On-demand Transit Toolkit

A resource guide for service implementation

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METROLINX

Notice

This Toolkit has been jointly developed by the Transit Integration team, within the Planning, Design, and Sponsorship team at Metrolinx along with the Research, Data and Technical Services team at the Canadian Urban Transit Association (CUTA) with support from Leading Mobility Consulting. The Toolkit is to be used for internal and external stakeholder engagement to inform and guide the implementation of On-Demand Transit across Canada.

The On-demand Transit Toolkit is intended as general guidance for consideration and is not intended to inform decision making on service delivery models, labour disputes or negotiations.

Metrolinx, an agency of the Government of Ontario under the Metrolinx Act, 2006, was created to improve the coordination and integration of all modes of transportation in the Greater Toronto and Hamilton Area.

CUTA is a non-profit membership-based association that promotes public transit's role at the core of integrated urban mobility. CUTA acts as the collective and influential voice of public transit in Canada. CUTA is the "go-to" organization for information, trends, data, research, networking, training, events, and advocacy specific to Canadian public transit.

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Burlington Transit
Calgary Transit
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Medicine Hat Transit
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Coast Mountain Bus (TransLink)
Simcoe County LINX
Durham Region Transit
exo
Fort McMurray Transit
Hamilton Street Railway
Leduc Transit
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Codiac Transpo
Oakville Transit
OC Transpo
Red Deer Transit
Regina Transit
Grand River Transit
Rocky View Regional Handibus Society
Saskatoon Transit
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INTRODUCTION

1.0 Introduction

1.1 Objective

CUTA and Metrolinx have partnered to develop this Toolkit to help advise service design objectives, implementation strategies, and considerations for On-Demand Transit projects. It provides design and implementation strategies as well as considerations that a municipality and/or transit system should consider when looking to provide on-demand transportation services. It represents a summary of known research, case studies across Canada, information from current deployments and documented analysis where it can be used to help inform future decisions on this service delivery model.

1.2 What is on-demand transit?

On-Demand Transit (ODT) is an alternative form of providing transit, where vehicle routes and schedules are determined by passenger demand typically facilitated through a technology application unlike fixed-route transit where transit service has a predetermined route and schedule. ODT is typically applied in areas with lower transit demand or areas where there are lower densities of population and employment (Volinski, 2019), areas with circuitous and disconnected road networks which impede the efficient use of fixed-route transit service, and areas where demand for transit service is lower during specific time periods (e.g. evenings and weekends). ODT services can utilize vehicles of all sizes including transit buses, shuttles, vans, or sedans.

Historically, to book a trip on an ODT service riders needed to dial a number for a dispatcher to send a vehicle to their pickup location. The driver would then determine the most appropriate route to the destination and pick up any other riders along the route (KFH Group, 2008). Offering a wide range of options for customers to book trips is an important planning step to make the ODT service accessible. (Tooley et al., 2019). Today, riders can book a trip on ODT services through a smartphone, web application, kiosks, or by calling a customer service representative, depending on the transit system.

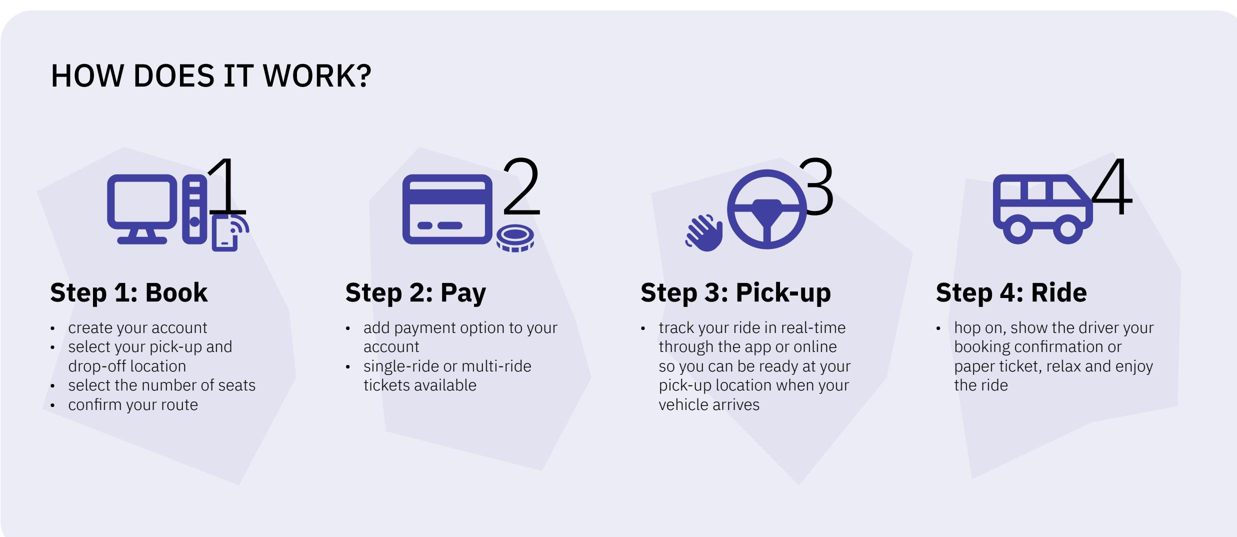


Figure 1: A graphic showing how On-Demand Transit works in Okotoks, Alberta

The process can be described in four steps:

1. The customer chooses their pick-up/drop-off locations and specifies when the service is needed, they are then offered ride options that may include pick-up and/or drop off times/windows.
2. In some cases, payment options are provided to the rider through the application, which can be in the form of credit card, pass, transfers or cash.
3. The transit vehicles are then routed and deployed based on the optimized route selected by the routing software, considering several inputs (i.e., traffic, availability, vehicle accessories, etc.) as well as the locations and number of customers in need of a ride.
4. Riders can then optionally track their ride in real-time through a mobile application if it is accessible to them.

Vehicle routing and vehicle dispatch is managed autonomously through software and technology. The levels of transit service and concepts are defined through a planning process and the creation of service standards/objectives. In areas without existing transit service, transit agencies could determine service levels through demand forecasting and software-assisted simulation exercises. One of the complexities of appropriate service provision is finding the most efficient route for customers and promoting shared trips to increase efficiency for the ODT service.

On-demand technology vendors have different approaches to the algorithms they use to find those "most efficient" routes, and some also provide configurable parameters for agencies to balance certain standards such as trade-offs between convenience (e.g., how far a rider may need to walk to meet a shared ride) and efficiency (e.g., the ability for the transit vehicle to maintain a relatively straight and time-effective path of travel).

Other considerations can impact vehicle routing, such as road design, stop placement, road closures, real-time traffic alerts, local policy, vehicle size, and fleet capabilities (See Section 2.13). The routing applications adjust and adapt the routes in real-time, in accordance with the demand and service area

1.3 How to use this toolkit

This toolkit helps transit systems navigate the on-demand transit landscape as they consider or begin to implement on-demand transit within their own service networks. The intended readers of this toolkit are the planners and decision-makers within a transit organization who that are considering or have decided on implementing on-demand transit within their operations.

The toolkit also speaks to what considerations transit systems could use to evaluate the effectiveness of their On-Demand service after their respective pilots along with a continuous service performance review evaluation once a service transitions from a pilot project to a permanent deployment. Its guidance is not intended to be prescriptive, but to highlight the opportunities and challenges in the different facets of designing on-demand transit services. Each transit system is unique in terms of its size, service area, and ridership therefore the guidance in this report should be interpreted in its own terms. On-demand transit is not a "one-size-fits-all" solution so users will need to exercise their own judgment when deciding what is right for them.

It's organized to present the opportunities and challenges that should be considered when planning On-Demand Transit into five major areas:

Planning

Service model selection, implementation, ridership benchmarking, service area size, customer access to the service, (outlined in section 2)

Operations

Fare structure, service provision, and administration, (outlined in section 3)

Accessibility

Fleet accessibility, trip booking, specialized transit integration, (outlined in section 4)

Customer Experience

Planning for a high-quality customer experience, booking, fare payment, (outlined in section 5)

Data Monitoring and Performance Evaluation

KPIs, evaluation considerations, (outlined in section 6)

2.0

PLANNING ON-DEMAND TRANSIT

2.0 Planning On-demand Transit

2.1 Thinking about on-demand transit

There are numerous considerations that a municipality and/or transit system should account for when designing a new ODT service. Each region and transit system's environment are unique; and the differences can strongly impact whether ODT service is warranted, feasible, or appropriate. Designing ODT services requires the municipality and/or transit system to take a customized approach and consider variables such as population density, employment density, age, income, vehicle availability, service area, origin/destination data, and median income (Crocket et al., 2010). It is important that transit systems considering ODT service develop an understanding of the relationship between supply, quality of service, and demand for service, together with their goals for what the service should accomplish (Klumpenhouwer, 2020).

To apply the understanding of the interconnected relationship between supply, demand, and quality of service, it is important to address several considerations through the service design process. Below is a list of considerations that should be addressed during the service design process:

1. What are the objectives and goals of the service?
2. What is the size of the service area?
3. Who is the customer base (specific demographic groups) the service is trying to serve?
4. What will be the service delivery model?
5. What type of vehicles will be used and how many?
6. When will the service operate?
7. What are the benefits of implementing ODT into the current system?

Transit agencies will also need to consider the inherent trade-off between the inflexibility of a fixed-route, fixed-schedule service that does provide some level of customer comfort due to its predictability and the far more flexible but far less predictable availability to service that ODT can provide. Some customers like predictability while others like modernized options that cater to their individual needs.

These considerations have a significant impact on the type of ODT service that can be operated, its level and its quality. The Toolkit breaks down these factors and discusses them in further detail.

2.2 Understanding implementations of on-demand transit

Each transit system's service area characteristics are unique and affect whether ODT service is warranted, feasible, or appropriate.. It is important that transit systems considering ODT service develop an understanding between supply, quality of service, and demand for service; together with their goals and objectives for what the service should accomplish (Klumpenhouwer, 2020). ODT is often deployed as a solution for inefficient or infeasible fixed-route transit service. Therefore, careful consideration of planning appropriate levels of service is necessary to achieve a better service quality than what preceded the ODT service.

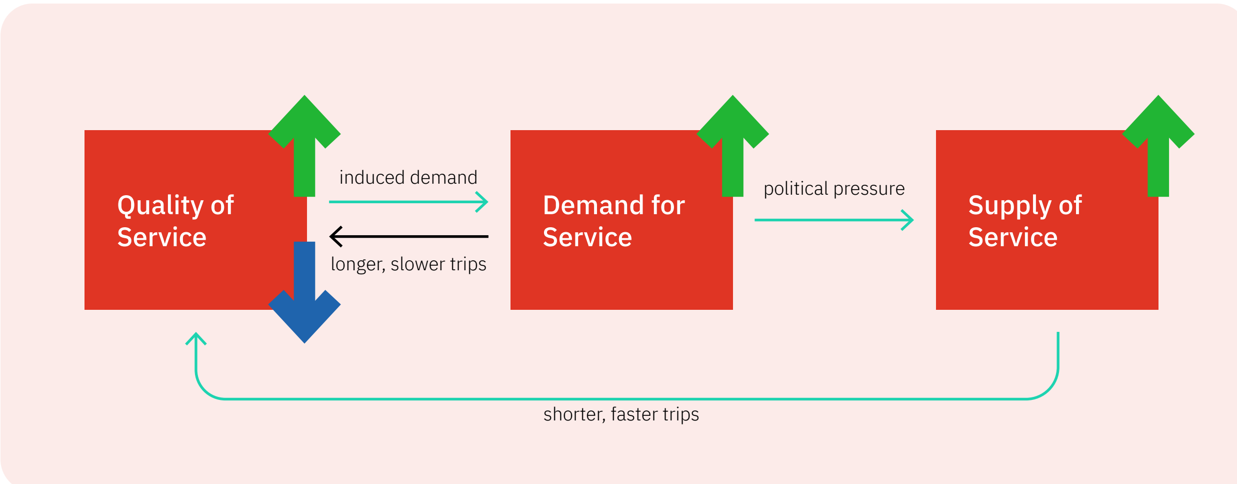


Figure 2: The interconnected relationship between supply, demand, and quality of service (adapted from Klumpenhouwer, 2020; University of Toronto)

Figure 2 illustrates the relationship between supply, demand, and quality of ODT service – three strongly interconnected components. Supply is usually described quantitatively through revenue hours, number of stops, and service area size, and qualitatively through the technology platform and vehicles used. Quality of service focuses on customer experiences of interactions with the service such how directly takes someone from origin to destination, waiting and on-board travel time, and trip ratings through the application (if applicable). Transit demand is quantified through daily ridership, mode share, and trip distributions. Project stakeholders have also noted that quality of service is also determined by interactions with operators, dispatch staff, customer service staff along with the condition of the vehicle. (Klumpenhouwer, 2020).

Understanding the interconnected relationship between supply, demand, and quality of service will lead to the development of an appropriate level of service for the proposed service type. It's also critical to evaluate the benefits of non-dedicated services such as taxis and TNCs, to mitigate quality of service issues when demand spikes during peak hours, as well potentially offering a more cost-effective service during periods of low demand, such as late at night.

To apply the understanding of the interconnected relationship between supply, demand, and quality of service to develop the appropriate levels of service, it is important to address several considerations through the service design process:

1. What are the objectives of the service?
    a. Will the service provide cost efficiencies over the existing service?
    b. What customer groups are the service designed to serve?

c. Will your service complement an existing fixed-route service or provide a new service within an existing system (e.g., service to a new area that does not have fixed-route service)?
d. Will your service connect to fixed stops such as transit terminals/hubs or large retail/employment hubs?
e. Are you trying to grow the customer base and increase ridership?
f. Will the implementation of on-demand transit provide an improved level of service?

2. What will be the service delivery model?
   a. How will the fleet size be determined? Will the transit agency use existing vehicles, acquire small vehicles? Should the vehicles be made accessible if not already?
   b. What resources exist currently that can support the on-demand service? (ex. call centre for customer support, vehicles, drivers, maintenance facilities, routing software, digital payments, etc.) How does the software platform interface with the operational requirements of the transit agency?
   c. What type of transportation service will this be? (door-to-door, stop-to-stop, curb-to-curb, curb-to-hub, frequency of service, service coverage, etc.)
   d. How will software and technology be used to organize a booking, dispatching, mapping, and routing?
   e. What will be the fare structure for this new service be?
   f. How will the service be marketed to new and existing customers during service launch along with the long term operations of the service?
   g. How will you manage the introduction of the new ODT service particularly if it involves a change to the existing transit system? For services that interact with fixed-route transit, how would transfers work?
   h. Is there an opportunity for collaboration and partnership in service delivery between the fixed-route operations department deploying on-demand transit and the paratransit department that has extensive experience with operating a booking-based customer service?
   i. Will there be a significant modal shift where ODT service is implemented?
3. What market is being served by the new service?
   a. First-mile-last-mile to local transit, or higher-order transit
   b. Augment service to a local route
   c. Replace an existing route, either fully or partially
   d. Provide a service to a new community and/or low-density area
   e. Provide night-time or weekend service
   f. Provide service for specific demographics (e.g., seniors, students, equity-deserving groups, etc.)
4. What is the size of the service area?
   a. What is the appropriate size of the service area based on your service objective and operating business model?
   b. Where do your customers want to travel?
   c. Where is ODT feasible?

2.3 Customer-centred service

When implementing an ODT transit service, it is important to recognize the local context and implications the service can have on existing transit services and the community (Shi & Sweet, 2020). A crucial step in designing an ODT program is to understand customer needs and wants. On-demand transit services are filling a mobility gap (Shi & Sweet, 2020); therefore, designing an ODT service to better serve the community can make for an efficient and effective service. Table 1 lists several considerations to achieve a customer-centric service.

Table 1: Customer-centric considerations

Customer Market Segments e.g., daily commuters, students, seniors, persons with accessibility needs	Understanding the profiles and needs of the customer(s) will assist in determining the types of vehicles, vehicle capacity, service area, and levels of service needed to ensure reliability for customers and meet their travel needs.
Travel Patterns e.g., daily commute to and from work or school, medical appointments, social and recreational, planned and spontaneous trips.	This will assist in determining peak periods and coverage for non-peak times including early morning and late evening service. Understanding planned vs. spontaneous trips will assist in designing the booking process (pre-booking, on-demand, subscription availability)
Passenger Amenities e.g., legroom, accessibility equipment, children's seats, bike racks, electric ports for wheelchair battery charging, lifts and ramps, smartphone ports for charging, lighting, stop announcements, multi-lingual signage	This will assist in ensuring that the service accommodates the needs of customers to use it comfortably and easily. It also provides opportunities to attract new customers through the provision of amenities that make the service more attractive.
Customer Assistance Needs e.g., Curb-to-curb, policy on door-to-door	This will help in understanding customer preferences on how to access the service and which options may be more preferred by customers.
Understanding Customer Resistance e.g., concerns around reliability, trust in drivers or other passengers, safety concerns, overcoming resistance to change, adaptability to the use of technology, providing different options to trip booking.	This will assist in designing the service and communications to highlight customer identified benefits and how the provider is addressing elements identified by customers as barriers to using the service.
Protecting Customer Privacy	Ensuring the privacy of individual customer data in terms of collection and management.

2.4 Potential applications of on-demand transit

A key characteristic of ODT services is flexibility. There are many potential applications of ODT as a mobility solution depending on the needs of the community and the established service goals and objectives. Municipalities and transit systems may find efficiencies by replacing existing fixed-route transit where public transit is underutilized but still a necessity for some. ODT can also be considered in implementing new transit options where none currently exists and where fixed-route transit may not be as efficient compared to ODT service for performance or financial reasons. Table 2 outlines various types of ODT applications, highlighting their intended service objectives and examples of ODT implementations across North America.

Table 2: Various types of ODT service

TYPE	DESCRIPTION	EXAMPLE
Service to Existing Transit hubs (first-last mile)	Providing riders with connections to existing fixed route transit hubs	Oakville, ON Edmonton, AB
Replacing Low Performing Routes	Replace a fixed route service with ODT service for a specific catchment area.	Calgary, AB York Region, ON
Off-Peak and Weekend Service	Replace fixed route service during specific times with ODT service for a specific catchment area.	Belleville, ON North Bay, ON Sault Ste Marie, ON
Overnight Service	Providers transit service throughout an urban area during overnight hours when demand is very low and scheduled fixed-route service does not operate	Durham Region, ON
Service to augment existing fixed route services	ODT service to complement existing fixed route services	Barrie, ON
New Service	ODT service serving specific catchment areas where no transit systems or service exists.	Calgary, AB Cochrane, AB Okotoks, AB Innisfill, ON

TYPE	DESCRIPTION	EXAMPLE
Overcoming barriers to service area expansion	Utilizing ODT to provide the transit agency to expand the transit coverage area where a conventional fixed route service may require additional funding, vehicles, vehicle kms and operator resources	Hamilton, ON
Regional Cross-jurisdictional Service	New ODT service or replacing fixed route service connecting regional hubs across jurisdictions within a larger catchment area (County or Regional scale).	Niagara Region, ON
Service to Community Hubs/ centres	New ODT service to community points of interest	Calgary, AB
Specialized service for specific populations (i.e. seniors, essential workers, etc.)	New ODT service serving specific populations	York Region, ON Edmonton, AB
Augmenting paratransit/ non-emergency transport services	Providing service to eligible paratransit customers who do not have mobility aids or devices requiring a fully accessible vehicle	

2.5 Potential benefits to implementation

1. CONVENIENCE FOR RIDERS

The ability to provide customized service(s) to customers as they need it and when. On-Demand Transit changes how transit is provided to better serve riders according to their convenience, in line with the transit agencies' service principles; rather than relying on a set schedule, with traditional fixed-route transit. Customers also have the option of booking trips in advance and setting schedules that work according to expected commutes or appointment times. ODT can allow agencies to operate service later in the night and on weekends while providing service to more destinations than might be possible within the rigid available cycle time of a scheduled fixed-route service. Depending on the structure of the On-Demand service, customers could see shorter wait times, reduced travel time, and fewer transfers when compared to conventional fixed-route service.

2. SHARED RIDES

Shared rides provided by on-demand transit allow for a more efficient use of resources by aggregating riders onto trips traveling in a similar direction, on the same vehicle. Shared rides can increase a service's efficiency and support future transit expansion by encouraging transit-friendly behaviours. Inversely, the greater amount of pooling that takes place, the longer and more indirect a trip can become for the customers who board first.

3. RIGHT-SIZED VEHICLES

Operators can introduce smaller transit vehicles and/or other right-sized vehicles to meet customer needs. Potential options for ODT providers may include paratransit vehicles, minivans, sedans, taxis, etc., along with conventional buses (depending on demand).

ODT results in the more effective use of vehicles and fleet as transit providers can match capacity with demand and availability. There is an initial capital upfront cost of acquiring new fleets or repurposing existing fleets but, providing the right-sized vehicles increases operational cost savings for the transit provider while still providing service that meets demand. To reduce upfront capital costs, depending on the service delivery model, transit agencies could potentially contract/lease on-demand transit vehicles from a third-party provider. Many agencies and providers have also reported a reduction in vehicle kilometres travelled compared to the previous conventional fixed-route, with the additional benefits of reduced vehicle operating costs and greenhouse gas emissions.

4. INCENTIVIZED SERVICE

Transit systems can provide incentives to customers for using the ODT service such as the option to pre-book in advance, discounted fares, variable pricing based on trip time or pick-up location, or customized pickup/drop off locations. This can help attract new riders and/or increase transit ridership.

5. COST EFFICIENCIES

Transit systems can provide more cost-efficient transportation services in areas where fixed-route transit would be too costly to operate or implement. In areas with low ridership, due to low population density or lack of demand, ODT can be a more cost-effective solution as the cost matches the demand for the service whereas fixed-route transit can sometimes provide too much service for not enough demand. Further, ODT can be delivered through dedicated resources (e.g., transit agency vehicles/drivers) or non-dedicated resources (Ride-hailing, Taxi), an important consideration for Quality of Service and Cost of Operations.

6. MORE FLEXIBLE SERVICE PLANNING

ODT gives transit agencies more refined origin-destination data to better understand customer travel needs. Service changes can generally be made much faster with the changing of service parameters to better demand than conventional fixed-route services. On-demand services generate pure Origin-Destination pairings and give the agency a very strong understanding for travel patterns in an area. With ODT services being booked by the customer, the agency will have access to search origin-destination data. This is very helpful in understanding if zone boundaries need to be expanded or service hours need to be expanded. The agency should be able to look up searches that were booked (because they were outside the zone or service hours) and use that information in zone adjustments.

7. CONTINUOUS FEEDBACK FROM RIDERS

ODT applications typically allow riders to rate their experience after every trip, which provides a barometer for customer satisfaction without the need for customer surveys. ODT is enabled using software and technology that have the potential to capture passenger travel data and feedback on service attributes through rider surveys to a greater degree than fixed-route transit. This data can be further leveraged to improve the transit network.

2.6 Potential challenges to implementation

1. CUSTOMER SERVICE VS. CAPACITY DISCIPLINE

Managing the trade-off between customer expectations and capacity control is particularly challenging for ODT service due to the additional considerations that are present compared to fixed-route transit (Teal & Becker, 2011). With ODT service, increases in demand, that are not planned or budgeted for, can quickly affect the quality of service provided. This can impact service delivery due to limited vehicle capacity or when the routing algorithms are unable to find a trip for passengers (Klumpenhouwer, 2020). This may result in longer wait times or service being unavailable during specific times for customers. Advance bookings may also result in cancellations or no-shows, further impacting the levels of service.

2. BUDGET PLANNING AND CONSTRAINTS

The evolving nature of ODT service can make budget planning difficult. As many municipal transit planners work with a set and finite budget, the variability in demand for the service can result in a need to adjust the supply, requiring more vehicles and drivers and therefore higher operating costs.

3. CUSTOMER SERVICE AND ACCESSIBILITY

As the modern form of ODT is heavily reliant on technology and passengers booking from smartphone or web applications, there has been concern about those who do not have access to smartphones and are not adept at using new technologies (Klumpenhouwer, 2020). Many transit systems which implement ODT provide call-in options and customer service booking agents during business hours to address accessibility concerns and to support customer adoption. Whether call centres are available throughout the service day may depend on passenger volumes and hours of service; particularly at agencies that operate late into the night. ODT smartphone applications give customers real-time updates about estimated arrival times and trip cancellations, information that might not be available to those travelling without a smartphone. There is also a greater need to continuously update service information (e.g., changes to on-demand zones, time periods, operating conditions) when compared to fixed-route services. Additionally, customers may be used to a fixed-route rider experience (e.g., consult a schedule, walk to a stop, board a bus) rather than a booking process. Accommodating walk-ons might be a challenge.

4. LIMITATIONS OF ROUTING APPLICATIONS

Each service provider has its own proprietary routing application, with its own set of parameters and algorithms to determine vehicle routes. Each application also provides different services including providing trip booking and planning for customers, driver navigation, the ability to pool passengers based on the origins and destinations, and payment integration, among other features. Different data sources for routing and address lookups provide different advantages and drawbacks. Proprietary data sources like the Google Maps Geocoding API are often thorough collections of destinations, points of interest, and address; but are more difficult to correct or amend. OpenStreetMap-based systems are much easier to edit but might not be as complete a data source in some areas.

2.7 Determining service goals

Determining service goals early in the process provides an understanding of what level of service quality is appropriate and what resources are required to provide the appropriate supply (Klumpenhouwer, 2020). Setting realistic goals and establishing clear and measurable objectives was a key lesson learned for public transit systems in the United States who implemented some form of demand-responsive transit (Volinski, 2019). Some potential goals that helped guide previous and existing ODT projects include:

- Building ridership on existing routes
- Providing new transit service in areas with no existing transit
- Providing First and Last-Mile connections
- Serving specific populations or age groups
- Increasing service area coverage
- Operational and cost efficiency

Framing ODT transit services around goal setting is crucial to implementing an efficient, effective, and reliable transit service that benefits the community in a meaningful way. Determining the service goal for the ODT service will help in determining the supply and demand of the service required to meet the outlined goals and objectives.

2.8 Integration with existing transit networks

Shared modes of transit and ODT transit services can complement existing transit networks, with the possibility to grow in popularity and scope over time (Feigon & Murphy, 2016). When ODT services are introduced within an existing transit network, several aspects need to be addressed to ensure a seamless customer journey. This is especially important when connecting to fixed-route bus, light rail, commuter rail, or connecting at stations where infrastructure is fixed -such as transit terminals or hubs.

1. STOP AND STATION DESIGN

With unscheduled arrival and departure times, ODT vehicles require dedicated areas within the station footprint to ensure vehicles can arrive and depart on time in accordance with demand. If smaller sedans, vans, or mini shuttles are used, the ODT vehicles may use the existing pick-up and drop-off areas or dedicated curbside zones. However, if multiple vehicles are in the same area, it may be challenging for customers to know which vehicle they should be taking. Having dedicated access to the pick-up and drop-off areas and designated waiting areas may contribute to increased reliability, as vehicles will not be impacted by increased traffic flows during peak hours and it will be clear to customers which vehicle to take.

If larger transit buses are being used for the ODT service, a bus loop or layby is the most appropriate with dedicated access, to ensure separation of larger transit vehicles and smaller passenger vehicles. This may contribute to increased reliability for customers and safety for all vehicles and passengers on the station site if the ODT vehicle is stopping in an on-street environment

Passengers also require waiting or loading areas at the station or stop, especially if large numbers arrive or depart during peak or rush hours. Transit systems need to ensure that there is enough space allocated for passengers to wait or board ODT vehicles safely. The waiting and boarding area should take accessibility requirements into account by providing enough space for ramps, lifts, a level platform, etc.

Alternatively, if no pick-up or drop-off areas are available or if there are no bus loop/laybys at the end station, signage and paint markings can assist in identifying specific drop-off and pick-up areas along with potential dedicated access points, and passenger waiting areas. Information in the app and/or during the booking process can also be provided to customers explaining where to find the ODT vehicle.

2. CYCLE TIME

Synchronizing ODT transit services with fixed-route services such as bus and train schedules can present some challenges, particularly for the first and last-mile types of services. For example, when ODT service must connect to fixed-route services at scheduled times (such as for time transfers), it can impact the routing and the distance the ODT vehicle can travel within a certain period of time. Cycle time is the round-trip time, including layover, for the vehicle to return to its cycle point—the point at which it connects with regional bus or rail service (Volinski, 2019). The cycle time can impact the boundary limits or size of the ODT service area as the ODT vehicle can only cover a certain distance before having to come back to connect to the fixed-route transit point. Otherwise, additional vehicles will be required to fill these gaps.

It's important, therefore, to consider the cycle time required for the ODT service to ensure passengers can connect to fixed-route services at scheduled times, while still meeting the outlined objectives and goals of the service. Most ODT software can now synchronize with the schedules of connecting fixed-route services to facilitate transfers. In the planning of a new ODT service, technology providers can provide modelling simulations to predict cycle time and the ability to provide timed connections to fixed-route services.

3. CAPACITY

Connecting with fixed-route transit services may result in high demand of passengers at scheduled times. Since ODT service is generally small scaled with smaller vehicles and a relatively lower number of passengers (see Section 2.13.4), it's important to ensure that vehicles and the system have sufficient capacity to handle potential high passenger demand at scheduled times and specific locations. This can impact the number of vehicles required at any given time and the customer experience. Depending on the design of the ODT service, new riders transferring from a conventional fixed-route service to ODT may not be aware of the need to pre-book trips at transfer points. ODT systems should be able to accommodate some degree of walk-on riders.

4. SERVICE OPERATIONS

Transit control centres are now responsible for two services, or one fully integrated service. Each service has its standard operating procedures as well as customer communication protocols during operational issues. Staff, fleet, software, and technology all need to be considered when implementing ODT services, as these resources may be traditionally allocated for fixed-route and may need to be repurposed, retrained, or reconfigured to include ODT service.

5. PRIORITIZING CONNECTIONS TO FIXED-ROUTE TRANSIT

Some routing algorithms can set parameters in a way that prioritizes connections to fixed-route services and ensure that trips that are more time-sensitive, such as connections to lower frequency routes.

6. WORKFORCE TRAINING

In implementing ODT service, transit systems will need to consider the impact of introducing a new service to operate amongst the existing workforce. They may choose to train existing staff; such as operators, dispatchers, customer service representatives, call centre staff, etc., to take on more responsibilities to operate the ODT service or choose to hire new employees who only operate the ODT service. If the option to train existing staff is considered, then transit agencies will need to engage with their respective transit employee union on the development of new standard operating procedures for the ODT service.

2.9 Determining the size of the service area

Transit systems establish service areas based on the geographical, jurisdictional, or political boundaries of the communities they serve (Klumpenhouwer, 2020; Volinski, 2019). The size of the ODT zone is highly dependent on the type of ODT that is proposed, the level of existing or projected demand, known or anticipated markets, desired travel times, and alignment with the transit system's overall service goals and standards. How large a zone is will also impact the number of vehicles required for the service and the capabilities of the ODT routing application platform to accommodate and satisfy the real-time trip requests made by customers (Volinski, 2019).

Applications of ODT in the United States indicate that zone size can vary considerably, from 3 to 75 square kilometres. Generally, larger zones enable more direct trips and connections to more places (Klumpenhouwer, 2020). However, larger zones also increase the number of potential route combinations, number of stops, and may result in increased travel times, largely depending on how many vehicles are assigned to it. Smaller zones, therefore, may be more appropriate to ensure service quality and levels are achieved.

The configuration of the ODT zone is related to the geographic size of the service area. A ODT zone might be subdivided into smaller areas where anywhere-to-anywhere service is available and connections can be made to specific nearby bus routes, but the local transit terminal is also accessible from all the zones. The configuration can change by time of day (e.g., a broader anywhere-to-anywhere service might operate overnight or on weekends depending on what scheduled bus routes are operating). More combinations of zone/service setups can be more complex to manage and communicate to customers.

2.10 Determining the vehicle types and sizes

The type of vehicle used for ODT is highly dependent on how large a service area is, how many passengers are expected per hour, and the type of service provided. The choice of vehicle(s) is understood to be an output of the estimated service area demand (rides/unit time), the estimated cycle time (unit time), and in some cases the desired productivity and cost (rides/vehicle/unit time) (Klumpenhouwer, 2020). A survey of transit systems operating ODT services in the United States showed that most used minibuses with capacities ranging from 12 to 26 passengers (Volinski, 2019). In contrast, ODT services in Belleville, ON, and St. Albert, AB use their conventional full-size 40-foot buses for evening services, taking advantage of their existing fleet and avoiding the capital purchase of new vehicles (Klumpenhouwer, 2020). Operating an ODT transit service with an existing fleet can be beneficial because the transit system is utilizing its existing infrastructure to improve efficiency and access.

Reasons for using smaller vehicles include:

- Lower operating costs;
- Ease of access to communities and smaller roads;
- More acceptable in residential areas;
- Easier navigation on narrower rights-of-way especially for door-to-door service;
- The capacity is better suited to low levels of ridership; and
- Lower greenhouse gas emissions

(Klumpenhouwer, 2020; Volinski, 2019)

Vehicles generally fall into four categories:

- Sedans: 1-3 passengers
- Mini-vans and Vans: 1-5 passengers
- Minibuses or shuttles: 1-26 passengers
- Transit buses: 1-40 passengers

2.11 Technology & software

Several transit systems have run various forms of dial-a-ride or low-tech ODT service for many years. Dial-a-ride services rely on manual booking and reservations, which often require booking either a day in advance or within a limited timeframe. Routing is done manually either by a booking agent or by the drivers. This system works well with a low level of demand but is not scalable and able to handle multiple, simultaneous requests for service (Volinski, 2019). Several transit systems still use dial-a-ride transit services for late-night transit or paratransit.

The main difference between dial-a-ride services and newer forms of ODT is the emergence of new software allowing both dynamic reservations and scheduling along with routing capabilities. This offers more support and adaptation to transit technology in the future. New software capabilities have enabled the providing more efficient service with fewer resources. The advantages include improved customer service through automated booking and provision of real-time arrival and departure times; automated scheduling and routing; and real-time data collection and analysis (Volinski, 2019).

Advancements in cloud computing and routing algorithms have optimized the process of dynamic routing and removed the need for drivers to do individual trip level route planning. Cloud computing is beneficial for ODT transit services because it allows for large amounts of data and information to be transferred between devices (Hashem et al., 2016). The technologies, therefore, can help adapt routes to better reflect changes in passenger demand throughout the service area at any given time. To increase efficiency and optimization, the technologies also allow the service provider to set constraints on maximum trip times, vehicle capacities, and the location of stops. The routing algorithm will then only conduct the routing procedure based on the constraints, ensuring specific service goals and objectives can be met. It also allows for scaling to smaller or larger zones, while maintaining the same level or quality of service (Klumpenhouwer, 2020).

There are constraints to ODT technology and software. This includes deviations from the shortest path, flexibility in pickup or arrival time, flexibility in pickup/drop-off locations, and limited pickup or drop-off times at particular stops or zones (e.g. to facilitate timed transfers).

2.12 IT and data security

ODT operations are reliant on new technology or software that may be sourced from vendors. When working with external software and technology providers, it is important to consider whether vendors align with local data security policies and legislation. Transit systems may have internal data security policies or legislation from their local municipal or regional governments that affect how data is managed, stored, encrypted, and accessed. It's important to involve internal IT departments during the procurement process to ensure that vendors can comply with local policies and legislation around data security.

Technology and software can capture passenger, routing, operational, and other data.. Passenger data such as names, home addresses, travel patterns, email, phone numbers, and other demographical data should be anonymized as much as possible. ODT services need to design an element of consent into their apps and software that informs the passenger about the data that is being captured and how it may be used.

2.13 Trip routing

Several variables impact trip routing and have a direct impact on the amount, type, and level of service the transit system can provide. The route algorithms that are produced by routing applications are based on several variables that determine the parameters within which the routes are developed.

2.13.1 CONSIDERATIONS AND VARIABLES FOR TRIP ROUTING GEOGRAPHY AND ROAD DESIGN

Forms of ODT are operated in a range of geographies including rural, urban, and suburban areas. Road network design can have a considerable impact on where and how ODT service is provided. Careful thought should be given if ODT service is planned for suburban and rural roads as the vehicle type will determine how feasible it is to navigate these roads. Road networks in suburban or rural areas may be small, curvy, narrow, unpaved, with tight turning radii, and lacking curbs which affect a vehicle's ability to navigate and be accessible to service stops (Klumpenhouwer, 2020).

2.13.2 DEMAND PATTERNS

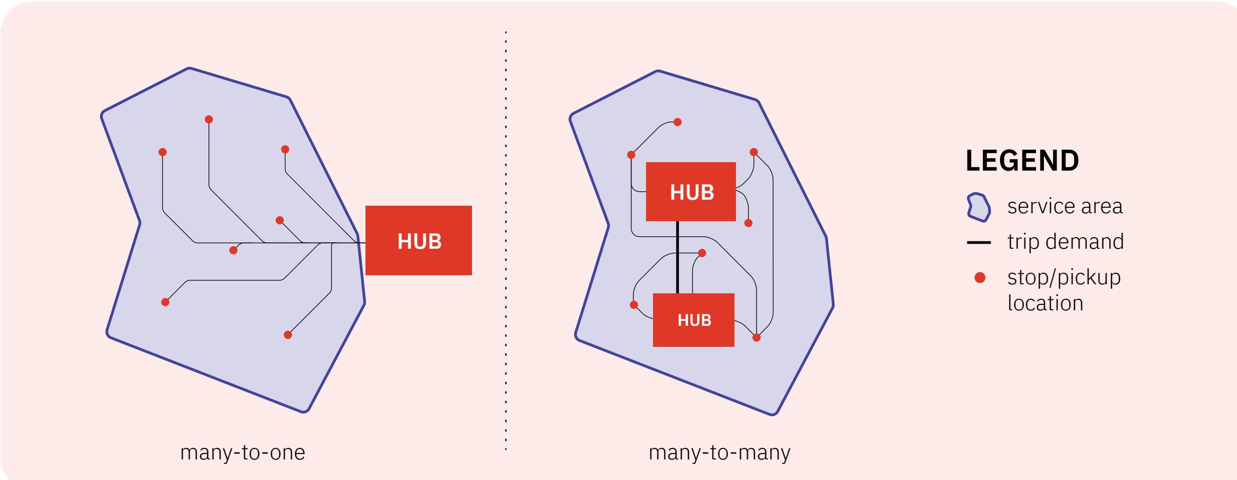


Figure 3: The two categories of demand patterns within trip routing. (adapted from Klumpenhouwer, 2020; University of Toronto)

There are two broad categories to describe demand patterns within an ODT service: Many-to-one service and Many-to-many service as depicted in Figure 3 below. Many-to-one service have either the origin or destination focused on one stop - a hub. This is often referred to as an FMLM service where the hub destination is a transit terminal or connection to the transit system. In some cases, the ODT connection's to the hub is coordinated to match the arrival or departure of other fixed-route services at the hub like commuter rail, light rail, heavy rail, and/or high-frequency bus services. Some transit agencies such as Grand River Transit have also combined service models where the ODT operates as a many-to-many within the service area with connections to a fixed-route hub.

A variation of the many-to-one model is the market-specific model. It's a service that offers ODT service specifically designed for a customer group that frequently uses transit to specific locations. The market-specific model tailors the ODT service towards a certain customer group and designs the service towards specific locations. An example of this model is York Region Transit's "Mobility on Request 65+" service, which provides transportation for seniors anywhere within a 5km radius of their pickup location. Seniors are significant users of public transit and so the market-specific model focuses service to retirement homes and/or villages, medical appointments, grocery stores, and other essential services. Vehicles are also designed to meet user needs such as accessible entry, room for mobility aids, and providing additional support for boarding and alighting vehicles.

Many-to-many service is more common in areas where the ODT service covers the whole city or town. In this case, service is provided from several locations to many other destinations across the service area, not focused on a hub (Klumpenhouwer, 2020).

2.13.3 STOP PLACEMENT

A bus stop's location determines the potential routes the vehicles can take. The transit system can decide whether to use existing bus stops, if possible or determine new stops based on where passengers may want to be picked up or dropped off. Stop placement sometimes needs to consider the needs of both ODT and scheduled service, especially if the ODT service is intended as a precursor to fixed-route service. Potential stops can include shopping centres, educational or health institutions, and community or recreational centres. Therefore, selecting stops within a reasonable walking distance for passengers and providing enough coverage throughout the service area is of utmost importance (Volinski, 2019). Some routing applications and software providers allow for dynamic 'virtual' stops, which are created dynamically selected based on real-time passenger demand while meeting specific criteria such as a maximum walking distance from the passenger. The transit agency can specify that all virtual stops identified in the technology application are accessible.

2.13.4 VEHICLE CAPACITY

As discussed in Section 2.10, there is a range of vehicle sizes and types that can be used for ODT service. A vehicle's capacity can impact trip routing as it may only accommodate a set number of passengers on a shared journey. If smaller vehicles are used, the trips may be more direct as a smaller number of passengers can be accommodated in the vehicle. If larger vehicles are used, the trips may be more indirect as the number of passengers is not constrained by the size of the vehicle. Larger vehicles also have less flexibility to go on-site to certain destinations, particularly in the lower-density area where buildings don't front onto street right-of-ways.

2.13.5 PASSENGER WAIT AND TRIP TIMES

All trip routes are determined based on on-demand requests from passengers and specific criteria set by the transit service such as maximum wait and trip times. The software allows for passengers to track their trip in real-time if travelling with a smartphone. Passengers' wait and trip times depend on the number and capacity of vehicles available, the size of the service area, and the level of sharing desired. Restricting metrics such as trip times can decrease the level of ridesharing the ODT service offers and thus increase the trip costs (Klumpenhouwer, 2020). Route deviation and ridesharing is a viable option for passengers who do not have a time restrictive trip. However, setting maximum wait or trip times for passengers can avoid the potential for long wait and trip times which are undesirable for passengers (Klumpenhouwer, 2020). To create additional certainty in trip time, the agency can add a 5-minute wait time before confirming a trip, which increases the chances of pooling and improves the efficiency of the service.

2.13.6 TRIP BOOKING TIME

The trip booking time is how far in advance the passenger books. It can range from immediately to five or more days in advance. Different booking windows can be used for different markets, passengers, and types of trips. A major benefit of the app-based booking system is passengers can book impromptu trips flexibly. However, being able to book a trip in advance can allow the transit system to plan for the demand through appropriate vehicle provision thereby shortening wait times. At the same time, it increases the chance of cancellations by passengers (Klumpenhouwer, 2020). Pre-booking also puts holds on resources and could make for decreased efficiency. Shorter booking times reduce the ability of the transit system to plan for the service, which may increase wait time for passengers. But shorter booking times are more convenient for passengers as they can book a ride immediately. Call centre hours will need to be taken into consideration when determining the appropriate time span for allowing customers to prebook trips.

2.13.7 ROUTING FORMS

An ODT service can use different forms of routing to meet the identified service goals and objectives. Four general forms of trip routing can be used for ODT:

1. Flex Route/Virtual Stop: Service that transports passengers from their current location to their

destination or scheduled fixed-route service. Routes are charted based on the location where passengers book their trips.

2. Flex Route/Fixed Stop: Service that transports passengers from fixed stops determined by the agency/municipality to their destination. Routes are charted based on the fixed stops where passengers book their trips. Routing is more efficient which minimizes travel time and operating costs; however, customers will need to find their own means to connect to the fixed stops, therefore, making this service less attractive for access. Inversely, fewer in-vehicle deviations will be possible which can make the service more attractive in terms of operations and performance.
3. Mixed-Route On-Demand: Service that transports passengers along a fixed-route. Vehicles operate on a fixed-route and are only deployed if passengers make trip requests along the fixed-route.
4. Deviated Fixed-Route: Service that transports passengers along a flexible fixed-route. Vehicles operate on a fixed-route but can make minor deviations in the route to pick up passengers.

2.14 Going from pilot to permanent service

Many transit systems in the United States and Canada have implemented ODT service as pilot projects lasting less than two years in length. At the end of the pilot project, a performance review is completed to determine if it should be made modified, made permanent, or cancelled (Klumpenhouwer, 2020; Volinski, 2019). There are advantages and disadvantages to this approach:

Advantages:

1. Presents the service as a new type of service or as an experiment may bring some added interest to the service and encourage customers to give it a chance.
2. Demonstrates the potential of the service in terms of operational and financial viability.
3. Allows customers and other stakeholders to participate in the service design with the implementing transit system through feedback and lessons learned.
4. Some transit systems in the United States noted that establishing pilot projects allowed them to establish the service without going through lengthy competitive bidding processes, as state procurement laws were more flexible for pilot projects. A similar example occurred in Powell River, BC where the municipality and Spare Labs proceeded with an On-Demand pilot utilizing funding from Innovative Solutions Canada, accelerating the deployment of the first ODT pilot in British Columbia.

Disadvantages:

1. There is potential for unrealistic goal setting and expectations to obtain the initial pilot funding. This may result in failing to meet goals and expectations, potentially reducing or cancelling the service.
2. Many behavioural or land-use decisions made by individuals, such as whether to own a car or where to live, that impact travel behaviour are long-term. Therefore, not having the certainty of the transit service may result in the service not attracting the ridership desired.
3. Initial steps to expedite procurement procedures to establish pilot projects may not facilitate a full implementation later as procurement processes may still be required.
4. While pilots maintain flexibility for the operator to adjust service to find operational efficiencies, changes can alienate customers who were attracted to the new service. Some tinkering to the operating model should be expected and communicated to customers early on.
5. On-demand technology providers have flagged that many pilots (e.g., with one or two vehicles) are too small to show measurable impact.

To take full advantage of a pilot project, data monitoring and performance evaluation need to be conducted throughout the duration of the pilot project. It is essential to evaluate the service based on the established goals and objectives that reflect probable demand and to measure performance in a manner that is fair and consistent. Each municipality and service area are unique, and therefore the service needs to be evaluated with an understanding of the local context.

Upon the conclusion of a pilot project, a program evaluation should be conducted to determine if the established service goals and objectives are met. The transit system may then either continue the service as-is, modify or expand it, or in some cases, as ODT services become highly utilized, replace it with a fixed-route which can more easily accommodate growth.

2.15 Implementation towards a permanent service

Transit systems may consider either doing an ODT pilot before going to a permanent service or directly implementing a permanent ODT service. Below is a sample roadmap of the potential steps are from planning ODT to implementation.

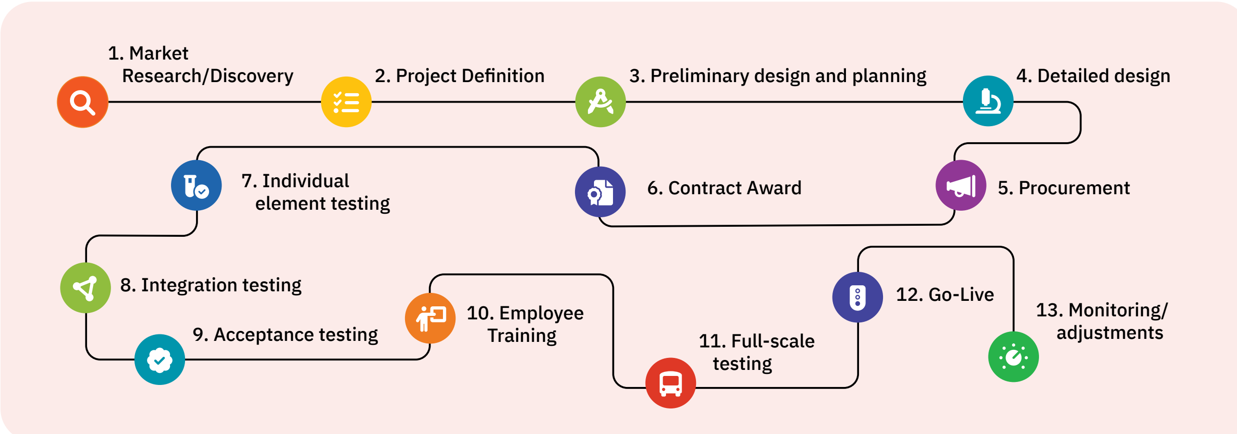


Figure 4: Illustration of the ODT implementation process

1. Market Research/Discovery: Conduct initial research and outreach to on-demand technology providers to discuss high-level pilot/program parameters.
2. Project Definition: Determine the main goals, scope, and KPIs for the project through research, data analysis, and vendor outreach. Vendor advice would support this task as the project definition stage will influence the cost, complexity, timing, and efficiency of the service.
3. Preliminary design and planning: Determine an overall plan for the service as well as high-level details for how it will operate.
4. Detailed design: Determine the detailed elements for design, including vehicles, drivers, service areas, trip booking, and other details. ODT software providers often have the tools and resources to assist with this phase, but they must be already engaged and procured.
5. Procurement: Procure the elements to implement the service such as vehicles, software, service provider (if ODT is a contracted service), etc.
6. Contract Award: Finalized procurement agreement (scope, schedule, and budget) and final project requirements with the selected vendor(s)
7. Individual element testing: Test each element involved in the new service individually so that they function as designed. Deviances from the design should be classified by severity. Retesting may occur until deviances are within an acceptable level.
8. Integration testing: Integration points between each element should be tested to ensure systems will function well together along with integration with existing transit agency software and data feeds
9. Acceptance testing: The whole system should be tested as close to real conditions as possible.
10. Employee Training: Employees should be trained across the system close to the project go-live date to ensure retention of training information.
11. Full-scale testing: Dependant on the size of the project, a full-scale test including trained employees could be performed.
12. Go-Live: The project is live including real end-users.
13. Monitoring/adjustments: The system should be monitored, and minor adjustments made as necessary.

3.0

OPERATING ON-DEMAND TRANSIT

3.0 Operating On-demand Transit

3.1 Agency and vendor operating roles

When operating ODT, transit systems may choose to own and operate the service to varying degrees depending on their resources, capacity and existing service delivery models. Generally, there are four operating models for the deployment of ODT as discussed in the following subsections. This toolkit documents considerations for each service delivery model and is not recommending one model over another.

3.1.1 TRANSIT SYSTEM OPERATING MODEL

ODT service is fully operated by the transit system including the provision of drivers and vehicles. The software is provided by a third party.

The Transit System Operating Model could be utilized for jurisdictions with existing transit systems and the associated transit infrastructure that can be leveraged to implement ODT.

In 2018, Belleville, ON launched an ODT pilot service to provide the community with safe and reliable late-night transit services. It utilized its existing transit fleet and infrastructure to serve the community. The ODT pilot project was successful, and Belleville decided to make the transit service a permanent program. Refer to Section 7.2 for more information on its ODT transit service.

3.1.2 THIRD-PARTY OPERATING MODEL

The ODT service is owned by the transit system, which contracts a third party for the provision of service including software, drivers, and vehicles.

For transit systems that are looking to implement ODT, but do not have the available resources for implementation, the Third-Party Operating Model allows for the development of a contracted service agreement with a Third-Party to deliver the service within specified parameters and requirements.

Metrolinx and RideCo partnered with the Town of Milton in May 2015 to launch an 11-month on-demand shuttle service pilot project. RideCo partnered with the local transportation services to provide the on-demand shuttle service. Refer to Section 7.9 for more information on Milton's ODT shuttle service.

An important note for any model that includes a third-party operator is pilot length. If the agency is considering a 12-month turnkey pilot, then an operator may need to procure vehicles and amortize that cost over 12 months. This will result in a very high hourly operator cost on any pilot quote or RFP response. Consider multi-year pilots with contacted service providers to reduce this cost.

3.1.3 TRANSPORTATION NETWORK COMPANY

ODT service is owned and administered by the transit system but operated by one or more Transportation Network Companies (TNC) platforms with fares partially or fully subsidized by the transit system. An advantage of this model is that there is no upfront capital investment to start a program, as the Transit Agency is only billed for the subsidy they provide as part of their Microtransit program.

If a jurisdiction wants to provide more of a ridesharing service that is more flexible for the customer's specific trip, a TNC Operating Model may be utilized if the jurisdiction has TNC enabling legislation and if the TNC has enough drivers and vehicles available within the service area.

TNCs are established companies with their own fare payment systems, fleets, and drivers which may be attractive to systems looking to contract one company versus many for different aspects of the service. Some TNCs offer Application Programming Interface (APIs) that have the ability to offer their service in Microtransit apps alongside or in supplement to dedicated services or when they are fully engaged. A limitation of TNCs, though, is systems may have less control over driver training, safety, customer service standards, employee availability, and meeting service standards and goals as these will already be set by TNCs. TNCs do have a track record of working closely with Transit Agencies to ensure service compliance before the launch of any transit program.

An example of the TNC model is Innisfil, ON. It partnered with Uber in 2017 to provide subsidized rides and local transit options to the community. Uber provided the software booking system, drivers, and vehicle fleet. Refer to Section 7.7 for more information on Innisfil Transit.

Examples of hybrid models with TNC operations complementing existing conventional and accessible services can be found at many locations in the US, such as Boston, San Diego, Denver, Dallas, Chicago, and many smaller municipal transit systems.

3.1.4 TAXI COMPANY

ODT service is owned and operated by one or more taxi companies where fares are partially or fully subsidized by the transit system. Similar to the TNC operating model, a transit system may choose to partner with taxi companies to provide a ridesharing service that is more direct but should also consider roles and responsibilities between the transit system and its vendor around driver training, meeting service standards , customer service, backend technology, etc.

3.1.5 HYBRID OPERATING MODEL

ODT service is provided by both the transit system operator and a contracted third-party provider where the locality or type of trip requested could determine which party dispatches their ODT service.

Calgary Transit employs a hybrid operating model for its ODT service. Service to new communities without existing conventional fixed-route service has been implemented through a third-party operations provider. Pacific Western Transportation is contracted to provide operators and small passenger vans for ODT serving new communities in North Central Calgary with connections to fixed-route Calgary Transit services at the North Pointe BRT terminal. Calgary Transit has also converted four low ridership conventional services in Southwest Calgary to ODT utilizing in-house operators and existing Community Shuttle vehicles. Both ODT service models utilize the same online application for trip booking and vehicle dispatching. Refer to Section 7.3 for more information on Calgary Transit's ODT services.

The selection of an operating business model is a critical decision when implementing any form of ODT. The flow chart in Figure 4 provides a high-level overview of the key questions that need to be considered when determining which operating business model to implement. Other considerations need to be addressed when selecting the operating business model, is listed in Table 3.

Table 3: A list of responsibilities that can be managed by either the service administrator or contracted provider.

Driver Training	All drivers and supervisors must be trained in customer service, providing customer information vehicle safety,, working with the ODT software and technology, assisting customers with mobility limitations, and diversity and inclusion. There is also an educational role where drivers will be able to answer customer questions about the differences between ODT, conventional and specialized transit services.
Managing Customer Concerns	Identifying who manages customer complaints, response times and remedies for common customer concerns.. This set of responsibilities could be paired with the operation of the call centre.
Supervising and Managing Third Party Contractors	Program to monitor operator performance, vehicle cleanliness standards, and vehicle maintenance.
Fare Collection and Operator Payment	Determining who is responsible for fare payments, onboarding procedures, and cash,e-ticket or smartcard payments.
Technology Support	ODT may require new software and hardware the transit agency is not familiar with. Ongoing technology support will be required for the duration of the ODT program.
Data Analysis	ODT software programs come with built-in data analytics functions that could be used for ongoing planning analysis and service performance reviews.

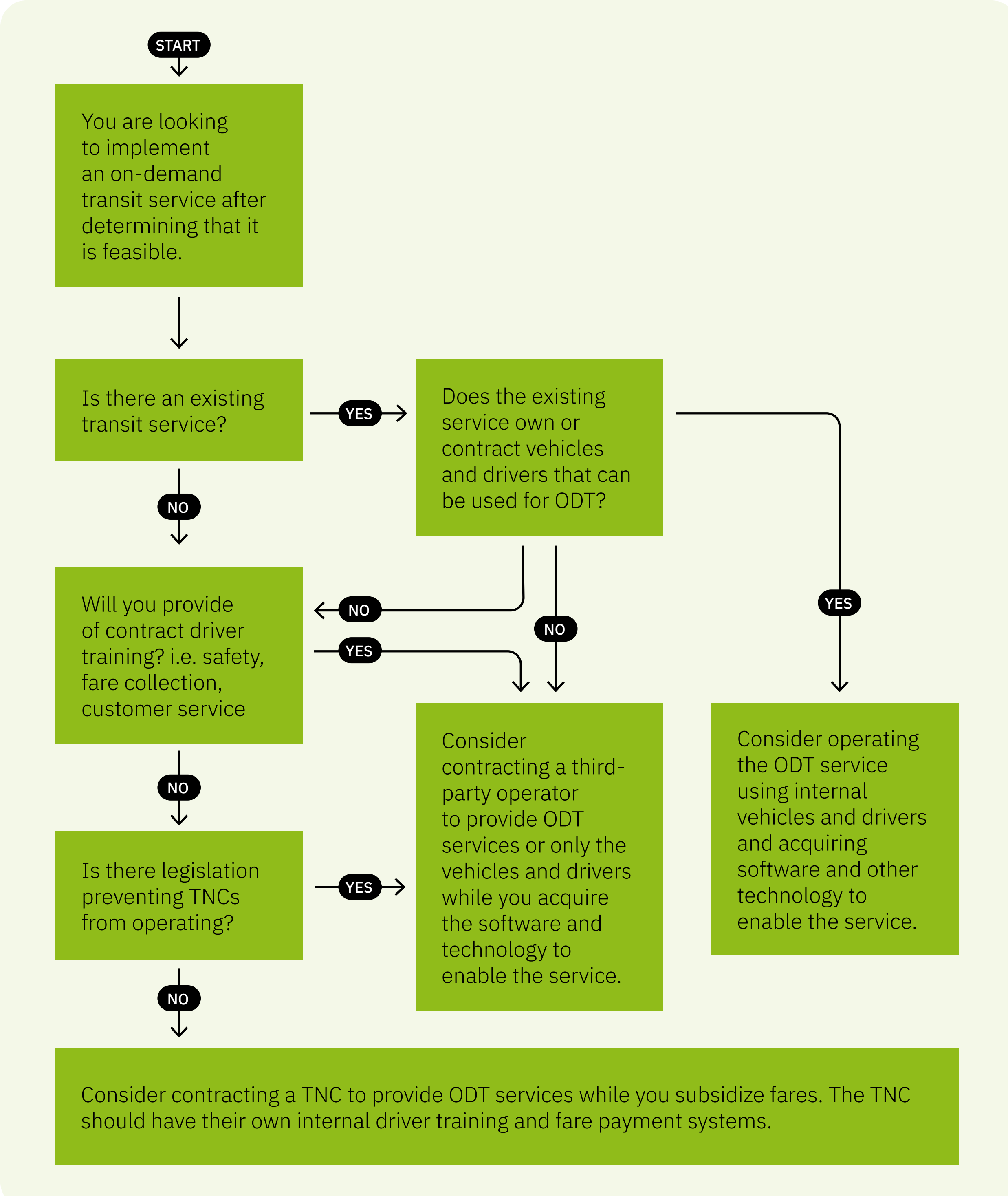


Figure 5: A simplified Flow chart to determine which operating business model may be utilized for ODT implementation. A TNC model is an on-demand flexible transportation service that has fees payable by the service provider to cover the costs of subsidized trips. Meanwhile, a 3rd Party Operating Model uses a third-party for software, drivers, and vehicles services. Municipalities Service Provider (MSP) is an agreement between municipalities and private companies or public authority to deliver transit services to a community.

3.2 Fare structure

When considering ODT services, a transit system or municipality should also consider the challenges and benefits of designing its fare structure. Three general fare structures can be implemented for ODT services as discussed below:

3.2.1 FIXED-RATE

The fixed-rate fare structure charges a uniform price for every ride. This fare structure provides simplicity in terms of customers understanding fares, marketing from the service provider, and less calculation for fare payment administrators. Fixed-rate fare structures do, however, raise issues of equity and fare subsidization. Passengers who travel short distances could be paying disproportionately more compared to passengers paying the same rate but travelling greater distances. Transit systems and municipalities may also have to subsidize more of the operating cost for longer trips as passenger fares would cover less of the operating cost as the distance travelled increases.

3.2.2 FARE BY DISTANCE

The fare by distance fare structure charges passengers by how far they travel. Fares can be calculated based on kilometres travelled on top of a base fare price. This fare structure provides greater equity in fare payment as each passenger pays in proportion to how far they go. Transit systems and municipalities can also maintain a better cost-revenue ratio by ensuring each trip recovers a desired amount through passenger fares. The challenges of this fare structure are that longer trips become unaffordable, more complex technology or software is needed to calculate fares, marketing and communication of fare prices is difficult, and complexity in how fares are calculated can discourage potential customers.

3.2.3 FREE FARE

The free fare model charges no fares for using the ODT services since it's expected that customers will use the service to transfer to more frequent forms of public transit, when a fare is collected at the transfer point, thus increasing ridership on higher frequency modes. It is a highly marketable fare structure given its obvious benefit to customers. The removal of fare payment also makes the passenger boarding experience easier. The disadvantage of this fare structure is that customers could misuse the system and use the ODT service as their primary mode of transportation and not transfer onto higher frequency modes thus creating a greater cost for transit agencies. This model could potentially negatively impact the transit agency's revenue-cost ratio.

3.2.4 OTHER CONSIDERATIONS

On-demand software can also be used to determine variable pricing based on trip purpose and other factors.

4.0

ACCESSIBILITY

4.0 Accessibility

4.1 Considerations for designing accessible on-demand transit

In many jurisdictions, paratransit services have operated through flexible or demand-responsive modes for many years.. Across Canada, many municipalities provide parallel transit services for persons living with disabilities that provide curb-to-curb or door-to-door service. This service has been referred to as paratransit, specialized transit, and custom transit. In recent years, most Canadian public transit systems have worked towards a fully accessible transit fleet for their conventional fixed-route services, providing people living with disabilities increased mobility and flexibility when using transit.

When planning ODT, accessibility is an important consideration in designing vehicles, stops, and routes, with consideration for persons with limited or restricted mobilities. Some provinces have or are developing legislation that requires compliance with certain accessibility standards when designing bus stops, shelters, platforms, and stations such as:

- Level or ramp for use by people with mobility devices;
- Shelters, platforms, and stations should be wide enough so that people using devices can turn around; and,
- Signage should have good colour contrast and large print.

As legislation and advocacy for universal accessibility continue to develop, ODT should strive to design all potential stops, virtual or existing bus stops, to be accessible. Depending on the service design, some ODT services also provide curb-to-curb service. ODT service providers should consider that all stops where the vehicles may pick-up, or drop-off customers are accessible in accordance with regional and provincial legislation or standards. Transit agencies that provide on-demand transit should ensure the vendors they contract can handle the complexity of eligibility requirements that come with providing paratransit service. This will be information that can influence routing in future co-mingling scenarios if applicable.

As all mobility options become more accessible, transit systems may consider integrating all their mobility options into a family-of-services model where a passenger trip can be fulfilled using a blend of mobility options including conventional and paratransit services. This extends to ODT services which may consider integrating with paratransit services, especially if there some technology, software, specialized fleet, and call centre in already use that could be scaled or expanded on for the ODT service. Additionally, when thinking about integration with paratransit services, transit agencies need to consider the impact of the paratransit system's service standards (e.g., pick up window, advanced booking, time on board, incident management).

If a transit system's ODT fleet includes vehicles that are not accessible, the booking app can prompt riders to identify whether an accessible vehicle is required for the trip.

As per the guidance and legislation for universal accessibility, transit information should also be available in other formats, such as braille, large print, audible, visual, or multilingual. This includes smartphone or web applications that should allow for screen readers or other literary devices to read the information. This will ensure persons who are visually impaired can also access the information. Additional features such as audio and visual announcements will also help persons who are blind or visually impaired use the service more comfortably.

4.2 Equity

Existing examples of ODT show service can increase transit access for low-income populations, people living with disabilities, and people with limited access to private vehicles. Compared to fixed-route service, the schedule of ODT services are more flexible and operating hours could be longer, allowing individuals with varied travel needs to be accommodated (Farber et al, 2020). Having more flexible operating hours allows for the passengers to access transit services during off-peak hours. If the proposed service area had no existing transit service, new ODT service can provide critical transit access to individuals who have never had access to transit (Klumpenhouwer, 2019).

Based on research from the Transportation Research Board in the United States, Table 4 shows which populations have the highest potential for using ODT or flexible transportation options, ranked by trip purpose (Crockett et al, 2010). This table demonstrates that equity-deserving groups such as seniors, persons with disabilities, and low-income persons have the highest potential for using ODT or flexible transportation options as they are more transit-dependent and trips are less time-sensitive (Crockett et al, 2010).

Table 4: Chart showing which populations have the highest potential for using ODT or Flexible transit options ranked by trip purpose. (Crockett et al., 2010)

<table>
<tr><th>DEMOGRAPHIC/ TRIP PURPOSE</th><th>YOUTH (<18)</th><th>ADULT (18-64)</th><th>EQUITY DESERVING GROUPS</th></tr>
<tr><td>Work</td><td colspan="3" rowspan="2">Low</td></tr>
<tr><td>School</td></tr>
<tr><td>Non-emergency Medical</td><td>High</td><td>Medium</td><td rowspan="4">High</td></tr>
<tr><td>Groceries</td><td colspan="2">Low</td></tr>
<tr><td>Shopping</td><td rowspan="2">High</td><td rowspan="2">Low</td></tr>
<tr><td>Social</td></tr>
</table>

At the same time, service providers need to ensure that equity-deserving populations are considered in service design. Issues such as an individual's ability to use technology or digital services, language barriers, or limited access to internet or wi-fi can make the service inaccessible and difficult to use. It is important that implementing transit systems are mindful of the needs of their local populations.

Some actions that can mitigate these concerns include:

- Providing options to call or text to book rides
- Providing options to book in a different language (based on local demographics)
- Providing accessible vehicles that can accommodate wheelchairs, strollers, and other mobility devices
- Providing tablets or areas with free internet or WIFI access to book trips
- Permitting both cash and electronic forms of payment
- Ensuring stops are accessible
- Providing exceptions to some trip criteria such as time-of-day restrictions, minimum trip distances
- Installation of phones at ODT transit hubs for customers to book trips through a call centre

5.0

CUSTOMER EXPERIENCE

5.0 Customer Experience

5.1 Considerations for on-demand transit customer experience

Introducing a new form of transit service such as ODT can present challenges for customers who are accustomed to using fixed-route, scheduled transit services. By creating a tailored and unique ODT service by understanding who and why customers will be can shape the overall customer experience. Implementing ODT services can improve service levels, customer experience, paratransit and accessibility, etc. (NCMM, 2018). One of the greatest challenges is to orient customers in how to use the ODT service. New scheduling and booking technologies may be intimidating for people with limited exposure to smartphones or computers. Therefore, extensive customer outreach and marketing promotions are essential in bridging the gap for customers during service design and launch (Volinski, 2019).

Passenger education and travel training are important parts of deploying on-demand transit services. Transit agencies should consider including this as part of their procurement processes to ensure that vendors are responsible for supporting transit agency training for their employees, but there is also assistance with rider outreach, education, and growth. It is important to note that social service agencies and organizations may also book rides for their clients. Therefore, operators of ODT transit services may want to partner with such organizations to provide efficient and reliable transit services to their clients. Figure 6 shows some examples of marketing advertisements and attractive branding used by Barrie Transit for its On-Demand service.

Figure 6: Example of an ad campaign and signage related to Barrie Transit's On-Demand Microtransit service.

Table 5 lists several potential actions to improve customer experience on an ODT service. The table outlines the impact the action has on both the customer and the transit system.

Table 5: Customer Service Considerations with On-Demand Transit Table 5 Customer Service Considerations with On-Demand Transit

ACTION	IMPACT TO CUSTOMER	IMPACT TO IMPLEMENTING TRANSIT SYSTEM
Community Engagement Pre-implementation	• Increased awareness and familiarity • Opportunity to shape service design and participate in the process (e.g., identify unique needs, service periods, shift times)	• Can plan for potential challenges with service design • Ensure the service is designed for customers • May result in changes to service design
Same Fare Media throughout system	• Ease of use for customers	• Consistency throughout the transit network • Reduced administrative costs
Range of Booking Options (smartphone, web, by phone)	• Provides flexibility to the customer • Achieves accessibility and equity	• Need to ensure software allows for a range of booking options • Need to ensure customer service agent is available during service hours • Specific communication strategies to inform the customer of the multiple ways to book an ODT trip
Option to book service in advance	• Provides flexibility and opportunity to plan ahead	• Gives transit system time to ensure there is enough supply to meet demand • Increases potential for cancellations • Potential for an efficiency penalty

ACTION	IMPACT TO CUSTOMER	IMPACT TO IMPLEMENTING TRANSIT SYSTEM
Provide real-time information (locations, times, driver, and vehicle information)	• Increased convenience • Ability to plan the trip accordingly	• Need to ensure software allows for the provision of real-time information • Higher level of accountability in case times or locations are inaccurate
Payment Integration through Booking Application	• Increased convenience and ease of use	• Need to ensure infrastructure for online fare payment is in place • Reduces chances of cancellations
Trip Planning through Booking Application	• Increased convenience • Ability to plan trips accordingly	• Need to ensure infrastructure for online trip planning is available • More opportunities for customers to use the service as part of a family of services
The decision between Stop to Stop, Curb to Curb or hybrid service model	• Impacts walking distance for customers • All stops must be accessible	• Transit system may be able to leverage existing stops • Transit system may need to ensure every stop is accessible (curb or stop)
Marketing Campaign to promote new service	• Informs existing customers and the public of new service	• Additional cost to plan and administer marketing campaign during service launch and continuation during service operations • Defining marketing and change management support from the contracted on-demand vendor
Work with vulnerable user groups to illustrate how to use the service	• Ensures the service is accessible to all customers. • Achieves accessibility and equity goals	• May need to conduct additional outreach and engagement to reach specific user groups and to tailor ODT services to specific customer groups

ACTION	IMPACT TO CUSTOMER	IMPACT TO IMPLEMENTING TRANSIT SYSTEM
Including customer-centric vehicle features (e.g. bike rack, child seat)	• Vehicle features could improve the attractiveness of the service to different customer groups	• Potential creation of subfleets

5.2 Payment systems

Many ODT applications accommodate some form of electronic integrated payments; however, many transit systems still allow bookings for monthly passes or through 'pay-as-you-board' systems (Klumpenhouwer, 2020). Improving mobility options and availability should be the goal of an ODT transit service while maintaining accessibility and equity (Feigon & Murphy, 2016). Extending fare integration and providing the passengers with a variety of payment methods allows for passengers who may not have access to a bank account or credit card to utilize the transit service. Accepting a variety of payment methods allows for the transit service to be more equitable and inclusive.

5.3 Importance of the vehicle operator

As a smaller and a more personalized transit service, the role of the vehicle operator is significant in an ODT service. Transit systems that have implemented ODT service say the interaction between the driver and the customer is an important aspect of customer satisfaction and experience. Therefore, drivers must receive appropriate training to assist customers in using the service, especially during the early implementation stage when many customers may be unfamiliar or uncomfortable with it. Part of the operator training should also include familiarizing operators with the ODT software from the customer perspective. Areas where vehicle operators may need to assist customers to include:

- On-board fare payment, validation, confirmation of online or in-app payment;
- Assistance with understanding the booking and tracking features on the smartphone or web application;
- Assisting customers who may have accessibility needs such as those with mobility devices, strollers, children, the elderly, or customers with luggage or large items;
- Connections to fixed route transit services;
- Wait time and travel time expectations; and,
- Safety while using the service.

6.0

DATA MONITORING & PERFORMANCE EVALUATION

6.0 Data Monitoring & Performance Evaluation

6.1 Monitoring and evaluating on-demand transit

As providing ODT services through modern technological applications is new, it is important to monitor performance through key metrics to determine whether the service is meeting the desired goals and objectives. A major lesson learned from American transit systems that implemented ODT was that its success or failure should be determined based on performance metrics that look at not just ridership and farebox recovery but also customer experience across various population demographics, improved mobility and increased safety (Volinski, 2019). This relates to the development of the appropriate balance of service levels against service quality, as noted in Section 3.2. It is essential to ensure that service levels were developed in a manner that considers the appropriate characteristics that the transit system, customers, stakeholders, and decision-makers are interested in.

Transit systems are under increasing pressure to improve performance and balance demand for service with financial constraints. The pressures and budgeting challenges may be more severe with ODT systems due to the need to add resources to accommodate additional passenger trips, unlike conventional fixed-route service which can absorb increased ridership more easily (KFH Group, 2008). Unlike traditional transit services, whose efficiency grows with more riders, the performance of ODT services can be stressed by un-planned growth. Customers who were first attracted to the convenience of ODT services can become alienated as wait times, crowding, and travel times grow as ridership increases.

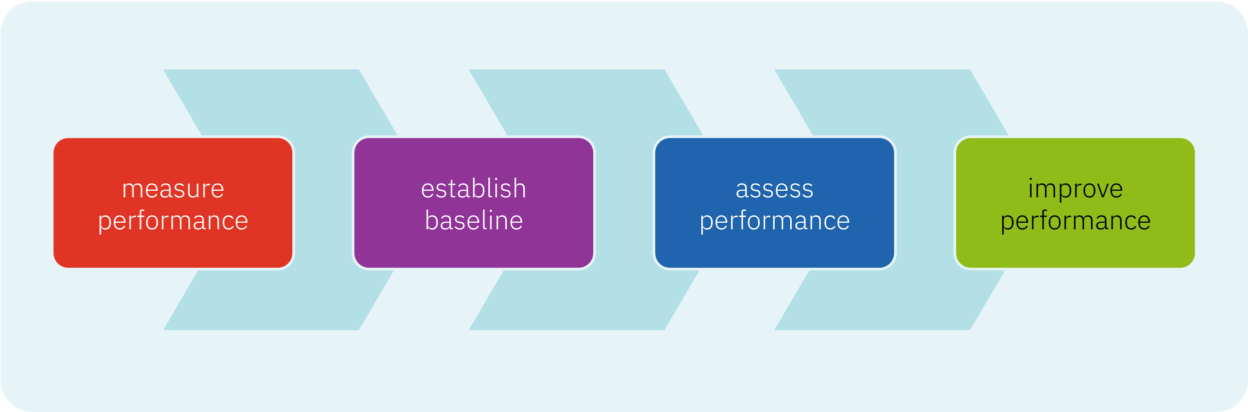


Figure 7: Measuring performance on ODT Systems (KFH Group, 2008).

It is important to have access to metrics that indicate how stressed the system is getting. For example, seeing the hour-by-hour vehicle utilization as well as reporting on the hour-by-hour wait times and search delays are all metrics that allow you to see how much ridership load the system is under.

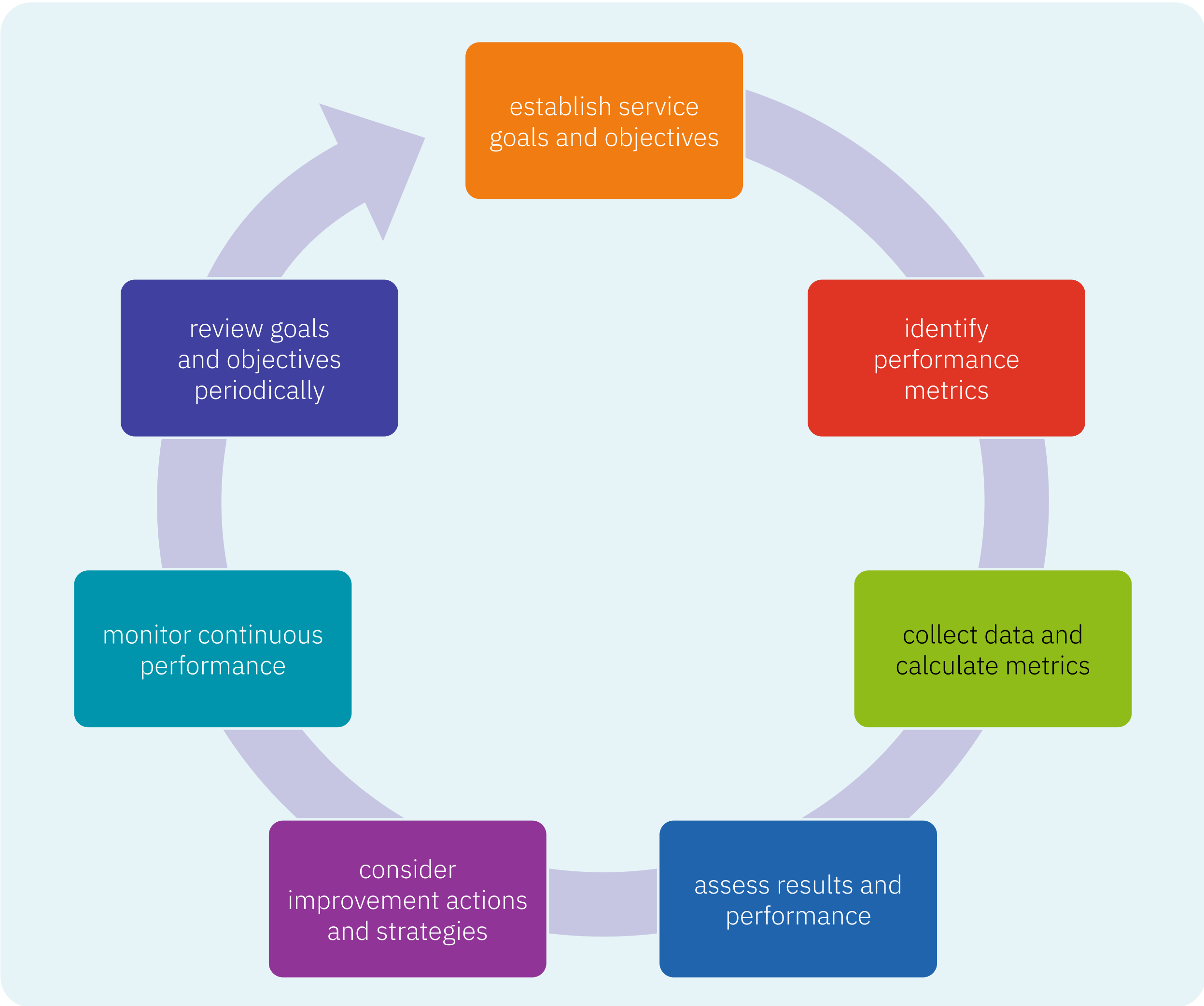


Figure 8: Measuring performance on ODT Systems (KFH Group, 2008).

Once service objectives and goals have been determined, the transit system should measure the performance through identified selected metrics or indicators, listed above, and establish a baseline. This allows for measurement through data collection and tabulation, and then assessing the resulting measures. Depending on the assessment, actions can be developed to improve performance and address deficiencies. It is also important to revisit service goals and objectives periodically to ensure the goals and objectives are still relevant and applicable (KFH Group, 2008).

6.2 Key performance indicators

Data is key to assessing the feasibility of ODT services and the effectiveness of the service once it is deployed. It is important to look at the data generated from existing transit services to determine where efficiencies can be made by replacing or supplementing services with ODT services. The table below outlines data metrics that can be used to assess different performance metrics of transit. Many metrics can be used to assess the pre-existing service, the system-wide integrated service once ODT is implemented, or just the ODT service alone.

Table 6: A list of transit key performance metrics that can be used to assess transit efficiency and quality

PERFORMANCE METRIC	DESCRIPTION	USAGE
Net direct cost per trip	Net cost of providing passenger trips after passenger fare revenue has been calculated to offset the direct operating cost on a per-trip basis. Note that this calculation uses direct costs which means it is a function of operating expenses directly related to providing transportation services netted with total revenue generated.	• Travel demand and supply • Service utilization • Feasibility of replacing fixed-route service with ODT - Low trips per hour = more feasible to replace with ODT
Revenue-cost ratio (R/C Ratio)	A ratio of expenses incurred from operating transportation services to total revenue generated by the agency.	• Financial efficiency • Feasibility of replacing fixed-route service with ODT - Low trips per hour = more feasible to replace with ODT
Customer satisfaction	Qualitative measurement of how satisfied customers are with the customer experience when using public transit which includes the booking, planning, riding, and customer service experience. Customer satisfaction can be gathered through surveys, interviews, travel diaries, or passenger travel data.	• Reliability • Access to service • Service design
Passenger trips per revenue vehicle hour	The number of passenger trips is provided for every hour a public transit vehicle is operated.	• Feasibility of ODT – fewer passengers per hour = less demand for transit • Travel demand (e.g. number of trips completed vs number of trips requested) • Service utilization

PERFORMANCE METRIC	DESCRIPTION	USAGE
Operating cost per revenue vehicle hour	The financial cost of operating a vehicle for passenger transportation.	• Financial efficiency • Feasibility of ODT – high cost per vehicle hour = more feasible to replace with ODT
Access	How many destinations can be reached commuting outwards from or towards a public transit stop? An example of access is how many public transit stops a passenger can commute to, within 35 – 40 minutes of travel time within a service network on public transit. This example is not a standard.	• Areas with little to no access to transit that are feasible for ODT implementation • Number of rides that can be serviced • Service network design efficiency • Comparison of public transit versus car access
Wait times	The time a passenger spends waiting to board a public transit vehicle. Wait times are measured beginning from when a passenger books a trip or when they arrive at a public transit stop and are waiting for a vehicle to board. Wait times should be considered in tandem with climate conditions as passengers are less likely to wait in harsher climates.	• Service network design efficiency • Customer satisfaction • Reliability and consistency in wait times - Passengers experiencing 5 vs 30 minute wait times show discrepancy in reliability • Pre-booking versus on-demand booking wait time
Travel time	Time a passenger spends commuting on public transit. Travel time excludes wait time.	• Average passenger travel time • Service network design efficiency – shorter travel time = greater efficiency

PERFORMANCE METRIC	DESCRIPTION	USAGE
On-Time Performance	The On-Demand trip for both wait time and onboard travel time is provided within the acceptable window of time aligning with the service performance requirements and customer expectations On-time performance is critical in establishing reliability and trust in the service. Customers will continue to use the service if they can trust the trip options they are provided. The low on-time performance also leads to poor or missed transfers to fixed-route	• On-time performance (actual wait time and onboard time vs service level agreement on wait times)

ODT service is most often deployed as a transportation solution unique to each agency's service network and circumstances. Benchmarking between transit agencies and developing service standards is difficult due to the unique goals each system's ODT goals are intended to be achieved. When looking at data generated from the service network, agencies need to establish what is an acceptable benchmark and target goals.

6.3 Data sharing and transparency

ODT is operationalized using technology that will generate and capture a wealth of data with which transit agencies may be unfamiliar. Examples of this data include travel demand, demographic, origin-to-destination, trip purpose, and more. It is important to consider the relevance of this data and how it can help the agency further improve its services.

Agencies should be mindful to establish access to their data with technology vendors to access, view, retrieve and analyze data generated from their operations. Monthly reporting, dashboards, data visualizations, data exporters, and periodic vendor meetings are valuable mediums that agencies can agree upon with their vendors to monitor operations and discuss strategies for success. Data provided by vendors are usually aggregated to preserve customer privacy. On-demand technology providers recommend that transit agencies should accept nothing less than owning data generated by their system. End-of-contract ownership and transfer of data (including user emails) should be explicitly written into contracts.

Agencies may also want to consider sharing their data with other stakeholders who can leverage it to improve civil services, such as municipal departments, academia, or other public data departments. Data sharing should always consider data privacy and security as well. Agencies implementing ODT should consider how users of the service can consent to sharing their data and whether it should be anonymized before usage or distribution. Some regions or jurisdictions may have legislation or policies in place that dictate how data can be gathered from users and shared with external groups.

7.0

CASE STUDIES

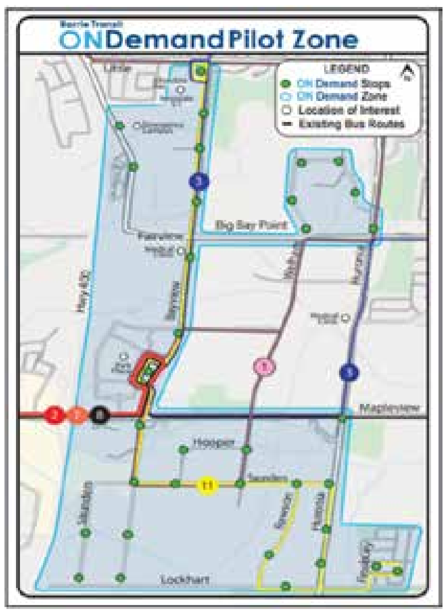
7.1 Barrie, ON

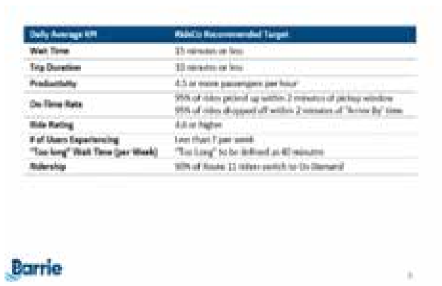
→ **More information:** barrie.ca/Living/Getting%20Around/BarrieTransit/Pages/Transit-ON-Demand.aspx

In August 2020, Barrie Transit commenced a pilot of On-Demand and Microtransit service within a selected area within the city. Operating traditional buses with fixed schedules within the selected service area was expensive and inefficient due to low population density. Barrie Transit and the ODT pilot service is intended to provide residents with accessible transit options, efficiency, comfort, and convenience (Barrie's Transit Vision, n.d.).

The On-Demand and Microtransit service provide bus stop-to-bus stop service within the identified zone, Monday to Saturday between 6:45 am to 5:30 pm. Rides can be booked up to seven days in advance or immediately through a smartphone, web app, or booking agent. A booking agent is also available during service hours. Fares for the ODT transit service are the same as regular Barrie Transit fares. Barrie Transit offers a variety of payment methods such as monthly passes, cash, transfers, credit, and app-based payments. Barrie has created a survey for passengers and residents to completed to obtain their passenger experience, comments, and suggestions for the future (Barrie's Transit Vision, n.d.).

Date of Service	2020
Type of Service	Local zonal service
Size of Service Area	Identified zone
Vehicle Fleet	Existing transit buses
Average Trips/ Passengers per Service Hour	1* - pilot was designed to operate in a low-demand area to better understand On-Demand technology. Replaced a low ridership fixed-route.
Average Cost per Service Hour	$55
Operating Model	Transit System Operating Model – Third-party contractor, the same contractor as the conventional and specialized transit service.





Daily Average KPI	RideCo Recommended Target
Wait Time	15 minutes or less
Trip Duration	10 minutes or less
Productivity	4.5 or more passengers per hour
On Time Rate	95% of rides picked up within 2 minutes of pickup window 95% of rides dropped off within 2 minutes of "Arrive By" time
Ride Rating	4.6 or higher
# of Users Experiencing "Too long" Wait Time (per Week)	Less than 7 per week "Too Long" to be defined as 40 minutes
Ridership	50% of Route 11 riders switch to On Demand

Barrie

7.2 Belleville, ON

→ **More information:** belleville.ca/en/walk-ride-and-drive/transit.aspx

In January 2018, Belleville launched an ODT pilot service to replace its nighttime fixed-routes with an on-demand service. It consisted of two buses and operated between 9 pm to 12 am on weekdays, and 7:30 pm to 12 am on weekends (Farber, Young & Zhang, 2020). By October 2018, a third bus was added to the fleet to better serve and accommodate increased demand and lessen overall wait times (Farber, Young & Zhang, 2020). The ODT service does not operate on statutory holidays. Riders can book their trips online through a smartphone application, website, or by telephone. Transfers from Belleville Transit are valid for 90 minutes.

During the ODT pilot service, the application had been downloaded over 2,000 times and had served about 1,570 monthly trips (Farooq, 2019). Since the ODT pilot service was so successful, Belleville has decided to make the ODT program permanent and plans to continuously provide evening on-demand transit service today. In early 2020, as the pandemic began, Belleville Transit temporarily made its full-time transit network on-demand.

Date of Service	2018
Type of Service	Evening Service
Size of Service Area	City of Belleville
Vehicle Fleet	Two 40’ buses (existing fleet)
Average Trips/Passengers per Service Hour	100 passengers (based on an estimate of 300-400 for evening service per day)
Average Cost per Service Hour	N/A
Operating Model	Transit System Operating Model – Belleville Transit with software from Pantonium

7.3 Calgary, AB

→ **More information:** calgarytransit.com/content/transit/en/home/plans---projects/on-demand.html

In 2019 and 2020, Calgary Transit began an On-Demand pilot in several communities. They were selected due to their low population density or identified as a new community under development. Existing low-performing fixed-routes were replaced with On-Demand service in Southwest Calgary. Introductory transit service was introduced in North Calgary through this On-Demand pilot. Riders can book their ride on a smartphone, web application, or telephone, up to five days in advance. The app-based booking system allows riders to see where to wait for their shuttle and provides real-time shuttle updates and its estimated time of arrival (Calgary Transit, n.d.). The ODT pilot service operates with Calgary's regular transit fares. Fares can be through the app or regular transit fare payment methods. Calgary transit uses shuttles (contracted vans for North Calgary and existing community shuttle buses for Southwest Calgary) to transfer passengers from their starting point to the selected destinations. These service also connect to a nearby transit hub.

	North Calgary (Carrington and Livingston)	Southwest Calgary (Springbank Hill)
Date of Service	August 2019	October 2020
Type of Service	Local community service with connections to fixed-route service at a nearby transit exchange	
Size of Service Area	4 sq km	17 sq km
Vehicle Fleet	2 – 15 passenger vans and a supervisor uses an accessible van to transport customers.	up to 6 – 21 passenger community shuttle buses during peak periods, four during off-peak, and one at late night.
Average Trips/Passengers per Service Hour	5 (November 2021)	4 (November 2021)
Average Cost per Service Hour	Southwest Calgary: $76	
Operating Model	Transit System Operating Model: Contracted to Pacific Western Transportation with software from RideCo.	Operated by Calgary Transit with software from RideCo

7.4 Cochrane, AB

→ **More information:** ridecolt.ca

The Town of Cochrane did not have a transit system and was looking for an innovative option to provide transit service to residents. In October 2019, the town launched Cochrane On-Demand Local Transit (COLT). Bus stops are located throughout the town and vehicles pick-up and drop-off passengers according to demand. This ODT pilot is expected to be running for 5 years to gather data and information regarding ridership and demand (COLT, n.d.). The goal of the five-year pilot service is to provide introductory transit service, understand customer demand and plan for efficient and effective transportation options for local residents.

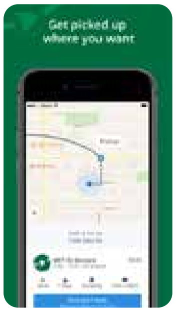
The on-demand transit service operates from 6 am to 8 pm on weekdays, and 9 am to 3 pm on Saturdays; it currently does not operate on Sundays. Passengers can book their ride up to a week in advance through smartphone or web apps, or can call a customer service number. The ODT service provides an interactive map to display the pick-up and drop-off stops. The service currently runs as a local transit service within Cochrane, but the town is looking to expand the service to connect to regional transit destinations. It's also planning to integrate 4 local deviated bus routes to enhance the overall regional transit service and provide the residents of Cochrane transit options to key destination locations (COLT, n.d.).

Date of Service	2019
Type of Service	Local Service throughout the municipality
Size of Service Area	Town of Cochrane
Vehicle Fleet	8 vehicles, up to 4 vehicles in revenue service
Average Trips/Passengers per Service Hour	4.6 trips per hour (pre-COVID-19), 2.9 trips per hour (during COVID-19)
Average Cost per Service Hour	$64
Operating Model	Third-Party Operating Model – Fleet and Drivers by Pacific Western Transportation; Software by RideCo

7.5 Durham Region, ON

→ **More information:** durhamregiontransit.com

As a response to reduced ridership during the COVID-19 pandemic, in September 2020 Durham Region Transit replaced 25 of its local bus routes with on-demand transit services. Although it was already providing an ODT service for some rural areas before the pandemic, this new initiative expanded the ODT service to serve urban zones primarily across Ajax, Clarington, Pickering, and Whitby. Durham Region Transit's ODT service operates in multiple communities to provide residents with on-demand transit options. The transit system increased fixed-route service on its busiest transit corridors to complement the ODT service. The on-demand transit service connects to bus routes and GO Transit services within the area (Durham Region Transit 2021). The app-based booking system allows riders to access real-time trip updates and notifications and can add the number of riders, accessibility requirements, and desired arrival or departure time (Durham Region Transit, n.d.). Riders can book their trips at least 15 minutes in advance through two applications, one for trip planning and one for requesting a pick-up. Riders are then picked up by either full-size transit buses or shared vans/sedans. As ridership recovers, Durham Region Transit will reactivate selected local routes as required as was done in Bowmanville in April 2022. The ODT service encourages route deviations and ridesharing.



Date of Service	2020
Type of Service	Local zonal service with regional connections
Size of Service Area	On-demand transit zones within a 2,525 square kilometres service area
Vehicle Fleet	Transit buses, Vans, Sedans
Average Trips/Passengers per Service Hour	N/A
Average Cost per Service Hour	N/A
Operating Model	Hybrid – Transit System and Third-Party Operating Model: Operated by Durham Region Transit and partnerships with local taxi services with software from Spare Labs

7.6 Edmonton, AB

→ **More information:** edmonton.ca/projects_plans/transit/bus-network-redesign-first-km-last-km-study

In April 2021, Edmonton Transit Service (ETS) implemented the largest On-Demand Transit program in Canada as a key service offering in the city's new bus network redesign. ETS transitioned lower ridership fixed-route services in 37 neighbourhoods to On-Demand transit where residents can book a trip from their community for travel to a designated transit hub (e.g. transit exchange, light rail transit station). To facilitate the transition, no fares are collected onboard the On-Demand transit vehicle, customers are charged a fare when they connect to conventional fixed-route and light rail transit services. On-demand transit service is provided with a fleet of 52 community shuttle-style vehicles, equipped with a rear wheelchair ramp and a children's car seat embedded in a designated seat at the front of the shuttle vehicle. Pick up and drop off within the On-Demand service areas occur at designated stops identified with signage and on the app. Hours of service are consistent for every neighbourhood-based service. Trips can be booked up to 60 minutes in advance through the Edmonton On-Demand Transit app, online or by phone.

Additionally, an On-Demand transit service was also launched to 16 large seniors residences across the city previously served by three fixed-route services, to allow for greater access from these residences to the rest of the transit network. A fleet of five low-floor community shuttle vehicles are assigned for On-Demand services to the large senior residences.

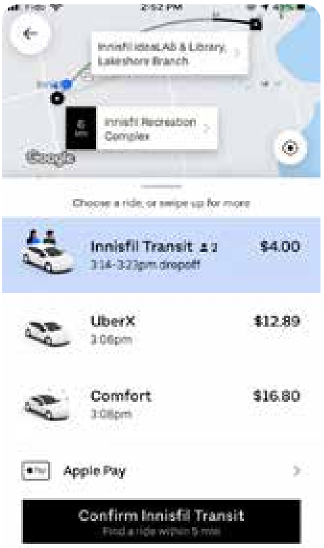
ETS On-Demand Transit is being operated for two years by Pacific Western Transportation in partnership with Via as the technology provider.

Date of Service	2021
Type of Service	Local zonal service and market-based services (e.g. seniors residences)
Size of Service Area	On-demand transit zones are situated throughout the City of Edmonton
Vehicle Fleet	52 (neighbourhood based service), 5 (seniors residence focussed service)
Average Trips/Passengers per Service Hour	46 passengers per hour (system wide average)
Average Cost per Service Hour	$68/hour
Operating Model	Third-Party Operating Model: Operated by Pacific Western Transportation with software from Via.

7.7 Innisfil, ON

→ **More information:** innisfil.ca/transit/

Uber | INNISFIL TRANSIT



In 2016, Innisfil had a population of about 36,566 people and needed a transportation system to serve its rural community (Valverde & Flynn, 2020). In 2017, it partnered with Uber to provide on-demand local transit options while using Uber drivers and vehicles. Innisfil decided to partner with Uber after the costs of fixed bus routes were determined to be too high. In 2018, almost 86,000 trips were using the partnership service.

Rides can be booked through the Uber application, web application or they can call a booking agent. In September 2020,Innisfil partnered with GoGoGrandparent to increase accessibility and bridge the digital divide in regards to Innisfil Transit. GoGoGrandparent provides residents who do not have access to a smartphone with an alternative booking option. GoGoGrandparent supplies residents with a toll-free phone number that is available 24/7 to book their transit rides.

Date of Service	May 15, 2017
Type of Service	Municipal - Contracted Service
Size of Service Area	Town of Innisfil
Vehicle Fleet	Varies with Uber driver supply
Average Trips/ Passengers per Service Hour	63,231 total trips in 2021 Average of 7.22 trips per hour
Average Cost per Service Hour	N/A – municipality pays an average of $11 per trip
Operating Model	Contracts/partnerships with Uber (general trips), Barrie Taxi/Driverseat (WAV trips), GoGoGrandparent (call-in trips)

In April of 2019, fares were increased from $3 to $6 per trip to $4 to $6 depending on the type of trip. If a passenger is travelling to a location that is not a listed key destination, then there will be a $4 deduction off their total trip cost. Fare payments are made either by credit card, PayPal, or Uber gift cards. In 2019, Innisfil implemented a 30 trips per month rule, however passengers can apply to increase their rides to 50 trips per month (Valverde & Flynn, 2020). If the passenger exceeds their set rides per month, then the passenger will pay regular Uber fares. This partnership between Innisfil and Uber significantly expanded the mobility of local residents and increased ridesharing (Valverde & Flynn, 2020).

7.8 Longueuil, QC

The Réseau de transport de Longueuil (RTL) announced an on-demand transit pilot project in 2018, making it the first transit provider in Québec to offer an on-demand transit service, where routes are determined based on demand. Using the RTL à la demande app, users in Saint-Bruno-de-Montarville living in a specific sector south of Route 116 have access to an on-demand taxi service. The pilot was later extended to also service the industrial areas in Longueuil and Boucherville.

Passengers can request a taxi through a mobile app to a point near their booking location and be dropped off anywhere within the service area. The on-demand service will routes trips so that passengers will share rides to maximize vehicles usage. The fare is the same as the RTL's regular public transit service. Service is limited to only off-peak times.

7.9 Milton, ON

→ **More information:** milton.ca/en/living-in-milton/milton-transit-ondemand.aspx#Transit-app

In May 2015 Metrolinx, in partnership with Milton, launched an 11-month pilot project that provided an on-demand shuttle service between the Milton GO Station and the surrounding neighbourhood. The service was available during the morning and evening peak periods. Riders could book their trips through smartphone and website applications either on the same day of their trips or a few days in advance.

According to a passenger survey, rider satisfaction with the service was almost 90%. Over 13,000+ rides were taken during the length of the pilot.

On May 3, 2021, Milton Transit launched an on-demand pilot service to serve the residents in Boyne Zone 1 (southeastern Milton). Boyne Zone 1 is a developing residential community without frequent transit service. This service area was selected to learn and gather more information and data regarding ridership and travel patterns (Milton, 2021). Thus, informing future opportunities and transit routes for the service area. Milton District Hospital, Commercial Street, Milton Sports Centre, and Milton Sports Centre are the 4 main transfer points for the ODT pilot service.

Rides can be booked through a smartphone application, web application, or calling in to speak with a booking agent. Rides can be booked at least 15 minutes in advance.

Date of Service	2015	September 7, 2021
Type of Service	First-mile/ last-mile service to a GO Station	Local community service
Size of Service Area	240 virtual stops around the Milton GO Station	2 zones: Boyne and 401 Industrial
Vehicle Fleet	14 five-seater vans (5-7 vans used at any given time)	6 RAM Promasters, 2 Arboc, 2 Journeys
Average Trips/ Passengers per Service Hour	3 passengers per service hour	2.31 Average Boardings per Vehicle Hour (Sept 2021-Dec 2021)
Average Cost per Service Hour	N/A	$42.45
Operating Model	Third-Party Operating Model: Operated by RideCo and partnership with local transportation services with RideCO software.	Third Party Contractor

7.10 Niagara Region, ON

→ **More information:** niagararegion.ca/transit/on-demand/

In August 2020, the Region of Niagara launched a regional On-Demand and Microtransit service which provides service in predominantly rural areas of west Niagara and connects residents to the transit hubs at St. Catharines Bus Terminal, Welland Bus Terminal, and Port Colborne City Hall. This is the first form of transit service in much of the region. The ODT service operates from Monday to Saturday from 7 am to 10 pm. Meanwhile, transit service for Niagara-on-the-lake operates from Monday to Saturday from 7 am to 7 pm (Niagara Region, n.d). It currently doesn't run on Sundays. The ODT service allows for transfers to local transit hubs for riders to complete their trips.

Riders can book shared rides for local trips within their municipality as well as rides between municipalities. Riders can book a trip up to 15 minutes in advance of their departure through a smartphone application, web application or they can call a booking agent. Trips within the municipality are $3, however, if a passenger would like to travel outside of the municipality, it costs $6. Due to the regional scale of the service, the vehicle picks up riders within an average walking distance of 100 meters with a maximum wait time of one hour. There is also a maximum detour time to accommodate rideshare of 20 minutes.

Date of Service	2020
Type of Service	Municipal and inter-municipal service
Size of Service Area	Specific municipalities with regional connections
Vehicle Fleet	10 high-capacity vehicles
Average Trips/Passengers per Service Hour	N/A
Average Cost per Service Hour	N/A
Operating Model	Third-Party Operating Model – Vehicles, drivers, and software provided by Via

8.0 Next Steps

The project team from the Canadian Urban Transit Association and Metrolinx will be releasing the first version of the On-Demand Toolkit in the Spring of 2022. This Toolkit's information and materials represent insights on planning, operations, accessibility, customer experience, data monitoring, and performance evaluation at the time of writing. It is anticipated that this toolkit will be a living document updated by CUTA/Metrolinx staff with support from the transit system member working group and the vendor community as On-Demand technology continuously evolves and additional deployments will glean new lessons and best practices that can be integrated into future versions of this toolkit.

9.0

GLOSSARY

9.0 Glossary

FIRST-MILE LAST-MILE (FMLM)

This describes the challenge of moving people between transit stations, mobility hubs, or fixed-route transit services and their home, workplace, or other major destination. The concept applies broadly to making improvements in transit access for all people trying to reach transit regardless of if they live within one mile of a transit station or mobility hub.

CONVENTIONAL FIXED-ROUTE TRANSIT

Refers to a form of transit provision with vehicle routes and schedules fixed and set in advance. Fixed-route transit is the most common form of transit provision, with a network of specified stops with vehicles arriving and departing at scheduled intervals. Fixed-route transit services include all modes such as bus, light rail, heavy rail, commuter rail, ferry, streetcar, trolleybuses, etc. Fixed-route transit is also called conventional transit or regular transit in some jurisdictions.

EQUITY-DESERVING GROUPS

Groups that experience collective barriers in participating in society due to disadvantage and discrimination. Such barriers could include attitudinal, historic, social, and environmental barriers based on characteristics including, but not limited to: Race and ethnicity; Indigenous status; Gender and gender identity; Sexual orientation; Disability; Age; Income and socio-economic status; Immigration status; Family status; and Employment status.

LEVEL OF SERVICE

Level of Service refers to standards by which the quality of the service can be measured, based on different operational characteristics of the service such as frequency, availability, safety, reliability, and accessibility. It also helps evaluate a route's capacity and frequency, namely the time between pickups at a station or stop.

MICROTRANSIT

Microtransit is a transportation service where vehicles will deviate from their current routes to pick up additional passengers requesting service in the same direction. Microtransit can be operated with buses, vans, or sedans. Some regions refer to Microtransit synonymously with ridesharing.

RIDESHARE

Rideshare can have multiple meanings within the context of on-demand transit. It can describe how multiple passengers can be organized during the booking or routing of trips to ride in the same vehicle towards a common destination. It can also refer to transportation network companies (TNCs) such as Uber or Lyft that provide on-demand transit services booked through software, or an app. Despite the term

"rideshare" not all rides booked on TNCs are shared depending on passenger destinations. Some may refer to rideshare synonymously with ride-hailing and Microtransit.

RIDE-HAILING

Ride-hailing refers to transportation services where passengers can hail a personal driver to drive them to their destination. Traditionally, ride-hailing referred to taxi services but expanded to also refer to TNC services such as Uber and Lyft as they all provide personal drivers via hailing through apps or other methods. Ride-hailing services typically do not pick up multiple passengers to share a ride but could do so. Some refer to ride-hailing and ride-sharing synonymously. Ridesharing is more commonly used to refer to TNCs than ride-hailing.

NEW MOBILITY

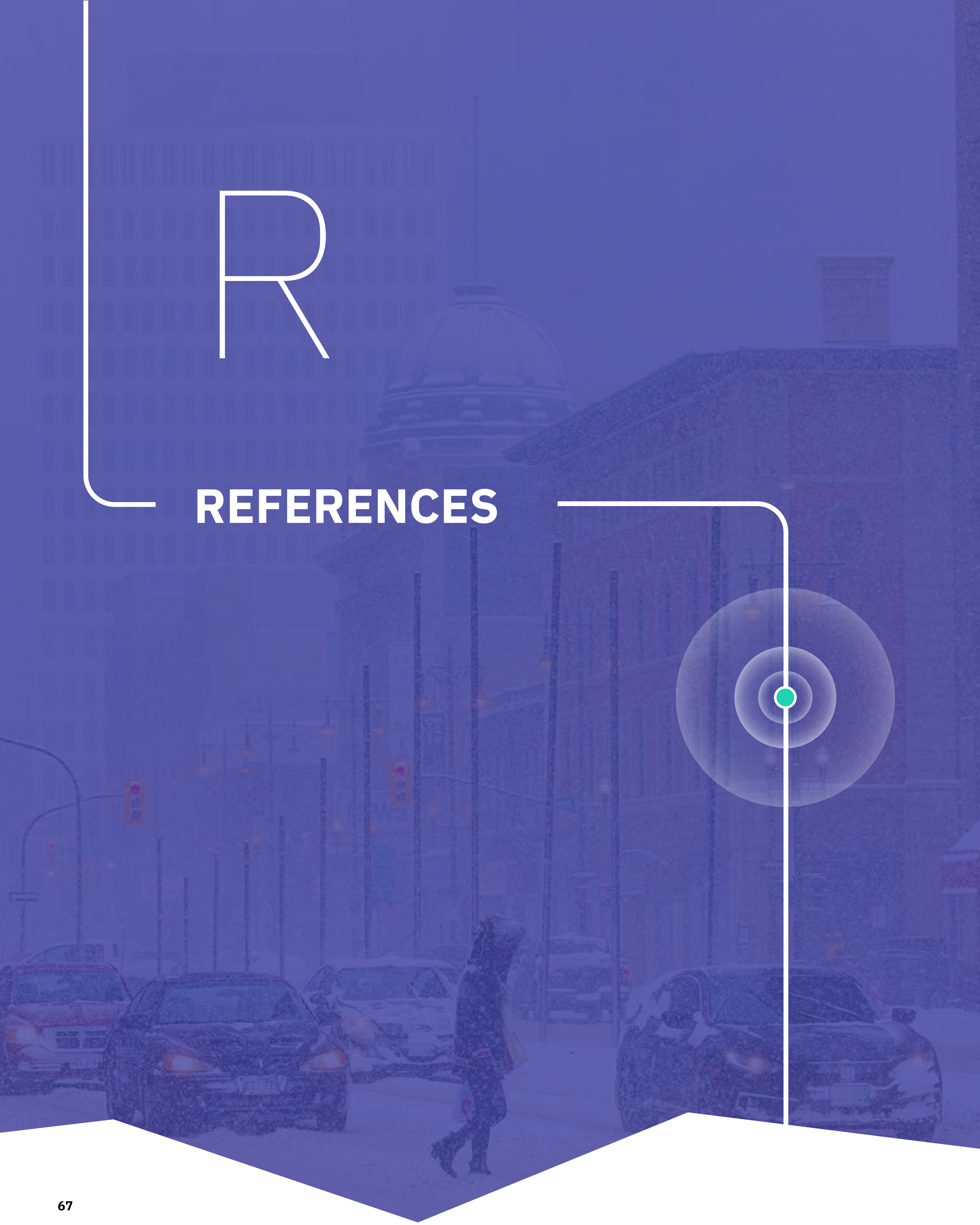
A term to describe the suite of emerging transportation services that are enabled through the development and convergence of technologies (e.g., smartphones, real-time data, autonomous and connected vehicles) and business models (e.g., shared mobility and mobility as a service). See autonomous vehicles, connected vehicles, mobility as a service, and shared mobility

ON-DEMAND TRANSIT (ODT)

Refers to an alternative form of transit provision, also known as Demand-Responsive Transit (DRT), where vehicle routes and schedules are determined by passenger demand. This contrasts with Fixed-Route Transit (FRT) or conventional transit service where transit routes and schedules are fixed and set in advance. ODT services utilize vehicles of all sizes including sedans, vans, shuttles, or transit buses.

SHARED MOBILITY

A type of new mobility that refers to a broad set of transportation services and business models that are shared among users, such as bike-sharing, car-sharing, micro-transit, ride-sourcing, and ridesharing. See new mobility.



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APPENDIX

11.0 Appendix

12.1 CUTA transit system consultation

CUTA invited its transit system members to participate in a working group who provided feedback on the work presented in this document. Participating transit agencies are documented on page 3.

12.2 CUTA business member consultation

CUTA engaged with several of its business members in November 2021 who are vendors of technology or other services associated with implementing ODT to provide recommendations to agencies on how to establish mutually successful relationships for both the agency and vendors. Below is a list of organizations who participated in this consultation as well as recommendations put forth through this engagement intended for transit agencies.

Invited Participants:

- Bytemark
- FAIRTIQ
- Pacific Western Transportation
- Pantonium
- Spare Labs
- Trapeze Group
- Via Transportation
- Uber

RECOMMENDATIONS

Engaging with vendors earlier will yield better and more robust solutions.

Vendors would prefer to be engaged with transit agencies as early in the ODT planning process so that they have enough lead time to share best practices from other case studies, consider functionalities that may not exist in the technology yet, scope service design specifics, provide service planning simulations, budget realistically, and overall provide stronger proposal responses for RFPs.

Take time to educate and understand ODT before putting forth an RFP.

Transit agencies should educate themselves sufficiently about ODT before putting forth an RFP. RFIs and market soundings should be part of the process to help draft thorough RFPs as well as facilitate an understanding of what vendors can provide as solutions. RFPs that lack understanding of ODT or have unrealistic expectations increase the risk of extending procurement processes through addendums and re-issued RFPs due to a mismatch of agency expectations of ODT and industry solutions.

Provide sufficient time for RFP submissions.

Vendors recommend that at a minimum, RFPs should allow vendors one month to prepare and respond. Q&A meetings to respond to vendor questions should be conducted early during the RFP timeline to give vendors sufficient time to revise and plan their proposals with a greater understanding of expectations. Giving a substantial amount of lead time for responses will ensure vendors have sufficient time to build strong proposals. Conducting a Q&A earlier on in the procurement process helps set proper expectations and understanding of the service objectives that the agency is working to achieve to sufficiently respond to RFPs.

Market sounding is essential to the procurement process.

ODT is intended to be a mobility solution that is malleable to each agency's unique circumstances. Vendors are equipped to provide various solutions that suit different needs. As such, agencies should provide openness to different solutions offered by vendors. RFPs that are written narrowly or with preconceived ideas about ODT can limit other options and solutions that are available in the market. Engaging with vendors on possible solutions is also conducive to learning more about capabilities in the market and making well-rounded decisions.

Leverage vendor knowledge as much as possible in the feasibility assessment step.

Vendors have a wide range of experience in deploying ODT for different service networks across North America. Vendor knowledge is a valuable resource to tap into when attempting to plan and assess the feasibility of implanting ODT. Vendors can assist with building scenarios, assessing fixed-routes for replacement, and sharing findings from other projects.

Plan and consider ODT from a holistic perspective that includes multiple teams and departments within the agency.

Planning ODT includes considerations for many aspects of transportation service such as financing, operations, customer service, communications, municipal planning, equity, technology deployment, etc. It is important to ensure that the team behind planning ODT represents a holistic perspective when planning ODT to mitigate scenarios where plans need to be brought back to the drawing board due to factors that do not comply with other municipal departments that were not consulted.

Consider piloting ODT with multiple vendors and scaling the best options upwards in an iterative approach.

As mentioned throughout this research, ODT is a flexible solution that can change to suit the unique needs of each transit agency. It is difficult for vendors to address specific solutions during the procurement process and so open-endedness and pilots are valuable in offering flexibility to test different scenarios and models.