of calls their limited staff receive daily.

Organizational Impacts

There was no impact to the overall organizational structure at Ride Norfolk. They continue to have two transit staff members. However, by using GTFS data, they succeeded in reducing the volume of phone calls, allowing staff to allocate more time to service and policy development and other duties.

Implementation Considerations

However, there are certain implementation considerations:

- GTFS is just data. It needs tools, like mapping systems, to be used effectively. Fortunately, there is a suite of tools that allow for this, many of which are user-friendly. However, some tools may require additional costs and training. RideNorfolk uses ArcOnline to visualize their information.
- ArcOnline is the only tool used by RideNorfolk. RideNorfolk consist of a two-person organization which presents resource, expertise, and financial constraints.

Realized Benefits

Select benefits realized by Ride Norfolk, include:

- Staff experienced a noticeable reduction in the volume of phone calls inquiring about specific transit information, allowing them more time to focus on other projects and initiatives.
- Better wait time perceptions as people can anticipate bus arrival time with more accuracy.

- Improved customer experience/service as a result of potential time saved from trip planning. While staff continue to receive phone calls pertaining to transit schedules, the reduced volume of calls and steady ridership suggests that customers are saving time on trip planning.

Case Study: Planning for a new Electronic Fare Collection System

Due to the aging infrastructure of Sault Ste. Marie Transit's farebox system which caused several operational challenges and inefficiencies, a new replacement electronic fare collection system was procured which included advanced fare media capabilities such as smart card and QR code technology.

COMMUNITY:	**City of Sault Ste Marie**
POPULATION:	73,300
TRANSIT SERVICE PROVIDER:	Sault Ste. Marie Transit
TYPE OF SERVICE:	Local, in-house service
CONVENTIONAL BUSES:	28
SPECIALIZED VEHICLES:	11
ANNUAL SERVICE HOURS:	81,799
COMMUNITY TECHNOLOGY STATUS:	Modern and continually improving
FARE COLLECTION TECHNOLOGY VENDOR:	Cubic

Sault Ste. Marie Transit is operated by the City of Sault Ste. Marie and provides urban connections within the city. Service is provided 7 days a week. They have 8 conventional routes, with on-demand service being provided on weekend evenings.

Technology Profile: Fare Collection Systems

Rather than requiring physical bus fare at the time of boarding, especially in the wake of COVID-19, fare collection technologies provide additional capacity to receive both the traditional and latest payment options, including payment via swipe cards and smartphones.

Year Implemented: Upcoming	**Stage of Lifecycle:** The technology has been planned and procured. Sault Ste. Marie is now going through the implementation phase.	**Set-up Timeline Before Deployment:** Not yet implemented – Sault Ste. Marie Transit is in the process of deploying the new Fare Collection system. Estimated set-up timeline is 12 months, but this is subject to change.

Purpose of Implementation: Replacement

Sault Ste. Marie Transit's current farebox system is experiencing significant issues and is aging beyond repair, causing many systems to fail completely. These issues are derived from the older technology no longer functioning properly, resulting in coin jams, system malfunctions, inaccurate data collection, inaccurate counting of money, and more. The cause of these issues is unclear. Possible reasons as to why the technology no longer works are:

- Unsupported software: As technology ages, the software that supports it ages as well. Over time, companies can provide software updates to maintain functionality. However, updates become less and less feasible as time progresses based on physical hardware limitations – not enough memory to upload updates, not enough processing power, or simply incompatible with modern data networks. Twenty years is a long time to support technology.
- Damaged hardware: Fare payment systems intake coins and material, and are regularly handled. While designed to withstand harm, they would be subject to dirt, debris, and damage from regular wear and tear. Over the course of twenty years, the dirt and debris may cause a system to overheat or impede scanning functions resulting in inaccurate counting.

Due to these reasons, a new system is required and Council has approved the acquisition of new farebox technology to replace the whole system. The new system will include smart card and QR code technologies, as well as traditional fare media.

Organizational Impacts

New farebox technologies will have an impact on the roles and responsibilities of staff within Sault Ste. Marie Transit. However, as the technology is not yet implemented, the following items remain anticipated:

- The new technology will result in additional work (both temporary and lasting), including but not limited to:
    - Customer service resources as transit users adjust to the new technology, they will have questions and comments for the municipality.
    - Analytics and data management as staff navigate new streams of data and the new system.
    - On-time performance capabilities as schedules may become adjusted due to delays caused by the new fare system.

Implementation Considerations

Similar to the projected organizational impacts, the following implementation considerations are also anticipated but remain untested:

- Temporary boarding delays caused by the public being introduced to a new fare payment system.
- Fare collection devices can provide revenue data. Current processes to reconcile fare collection information (actual fares paid) with ridership information collected from the

automated passenger count or CAD/AVL system may require review and update with the new system implementation. The new system will ensure precise fare collection information to be used in analysis.

- Farebox technology requires initial capital investment and on-going operating costs that may take smaller transit providers a longer time to recover due to lower ridership.

Anticipated Challenges and Mitigations

As mentioned in the purpose of implementation section, Sault Ste. Marie Transit's current system is aging and no longer functions properly – prone to various malfunctions or complete breakdowns. Therefore, the municipality is in the process of acquiring a new fare collection system. As such, Sault Ste. Marie Transit does not yet have realized benefits nor lessons learned. However, anticipations and expected outcomes of procuring the new technology are:

- In-person and Classroom Training:
    - Sault Ste. Marie Transit will have the vendor provide live, in-person training with individual staff and supervisors on-board buses in operation to ensure that staff understand how to use the technology properly and have the knowledge to perform ad-hoc troubleshooting for customers on an on-going basis.
    - Sault Ste. Marie will also implement an on-going "Train-the-Trainer" program for all staff.
    - To ensure adequate training, Sault Ste. Marie Transit has identified the desire to provide classroom training prior to the system implementation, in order to address questions prior to system launch. This will be specifically for administration and supervisory staff.
- Union Support:
    - Sault Ste. Marie Transit brought the union into the specifications, so there is support and input from the beginning.
- Installation Schedule:
    - In an attempt to disrupt service as little as possible, installation will be specified for evening/weekend installation only.
- Public Awareness:
    - Press releases will precede the new technology, along with a strong marketing campaign that is currently being developed in conjunction with the Corporate Communication team.
- Team Structure:
    - When implementing a project or new technology, there are important considerations when determining the appropriate team. Having the appropriate capacity, as well as team members who can liaise with other corporate departments, have decision-

making authority, and have expertise in the technology are crucial to streamlined implementation.

Case Study: Planning the Transition of Specialized Transit Technology Systems

In accordance with Thunder Bay Transit's Master Plan, the municipality has procured a new scheduling software for specialized transit to optimize and streamline manual scheduling coordination and management processes.

COMMUNITY:	City of Thunder Bay
POPULATION:	107,909
TRANSIT SERVICE PROVIDER:	Thunder Bay Transit
TYPE OF SERVICE:	Local, in-house service
CONVENTIONAL BUSES:	48
SPECIALIZED VEHICLES:	26
ANNUAL SERVICE HOURS:	146,817
COMMUNITY TECHNOLOGY STATUS:	Modern

Thunder Bay Transit is operated by the City of Thunder Bay and provides urban-centric local connections to the community, from the County Fair Plaza to Lakehead University, to Fort William First Nation Business Park. Service is provided 7 days a week across 17 routes, with a fleet of 48 low-floor and accessible buses and 26 specialized vehicles.

Technology Profile: Scheduling Software for Specialized Transit

Thunder Bay Transit uses two separate scheduling applications: one for conventional service and one for specialized service. The specialized service software is meant to help track and maintain customer information, streamline reservations, and build and optimize schedules and routes through both manual and automated scheduling methods.

Year Implemented: 2018	**Stage of Lifecycle:** This is an example of the planning stage. They are anticipating going to procurement.	**Set-up Timeline Before Deployment:** Not applicable – Thunder Bay Transit has not yet transitioned to a new transit technology system.

Purpose of Implementation: New Technology

Thunder Bay Transit's Master Plan establishes that the municipality should continually look to improve their regular business processes. They had an opportunity to acquire scheduling software for specialized transit by partnering with another municipality who was releasing an RFP for the software.

Prior to implementing the scheduling software for specialized transit, Thunder Bay Transit performed a lot of manual scheduling and coordination. Third-party software provided an opportunity to streamline. Further, Thunder Bay Transit had plans to grow into additional specialized services offered, including on-demand transit, a passenger app, and web trip management tools.

Anticipated Challenges and Mitigations

Thunder Bay Transit is not currently anticipating the challenges and mitigations of transitioning to a new specialized transit system. However, there remains general challenges and mitigations that agencies can anticipate when transitioning technology:

- Change Management:
    - It takes time for staff and management to adjust to new technology. Some staff may be resistant, or reluctant to learn a new system if the old one was perceived to be working fine for their needs.
- Temporary Loss of Expertise:
    - While the end product for technology may be similar, the process and ease of using the technology varies. Over time, staff would have grown accustomed to using the former technology. Therefore, things like processing, analysis, and troubleshooting will take longer on the new system as a new base of knowledge is established.

Lessons Learned

When Thunder Bay Transit upgrades its specialized transit technology platform, it will use and build on their experience and lessons learned from the initial implementation of third-party software:

- Vendor change: As with technology, vendors and providers change over time due to acquisitions, closures, and changing technology. This change is difficult to anticipate. For example, their software vendor was acquired by another company during the contract period. This acquisition introduced complexity, some of which may have been mitigated through a contract stating service assurances in the event of an acquisition.
- Partnering with another municipality's RFP and agreement was an excellent way to acquire and deploy the technology because it eliminated the duplication of work – for Thunder Bay Transit to go through the process of writing an RFP and vendor interviews is a significant investment in resources.

Case Study: On-Demand funding support for Mohawk Council of Akwesasne

Due to geographical constraints (i.e., long travel distances, high costs) and lack of formal public transportation service available within the Mohawk Nation of Akwesasne, the Council has completed a funding application to procure an on-demand booking and scheduling service.

COMMUNITY:	Mohawk Nation at Akwesasne
POPULATION:	12,000
TRANSIT SERVICE PROVIDER:	Volunteer Taxi-Cabs
TYPE OF SERVICE:	Local, contracted
CONVENTIONAL BUSES:	N/A
SPECIALIZED VEHICLES:	N/A
ANNUAL SERVICE HOURS:	N/A
COMMUNITY TECHNOLOGY STATUS:	Antiquated
ON-DEMAND FUNDING SUPPORT PROVIDER:	Pantonium

The Mohawk Council of Akwesasne is an elected Community Government that represents three districts within Akwesasne: Kawehno:ke (Cornwall Island), Kana:takon (St. Regis) and Tsi:Snaihne (Snye). The Council oversees ten departments governing Education, Police Service, Central Resource Services, Community and Social Services, Tehotiennawakon (Economic Development), Health, Housing, Justice and Technical Services.

There is currently no formal transit service offered in the community and no conventional or specialized transit fleet operated by the Council. The only transportation service available in Akwesasne currently is an ad-hoc taxi-cab service based out of the surrounding cities of Cornwall, Ontario and Massena, New York.

Technology Profile: On-demand Booking and Scheduling Software

Pantonium has supported the Mohawk Council of Akwesasne in developing their plans for a new on-demand system. Pantonium is a software company based in Toronto, Ontario, that specializes in on-demand transit technology that enables transit providers to provide real-time macro transit solutions. The community plans to use Pantonium's EverRun on-demand transit software to operate stop-to-stop service in major trip generation areas, as well as provide door-to-door service to allow address-based booking in the larger coverage area.

The EverRun real-time fleet optimization system determines an optimal route based on a customer request and assigns a vehicle to a driver in real-time to complete the trip. The technology is accessible via mobile application and web portal for customers to request trips. This on-demand technology system has been adopted in other municipalities such as the City of Belleville and the Region of Durham in Ontario.

Year Implemented: N/A	**Stage of Lifecycle:** The technology has been planned and procured. However, they are stalled in the procurement phase as they await approval for implementation.	**Implementation Timelines:** Not applicable – Implementation has not been initiated as the application is still awaiting approval. Based on other deployments, a reasonable timeline for implementation would be six months.

Purpose of Implementation: New Technology

Akwesasne's geographic area is located between the jurisdictions of Ontario, Quebec and New York State. As a result, this creates significant hindrances for travel such as long distances, increased travel times, and border delays that limit the residents' accessibility to major services. Furthermore, Akwesasne does not currently have many public transportation options available to residents. The community currently relies on an outsourced taxi service that charges high rates due to the added distances to reach the far-out districts of Cornwall Island, St. Regis, and St. Snye from surrounding cities.

Due to these challenges, the Mohawk Council of Akwesasne is seeking to implement an on-demand system that will provide residents enhanced mobility between the districts and access to their needed services at an affordable rate. The community is seeking to utilize the on-demand system to provide safer transportation options for female residents and children. To support this initiative, Pantonium worked directly with the Community Services department to propose a new on-demand transportation system and draft specific functionalities based on the Council's objectives. To help support the community in acquiring funding, this proposal involved a description outlining costs, additional requirements, general timelines and the potential benefits of the service for the community. The technology will be implemented once the funding has been approved.

Organizational Impacts

The introduction of the on-demand software will pave a way for a new service to be set up by the Council. As the funding application is still under review, the organizational responsibilities provided by the vendor are under anticipation and were largely based on assumptions from previous experience. It is anticipated that Pantonium will provide the software system and the Council will design and plan the new service based on the integration with the new software system. Some of the roles conducted by Council staff may include designating administrative staff to manage the deployment process, setting-up parameters (e.g., service hours, service standards, service area), and contracting and scheduling drivers.

Implementation Considerations

Some implementation considerations involve deciding on a primary service area and consistently monitoring and adjusting the service as demand increases.

Additionally, obtaining buy-in from key parties such as customers and drivers early on will dictate the latter success of the technology once deployed. Direct engagement with stakeholders can provide education and training on how to use the system, as well as increase the comfort level of users with the applications.

Anticipated Benefits

The Mohawk Nation at Akwesasne hopes to provide all residents with more reliable and convenient public transportation options for residents to travel between the districts, and to access community services. Anticipated benefits of the on-demand system include:

- Safe transportation options for all members of the community.
- Provision of mobility options that can promote the health and well-being of all residents.
- More affordable transportation fares.
- Increased access to fitness and recreation centres, healthcare providers and grocery suppliers.
- Provide an alternative to the private automobile.
- Reduced wait times and flexible booking options.
- Broadened access to data generated from the system that can be useful for planning and other business analytics.