PEMBINA institute

Fast Cities

A comparison of rapid transit in major Canadian cities

Photo: "O Train over Rideau by Wikier" from Wikimedia Commons

Investing in transit infrastructure is essential to relieve gridlock in Canada's cities and provide commuters with convenient ways to get around. However, not all cities are improving their transit systems to the same degree, and some are falling behind.

This report compares rapid transit in five of Canada's largest cities: Toronto, Montreal, Vancouver, Calgary and Ottawa. It analyzes how well transit networks serve residents in each of these cities, and how effectively they have responded to the pressures of growth and the need for expanded rapid transit that comes with it.

The factors we examined include the length of existing rapid transit networks — that is, subways, SkyTrains, light rail, right-of-way streetcars and right-of-way rapid buses — along with express bus networks (such as Toronto's Rocket and Vancouver's B-Line). We also looked at ridership levels and the proximity of each city's population to transit stations or stops.

Key findings

1 **Toronto has the highest rapid transit ridership per capita** with residents of the city taking an average of 133 transit trips per year.

2 **Calgary leads Canada's cities in rapid transit infrastructure per capita.** Despite its high ridership, Toronto has less rapid transit infrastructure per capita to accommodate riders than Calgary, Ottawa and Montreal.

3 **Vancouver has built the most rapid transit over the last 20 years,** opening 44 kilometres (km) of new lines, followed by Calgary with 29 km. By comparison, Toronto has opened 18 km of new rapid transit during the same time period.

4 **Over the past decade, Calgary and Vancouver built the most transit.** The two cities have opened 22 km and 20 km of new rapid transit lines respectively, followed by Ottawa with 9 km and Toronto with 7 km.

5 **Montreal leads the way in access to rapid transit** with 37% of its population living within walking distance of a rapid transit stop or station. It is followed by Toronto, where 34% of residents can walk to rapid transit.

Fast Cities is a project of the Pembina Foundation for Environmental Research and Education, which has entered into a service agreement with the Pembina Institute to produce this report.

Summary of analysis

		Toronto	Montreal	Vancouver	Calgary	Ottawa
Rapid and express transit	Length of existing rapid transit lines	**83** km	69 km	68 km	59 km	43 km
	Length of existing rapid transit lines per million residents	32 km	37 km	29 km	**53 km**	49 km
	Annual rapid transit trips per capita	**133**	93	52	74	104
	Residents living within 1 km of existing rapid transit service	34 %	**37 %**	19 %	21 %	28 %
	Length of rapid transit lines opened in past 20 years	18 km	5 km	**44 km**	29 km	23 km
	Length of rapid transit lines opened in past 10 years	7 km	5 km	20 km	**22 km**	9 km
	Length of express bus lines opened in past 20 years	**87 km**	0 km	38 km	16 km	0 km

Table 1: Comparison of transit infrastructure and investment in major Canadian cities

Table figures are for the service area of each municipality's transit system. See the "Transit service areas studied" section for more details. Trips refer to boardings of individual transit lines. See Appendix A for methodological details.

What is rapid transit?

This report examines both *rapid* and *express* transit infrastructure — transit systems that are capable of moving riders quickly, frequently and reliably. The distinction between rapid, express and other forms of transit is not always clear, and it has become increasingly blurred in recent years as new technologies and hybrid systems have proliferated.

Rapid transit

Rapid transit represents the highest order of transit service. It is the backbone that moves the largest volume of riders and provides the greatest level of mobility, frequency and speed. Common rapid transit technologies include subways, light metros, light rail transit, right-of-way streetcars and right-of-way rapid buses.

For this report, the criteria below were used to identify transit infrastructure that meets the definition of rapid transit.[1]

1. **Separated from traffic:** Vehicles that either travel on a grade-separated path, or in their own lane or track that interacts with other traffic only at intersections or crossings. This makes them immune to traffic congestion.
2. **Priority signalling:** For LRT, BRT, rapid streetcars and some express buses, vehicles that are not grade-separated receive priority from traffic signals. This can be done through measures such as changing the length of traffic light phases. It ensures that they can move at a consistent frequency and are not held up by automobile traffic.
3. **All-day, two-way service:** Routes that provide regular service throughout the day, including within the city core. This differentiates them from regional commuter routes with peak-only service, or commuter service that skips over stops within the city itself.
4. **Maximum wait of 10 minutes during peak times:** The frequency of service in peak times is a critical factor for commuters. Rush hour commuters should not be waiting longer than 10 minutes, and ideally not more than five minutes, for a transit vehicle.
5. **Maximum wait of 15 minutes during off-peak times:** Fifteen minutes has been identified as frequent enough service that riders don't have to plan their trip around a timetable.
6. **Optimal spacing of stops and stations:** Stops are spaced close enough for riders to walk to them, but far enough apart to keep vehicles moving. Vehicles stop less frequently than regular bus or streetcar service.[2]
7. **Network connectivity:** A rapid transit line needs to connect to a larger network, rather than terminate at, or merge into, non-rapid modes of transportation.
8. **Off-board fare collection and platform-level boarding:** The vehicle operator does not collect fares and passengers can step directly from a platform into the vehicle without using stairs. Both of these measures expedite boarding.

We have applied these criteria flexibly but consistently in this report, so as to recognize innovative modes and technologies that meet the intent of moving riders quickly, frequently and reliably. Not all types of rapid transit will meet every one of these criteria. Below we describe the various forms that are included as rapid transit in this analysis.

Photo: Roberta Franchuk, Pembina Institute

Subway / Metro

A fast-moving, high-capacity train that operates on a separate path from regular traffic. It is typically located in underground tunnels, but sometimes runs on the surface or elevated above street level.

Light Metro

Similar to a subway, a light metro operates on a separate path such as an elevated structure or underground tunnel, but it uses lighter, lower-capacity trains. Vancouver's SkyTrain operates at speeds that exceed some subways thanks to the use of automation, shorter station stopping times and the faster acceleration and deceleration time of lighter vehicles.

Photo: Roberta Franchuk, Pembina Institute

Photo: Roberta Franchuk, Pembina Institute

Light Rail Transit (LRT)

A fast-moving train that operates in its own right of way. It usually runs on the surface in a separated traffic lane or rail corridor, but sometimes runs in underground tunnels or on elevated structures. LRTs have about twice as many stops as subways but fewer than bus or streetcar routes. They are faster and carry more people than streetcars or buses.

Bus Rapid Transit (BRT)

A bus that travels in its own lane, separated from other traffic by curbs. It often uses other measures like priority signalling and off-board fare collection to provide rapid service using bus technology. In Ottawa, much of the bus rapid transit system operates on a series of completely separate roads known as the Transitway.

Photo: Association of Graduate Planners, University of Waterloo


Photo: Roberta Franchuk, Pembina Institute

Rapid Streetcar

A streetcar that travels in its own lane separated from traffic by curbs, such as Toronto's Spadina and St. Clair routes. It is faster and more reliable than regular streetcars that travel in mixed traffic, such as the Queen or College routes.

Express transit

Express buses — in some cases referred to as "BRT-lite" — do not run in a separated lane, but instead mix with regular traffic. However, they use other measures to offer an enhanced level of service approaching that of rapid transit. These measures may include greater spacing between stops, signal priority for vehicles and more comfortable waiting areas.

Photo: "Vancouver Transit" by ArielKettle, Wikimedia Commons

For example, Vancouver's Broadway B-line bus operates in an exclusive lane during rush hour. Calgary's 300-series routes include "queue jumps", exclusive lanes at key intersections with their own traffic signal, which allow express buses to proceed ahead of other traffic.

Express bus service is a cost-effective way to fill gaps in a city's rapid transit network, and it can be deployed much more quickly than most rapid transit technologies. Where demand remains steady or continues to grow along a corridor, an express bus may be replaced in time by a full-fledged rapid transit line.

In this analysis, express bus routes include all-day, two-way services with a maximum wait of 10 minutes during peak times and 15 minutes during off-peak times. Many bus services that are described as "express" by transit agencies only operate during rush hour, or operate infrequently at other times and therefore have not been included.[3]

Transit service areas studied

For the purposes of this report, we delineated the "core" transit service area for each city. In some cases, this is straightforward: the service areas of the Toronto Transit Commission, Calgary Transit and OC Transpo correspond directly to the municipal boundaries of Toronto, Calgary and Ottawa.

The Société de transport de Montréal serves the entire island of Montreal, an area larger than the city proper but smaller than Montreal's metropolitan area. We used that geography for our analysis, while excluding off-island municipalities that have only short Metro lines.

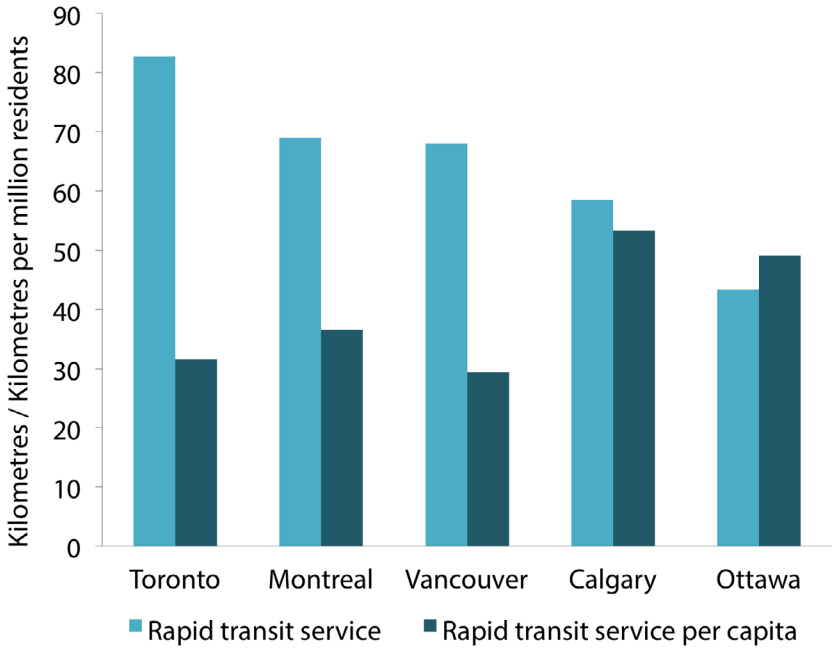
The City of Vancouver is relatively small — it has only 600,000 residents — whereas TransLink serves the entire metropolitan area. We used this full service area for our analysis. However, it includes many more low-density, suburban regions than the service area for Toronto, where comparable communities are not served by the TTC. Because of this mismatch, Vancouver's scores on some measures — including ridership per capita and transit accessibility — tend to understate the relative merits of its transit network.

Transit system	Area served	Population served[4]
Toronto Transit Commission	City of Toronto	2,615,060
Société de transport de Montréal	Island of Montreal	1,886,481
TransLink	Metro Vancouver	2,313,328
Calgary Transit	City of Calgary	1,096,833
OC Transpo	City of Ottawa	883,391

Rapid transit infrastructure across Canada

Both Montreal and Toronto built significant subway systems many decades ago, but have made relatively few investments in rapid transit infrastructure over the last 20 years. Only modest rapid transit expansion has occurred over this time period through the construction of short subway extensions, and for Toronto some right-of-way rapid streetcar infrastructure. Both cities lag behind other Canadian cities that are investing in quick-to-deploy rapid transit technologies.

Figure 1: Existing rapid transit infrastructure



Calgary leads Canadian cities in terms of most rapid transit infrastructure per capita, with its LRT network, as can be seen in Figure 1. It is followed closely by Ottawa, which has also been highly responsive to population and growth. When we look at overall rapid transit built in the last two decades, Vancouver leads the way thanks to considerable investments in its SkyTrain network (see Figure 2).

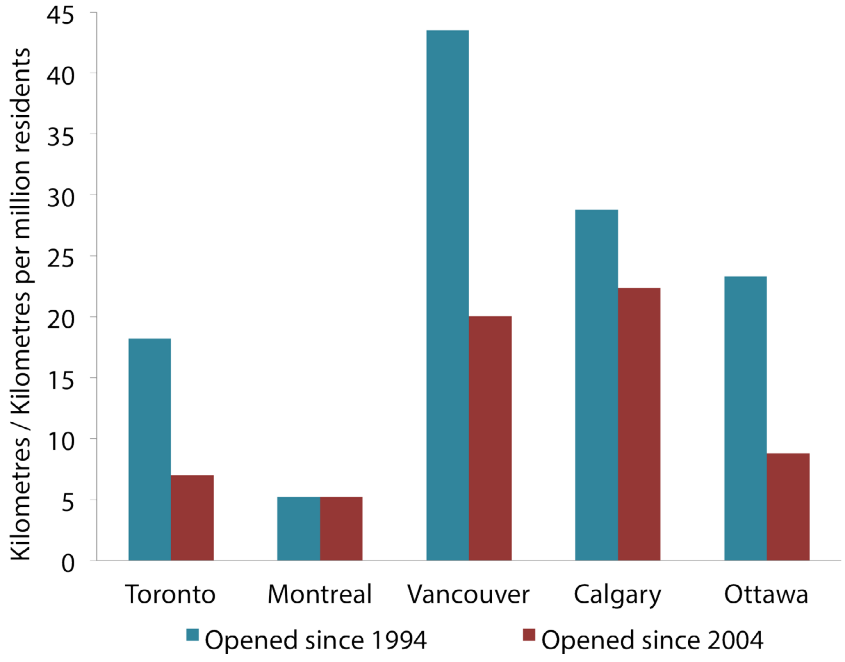


Figure 2: Rapid transit infrastructure opened in the last 20 years

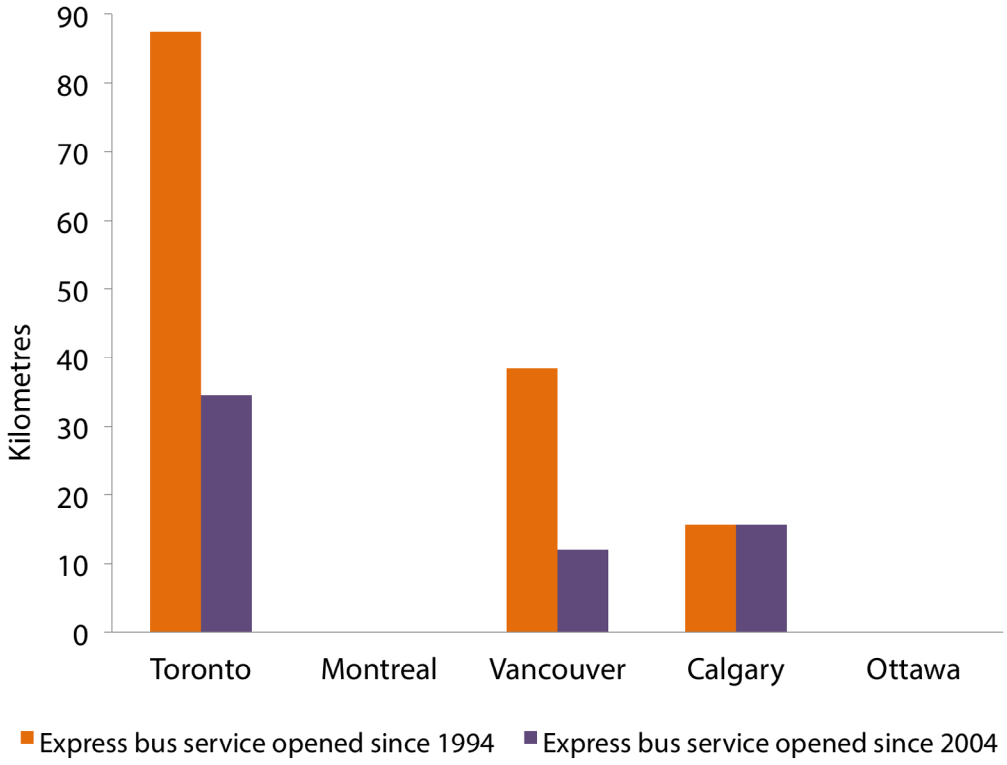
This is particularly problematic for Toronto: while the island of Montreal's population has not increased significantly since the 1970s — most growth has occurred in off-island suburbs — Toronto's transit has failed to keep up with the core city's rapid population and ridership growth.

In Toronto, virtually no new rapid transit service has opened in the last 10 years. The only exception is the conversion of the existing St. Clair streetcar to right-of-way service. Vancouver and Calgary have built the most transit infrastructure in the past 10 years.

Express bus service

Toronto leads the way in express bus service with 87 km of express Rocket lines that serve neighbourhoods that are not reached by rapid transit. It is followed by Vancouver with 38 km of B-Line buses and Calgary with 16 km of rapid buses. Most or all of these routes have opened in the last two decades.

Figure 3: Express bus service



Access to rapid transit

Being able to walk to rapid transit in 10 minutes — which we defined as being within one kilometre of a stop or station[5] — is a critical factor affecting ridership. Montreal leads the way in this regard, with 37% of its population within walking distance of rapid transit. It is followed by Toronto with 34% and Ottawa with 28% of residents within walking distance.

Although Vancouver and Calgary have made large strides in expanding their rapid transit systems, these systems are not walkable for much of their population. In both cities, express bus service helps to fill this gap.

Figure 4 speaks to the significant base of subway infrastructure that Montreal and Toronto invested in many decades ago, which serves large populations in each city's core. Vancouver is a special case: this analysis considers the entire TransLink service area (Metro Vancouver), which includes a number of lower-density suburban communities. The service areas for Montreal and Toronto include fewer comparable communities.

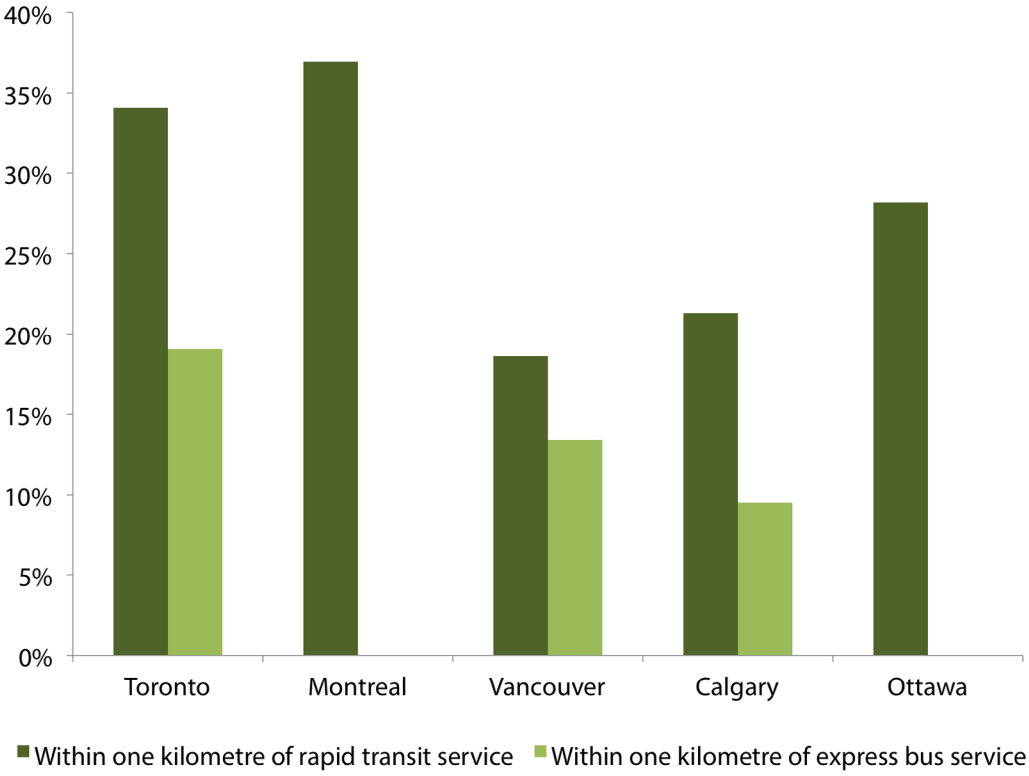


Figure 4: Percentage of population within walking distance of rapid transit or express bus service

As a result, Vancouver's accessibility numbers understate the amount of transit infrastructure. When we consider the City of Vancouver proper, access to rapid and express transit is considerably higher: 54% of residents are in walking distance of rapid transit, as can be seen in Figure 5.

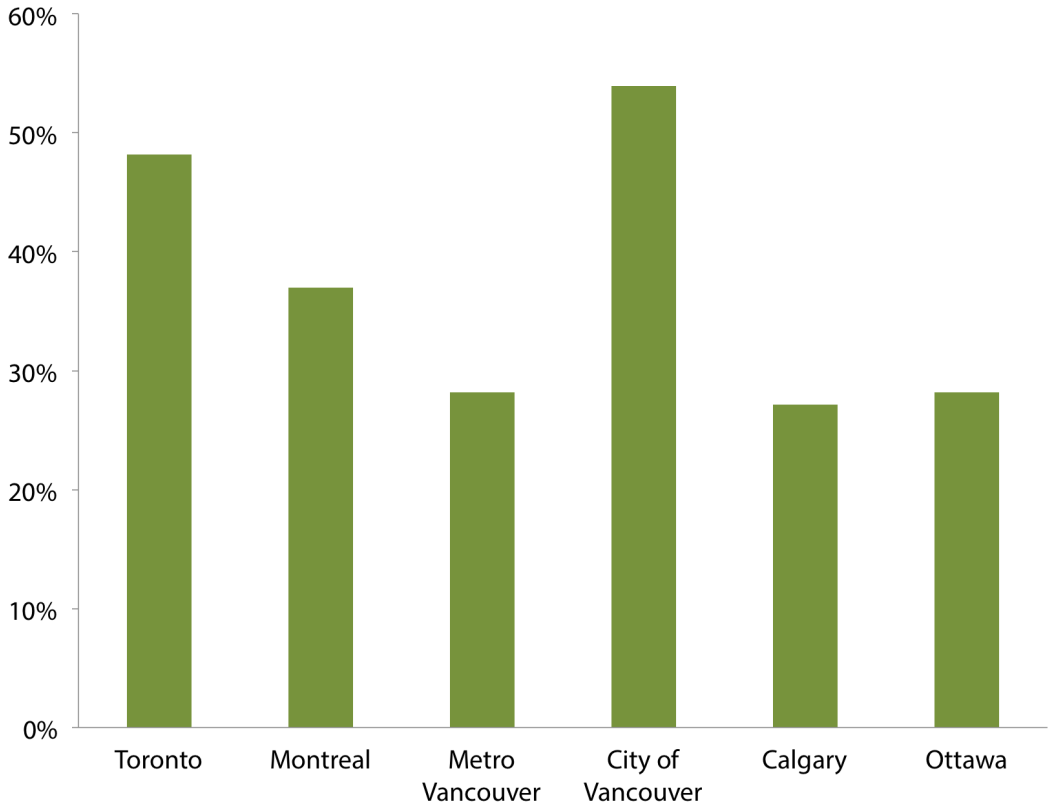


Figure 5: Percentage of population within walking distance of rapid and express transit (including Metro Vancouver and City of Vancouver)

Projects currently underway

Figure 6 shows how much each city's transit system will expand in the near future. While Toronto has built relatively little rapid transit over the past two decades, a more aggressive expansion is underway. A subway extension and several new LRT lines are either funded or already under construction.

Other cities are building new transit as well. Table 2 presents the details of these investments, in terms of both the cost and length of transit lines to be built. A new LRT line is under construction in Ottawa, Vancouver is building a new SkyTrain line and the construction of a new BRT line in Montreal is expected to begin shortly.

Calgary opened its most recent LRT extension in August 2014, completing a 17-station expansion program that began in 2001. There are plans to add new LRT lines and stations in the future, but none of them are funded at this time. The city has secured partial funding for the green line, a major BRT line that would operate on a transitway, and which would later be converted into light rail.

Figure 6: New rapid transit funded or under construction

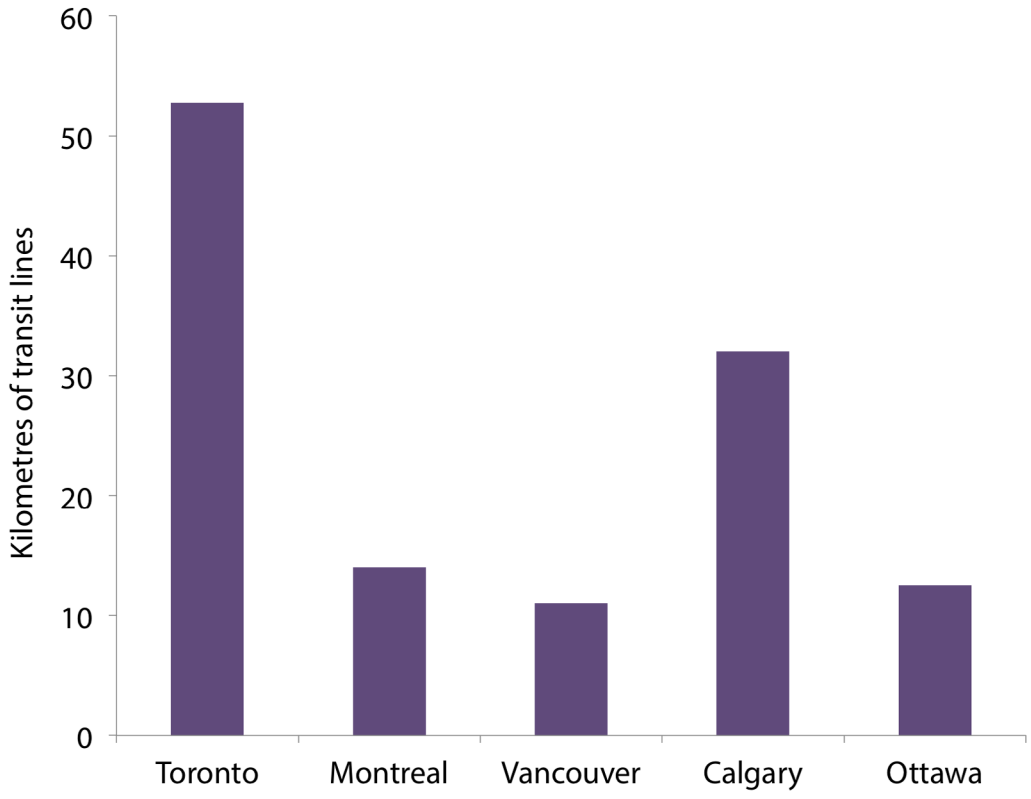


Table 2: Transit infrastructure underway (funded or under construction)
Table figures are in 2014 dollars

	Toronto	Montreal	Vancouver	Calgary	Ottawa
Length of transit lines	59.2 km	14 km	11 km	25 km	12.5 km
Total investment	$14 billion	$416 million	$1.55 billion	$802 million	$2.13 billion
Overall cost per kilometre	$236 million	$30 million	$141 million	$32 million	$176 million
	Spadina subway • 8.6 km extension • $347.7 million per kilometre **Scarborough subway**[6] • 7.6 km extension • $468.4 million per kilometre **Finch, Sheppard LRTs** • 24 km • $90 million per kilometre **Eglinton Crosstown** • 10 km below ground • 9 km on surface • $278.5 million per kilometre	**Pie-IX BRT** • 14 km • $29.7 million per kilometre	**Evergreen SkyTrain** • 11 km • $141.3 million per kilometre	**Green line BRT**[7] • 25 km • $32.1 million per kilometre	**Confederation LRT** • 2.5 km below ground • 10 km on surface • $176.4 million per kilometre

Toronto: Slow investment in fast transit

Transit to date

Toronto's early investments in heavy rail built a culture of transit: it has the highest ridership of any Canadian city. While this infrastructure has created a strong transit base for the city, investment has not kept pace with population growth. As a result, Toronto lags behind all other cities except Montreal in terms of rapid transit infrastructure built in the last 20 years. When we compare ridership levels to the amount of infrastructure available (see Figure 7), it is clear that Toronto's rapid transit system is working overtime to move riders around the city.

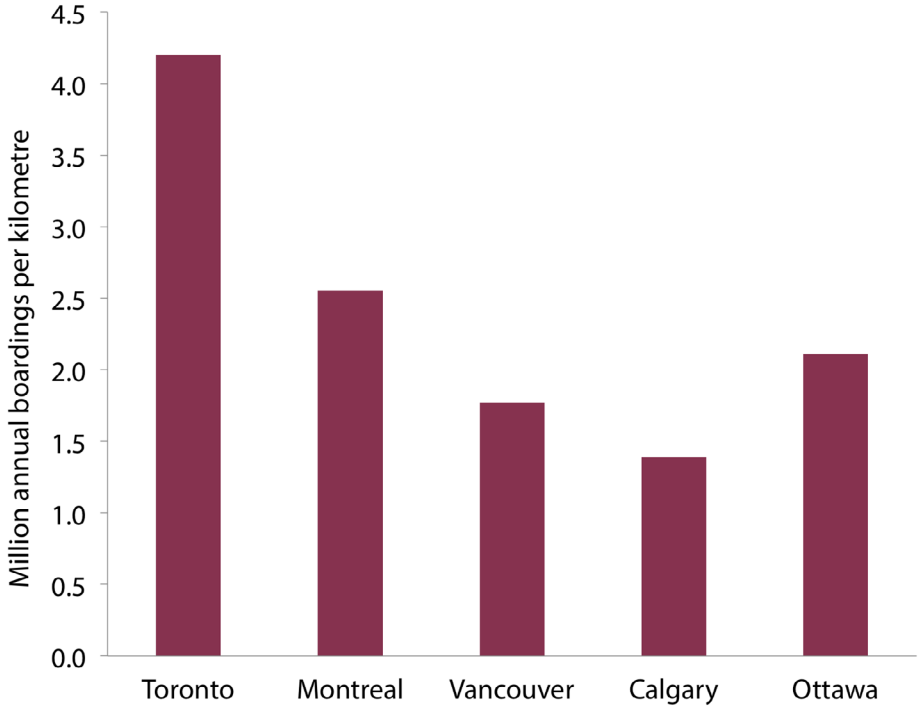


Figure 7: Rapid transit ridership by length of infrastructure

Rapid transit investment in Toronto has focused almost exclusively on subways, which are costly and require a decade or more to build. As a result, relatively little rapid transit has been built in the last two decades. The 8.6-km Spadina subway extension, scheduled to open in 2016, represents the first expansion of the subway system since the 2002 opening of the 5.5-km Sheppard subway line, and the 2.3-km extension of Spadina subway to Downsview before that in 1996.

Existing rapid transit	Length
Subway	61.9 km
Light metro	6.4 km
Rapid streetcar	15 km
Total	**83.3 km**

There has been some other progress: a new rapid streetcar service was constructed on Spadina Avenue and the existing St. Clair streetcar was upgraded to rapid service. Both lines run in separated lanes and therefore are less affected by traffic, run frequently all day and connect to the subway network at two locations on their routes. By comparison, the Queen streetcar route is separated along the Queensway but merges into mixed traffic on Queen Street and Lake Shore Boulevard, diminishing its benefits and connectivity.

Rapid transit investment in Toronto has been delayed due to repeated changes in transit plans, delaying the actual building of transit. On the positive side, Toronto has continued to increase express bus service. In recent years, the city has invested in its Rocket bus routes. They have a limited number of express stops, making the service fast and frequent — an important investment given that nearly 60% of transit passenger trips in Toronto are on the surface routes.

The regional GO train network provides excellent commuter rail service, primarily to communities outside the city limits on the Lakeshore East and Lakeshore West lines, which have been upgraded to all-day, two-way service. While these lines do serve nine stops inside of Toronto, those stops are often skipped during peak hours to expedite travel for regional commuters. Service at non-peak times is on a 30-minute schedule. Consequently, GO train service is not frequent enough *within the city* to deem it a rapid transit service for Toronto. There are currently proposals to upgrade and electrify the GO network and add more stops in Toronto, which could turn it into a rapid transit service within the city limits.

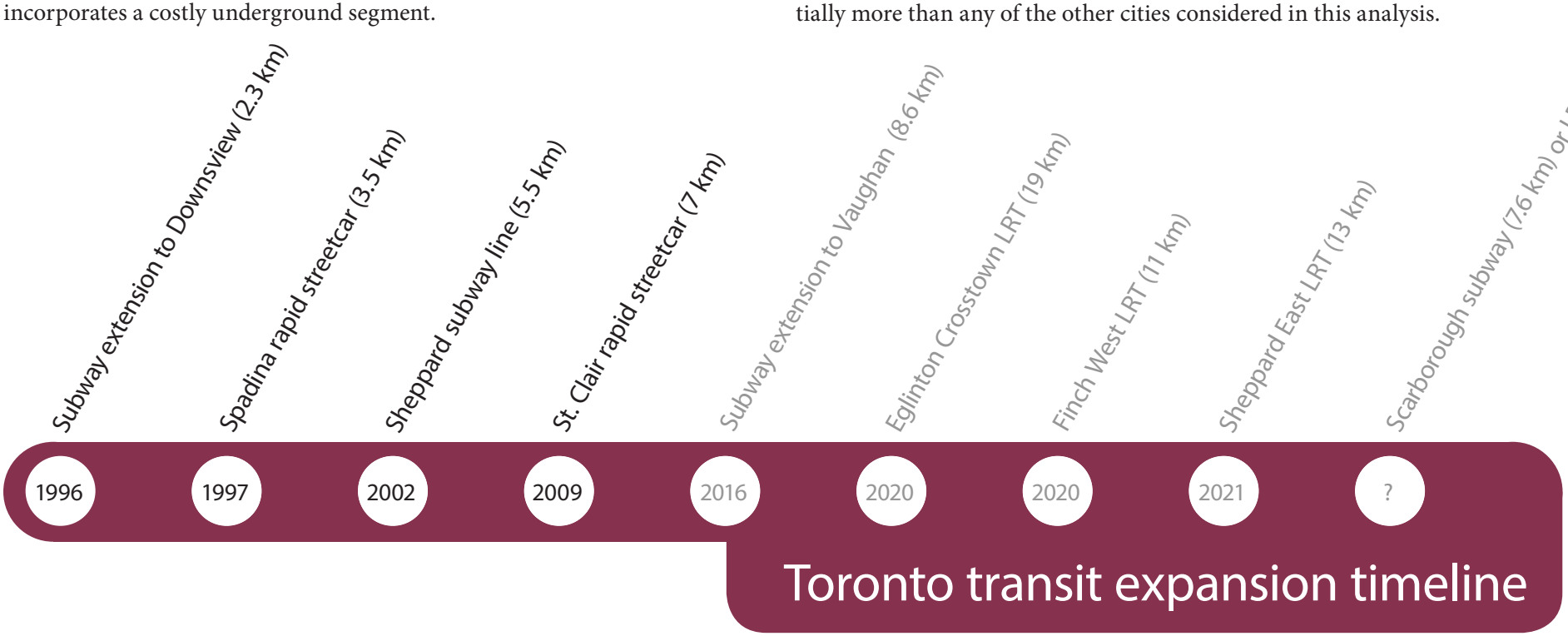
Projects underway

The 2007 Transit City plan proposed a new 120-km network of LRT lines that would be in place by 2020, and complemented by enhanced bus service throughout the city. Seven years later, the only Transit City project under construction is the flagship 19-km Eglinton Crosstown LRT line, which incorporates a costly underground segment.

In 2010, the construction of the 13-km Sheppard East LRT — a project that was already underway — was halted due to a change in transit plans. Had construction not been stopped at that time, the Sheppard East line would have opened in the fall of 2013. Work on the line is now scheduled to recommence in 2017 with a 2021 completion date — eight years after the original planned opening.

The construction of a Finch West LRT is scheduled to start in 2016. The Scarborough LRT, intended to replace the existing Scarborough RT line, is on hold as the city and province are planning to reconfigure it into a more costly extension to the Bloor-Danforth subway line. This will cost $468 million per kilometre, compared to $194 million per kilometre for the original LRT.

The 8.6-km Spadina subway extension to Vaughan is projected to open in 2016 at a cost of $348 million per kilometre. Because of Toronto's prioritization of subways and underground technology, it has the most cost-intensive transit investment plan of the five cities we examined. Toronto will be spending an average of $236 million per kilometre of new transit — substantially more than any of the other cities considered in this analysis.



Montreal: The metro is retro

Transit to date

Although Montreal has an extensive subway network that is within walking distance of many residents, expansion has been slow for the last two decades. Only a single, 5.2-km subway extension to suburban Laval has been built. While the island of Montreal's population has only grown slightly over this time, it now lags behind cities such as Calgary and Ottawa in terms of rapid transit infrastructure per capita.

Plans for future expansion continue to favour costly and slow-to-deploy subway technology: a 5.5-km eastern extension to the blue line was designated as the top priority by the Quebec provincial government. This was to be followed later by a yellow line extension on the south shore and another orange line extension line to Laval. No rapid transit expansion is planned for the West Island, and no funding is in place for the subway extensions at this time.

More cost-effective rapid transit solutions may be coming soon to Montreal, however. A 14-km, 21-station BRT service on Pie-IX Boulevard was originally announced in 2009, connecting Montreal to Laval. This route is now expected to open between 2017 and 2020. A new LRT or BRT line for the Highway 10 corridor is also being planned as part of the replacement of the aging Champlain Bridge. Montreal has also opened some bus routes with fewer stops and more direct service, but the service level is not frequent enough to meet our definition of express transit.

Photo: "Long Metro" by Francis Bourgouin, Flickr CC

Montreal transit expansion timeline

2007

Orange line subway extension to Laval (5.2 km)

2017

Pie-IX BRT service to Laval (14 km)

Vancouver: The sky's the limit

Transit to date

Unlike Toronto and Montreal, the majority of Vancouver's rapid and express transit infrastructure was built in the last 20 years, made up of both SkyTrain and express bus service. The SkyTrain system is now as long as the Toronto or Montreal subway, and it will surpass them both in 2016 with the opening of the Evergreen line.

Vancouver's growing SkyTrain network is complemented by a series of express bus routes. While not operating in a separated lane, these B-Line buses run frequently at all times of day and stop only at major arterials, making them fast and efficient. Large articulated buses are also used on certain routes to increase capacity. During peak hours, the curb lanes on the flagship 99 B-Line, which connects the University of British Columbia to the SkyTrain system, are reserved for exclusive bus use.

Express bus service has been particularly effective as a competitive service, building demand until full rapid transit can be deployed. The 98 B-Line, connecting Richmond to downtown Vancouver, operated from 2001 to 2009, when the Canada Line opened. Similarly, a portion of the 99 B-Line between Lougheed Mall and Commercial-Broadway station operated until 2002, when the Millennium Line opened.

Projects underway

Going forward, the 97 B-Line is expected to be phased out in 2016 when the Evergreen Line to Coquitlam opens. TransLink and the provincial government have also been leading a study in recent years to examine replacing the 99 B-Line with a full rapid transit solution, given its high ridership levels (it is the busiest bus route in North America).

Comparing Vancouver to the other cities included in this report involved some challenges. Although it is the largest municipality in the Vancouver metropolitan area, the City of Vancouver is relatively small at just over 600,000 residents. TransLink provides services for the metropolitan area as a whole, and much of the rapid transit and express bus network is located in the more suburban municipalities surrounding the city.

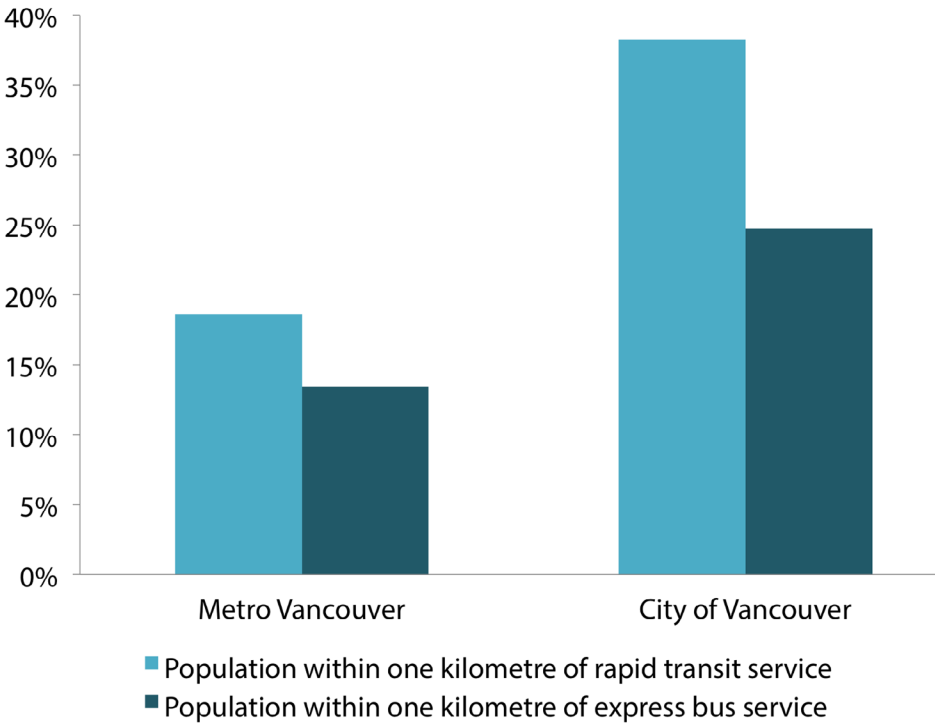
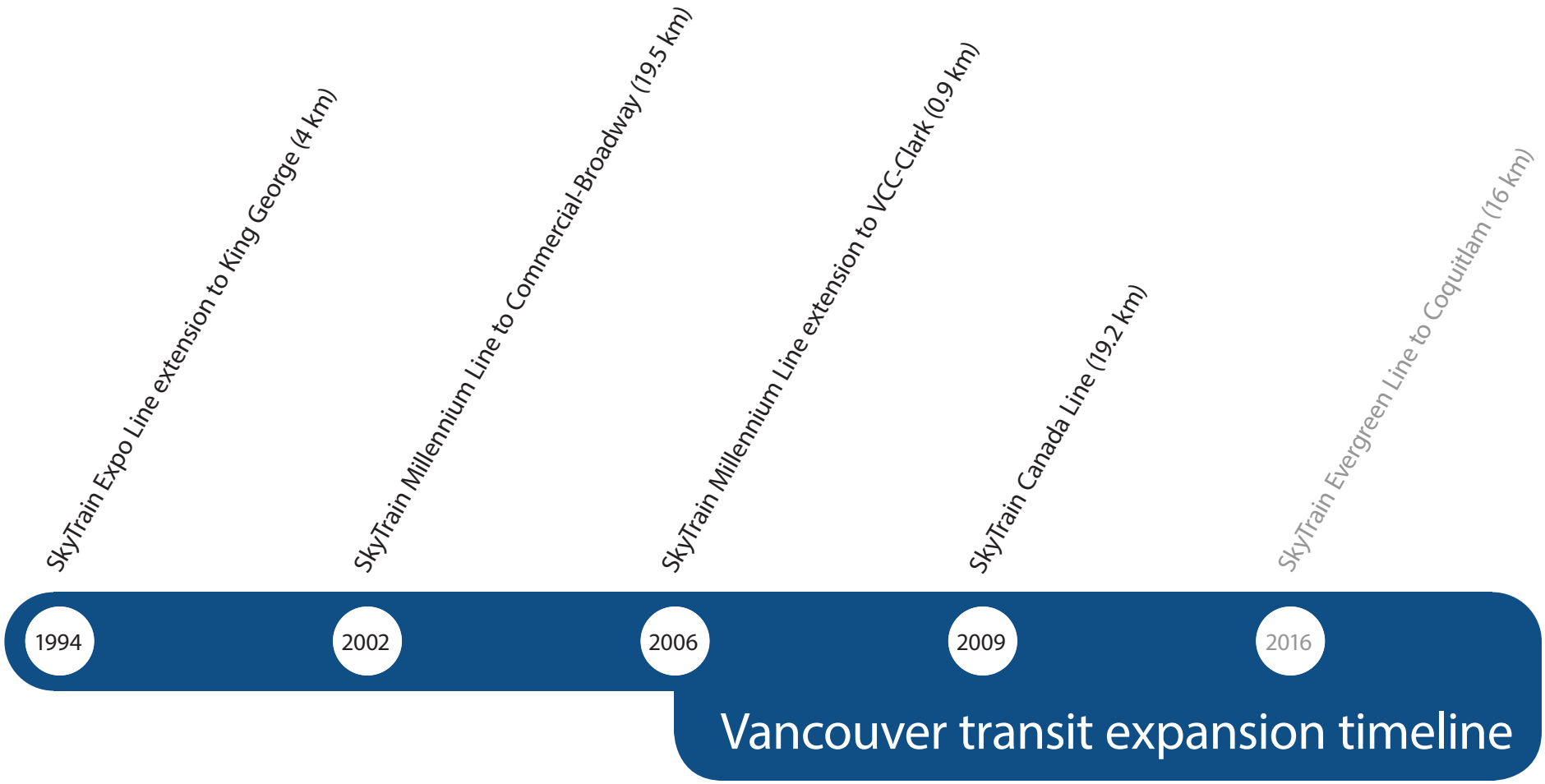


Figure 8: Accessibility of rapid transit in Vancouver

We examined the full TransLink service area for this analysis. As a result, Vancouver's rankings for ridership and walking-distance accessibility are relatively lower than the other cities, due to the more suburban, low-density character of much of TransLink's service area. The numerical results tend to understate the merits of Vancouver's fast-growing rapid transit network.

It is not possible to examine Vancouver's ridership statistics by municipality. However, it is possible to compare the population within walking distance of rapid transit and express bus service for Metro Vancouver versus the City of Vancouver. As Figure 8 shows, a considerably higher proportion of residents are within walking distance in the city proper. In fact, the city proper has a higher level of accessibility than the four other cities in the report.



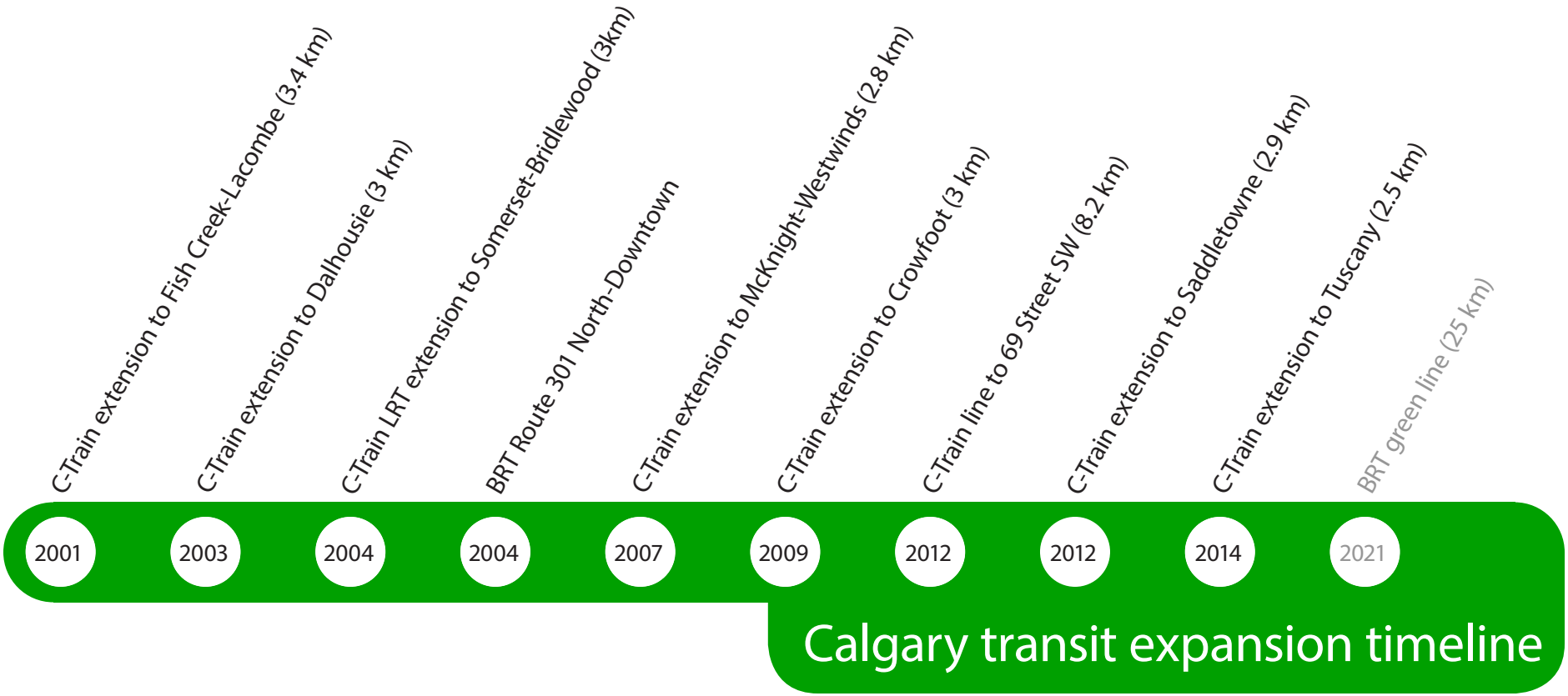
Calgary: Light rail leader

Transit to date

Calgary's rapid and express transit system has grown incrementally with extensions to the C-Train opening every few years, and a new westward line opening in 2012. Calgary also operates an express bus service under the BRT banner as a precursor to future LRT expansions

As in Vancouver, this approach is used to build ridership along key routes until investment in full rapid transit is warranted. However, in Calgary only the 301 North-Downtown route has been included as express transit in our analysis, as the other BRT routes do not offer consistent high-frequency service throughout the day.

Existing transit	Length
Light rail transit	58.5 km
Express bus	15.7 km
Total	**74.2 km**



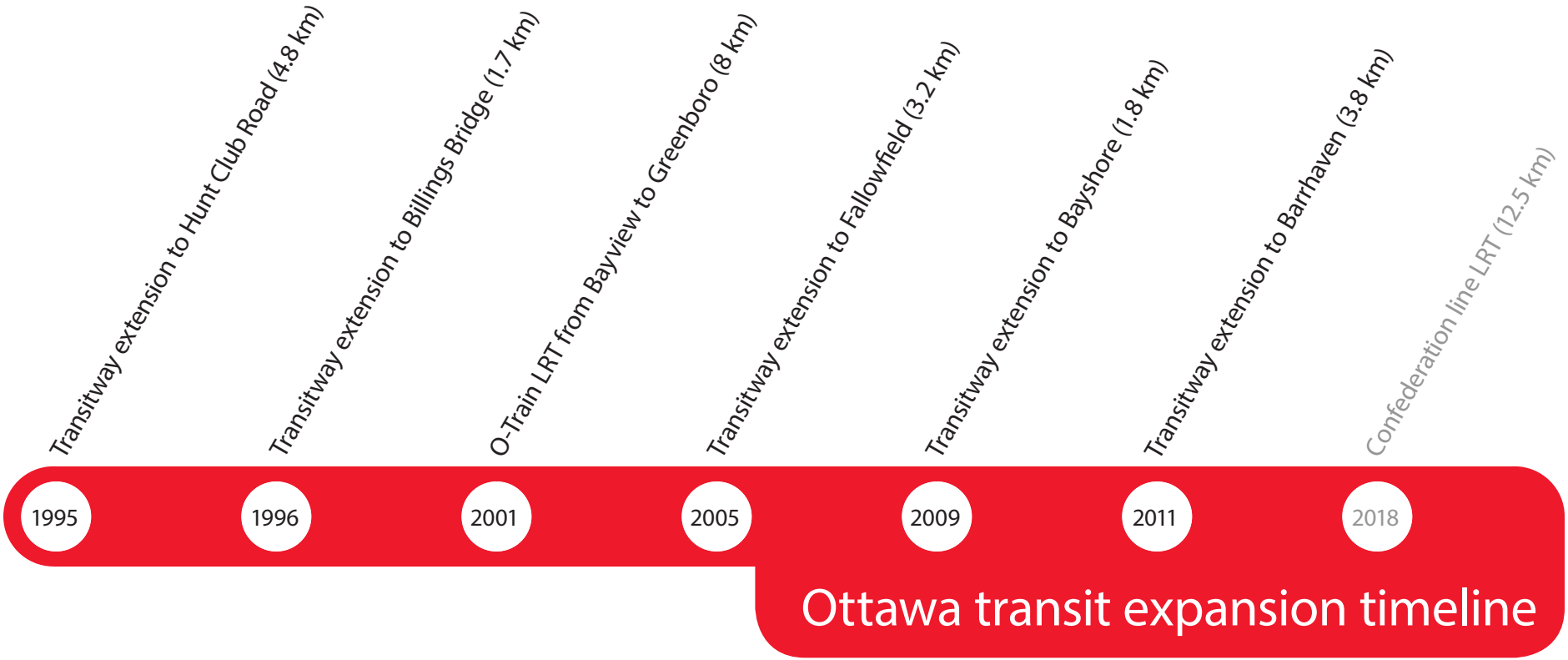
Ottawa: The better bus

Transit to date

Ottawa has incrementally expanded its rapid transit system over the past 20 years, focusing primarily on a low-cost and quick-to-deploy BRT system that suits the city's population density and demand levels.

However, Ottawa's BRT system has been so successful that it is now running at or over capacity. This is particularly true along the central section through the downtown area, where all of the routes converge. It may have been more appropriate to invest in LRT or other higher-capacity modes earlier, rather than exceeding the system's capacity and having to wait for LRT construction to relieve crowding.

In 2001, Ottawa opened its first LRT line. The 8-km O-Train uses diesel-powered vehicles on an existing rail corridor. LRT is also the focus of current expansion plans, with the Confederation line — a 12.5-km, electrified east-west route — currently under construction and scheduled to open in 2018. It will replace the congested central Transitway.



Appendix A: Methodology

Geography

For each city, our analysis used the level of geography that corresponds to the core transit system's service area:

City	Transit service area	Census geography
Toronto	City of Toronto (TTC service area)	Toronto census division
Montreal	Island of Montreal (STM service area)	Montreal census division
Vancouver	Metro Vancouver (TransLink service area)	Greater Vancouver census division
Calgary	City of Calgary (Calgary Transit service area)	Calgary census subdivision
Ottawa	City of Ottawa (OC Transpo service area)	Ottawa census division

In the case of the Montreal Metro, short sections of the orange and yellow lines extend off the island into Laval and Longueuil. These off-island areas were not included in any population-based calculations, but we did include the full lines when calculating the length of rapid transit infrastructure built.

Length of infrastructure

The length of rapid transit infrastructure, including growth over time, was calculated using documentation obtained from transit agencies and other online sources. Where data was not available in other forms, we calculated the length of individual routes using transit agency data published in the General Transit Feed Specification (GTFS) format. All lengths were measured as one-way trips.

Where possible, the length of infrastructure that supports interlined services (e.g. two or more rail-based transit lines that share some sections of a rail corridor or tunnel) has not been counted more than once. However, some duplication may exist in the case of express bus routes.

Ridership

Ridership figures are taken from reports published by the American Public Transportation Authority for 2012, the time period for which the most complete data is available for all of the cities we considered. The figures are "unlinked" in that each transfer to a new route is counted as a separate trip, even though a rider may count the entire duration of travel as a single trip. All trips taken by subway, light metro, LRT, BRT and rapid streetcar were counted.

APTA figures do not distinguish between rapid and non-rapid bus and streetcar trips. We therefore estimated the share of trips as follows:

- Ridership on the Transitway in Ottawa was estimated at 60% of all APTA-reported transit trips in the city. This estimate was based on information published by OC Transpo.
- Ridership on the St. Clair and Spadina streetcars was estimated at 31% of all streetcar trips. This estimate was based on weekday customer count of 87,800 trips for the two routes, out of a total 283,500 trips for all streetcar routes, based on information published by the TTC.

We did not calculate ridership for express bus routes.

Population within walking distance of rapid transit

The proportion of a city's population within walking distance of rapid transit and express bus service was calculated using 2011 census population counts published by Statistics Canada, along with rapid transit station and stop location data published by transit agencies in the GTFS format. Both of these sources are made available under open data licenses.

A one-kilometre buffer, corresponding to the maximum reasonable distance a transit commuter might be expected to walk, was drawn around each station and stop in order to select the centroids (geographic centres) of the census dissemination blocks that fell within the buffer zone. The population of the selected blocks was then summed, and divided by the total population for the transit service area. This results in the percentage of the population within one kilometre of any rapid transit station or stop. These calculations were repeated for rapid transit, express bus service and both types combined.

It should be noted that real-world walking distances along a one-kilometre radius will effectively be greater than one kilometre, since most street networks have a non-radial layout and there will be obstacles to pedestrian travel. This is an important consideration when planning individual transit projects. The purpose of this report is to compare transit services in different cities in a consistent way, rather than to provide precise estimates for planning. We therefore did not consider this factor, and instead used a uniform one-kilometre radius for all cities.

While the most recent census data available is from 2011, it should be noted that some rapid transit stations and stops included in this analysis came into service after that census was taken.

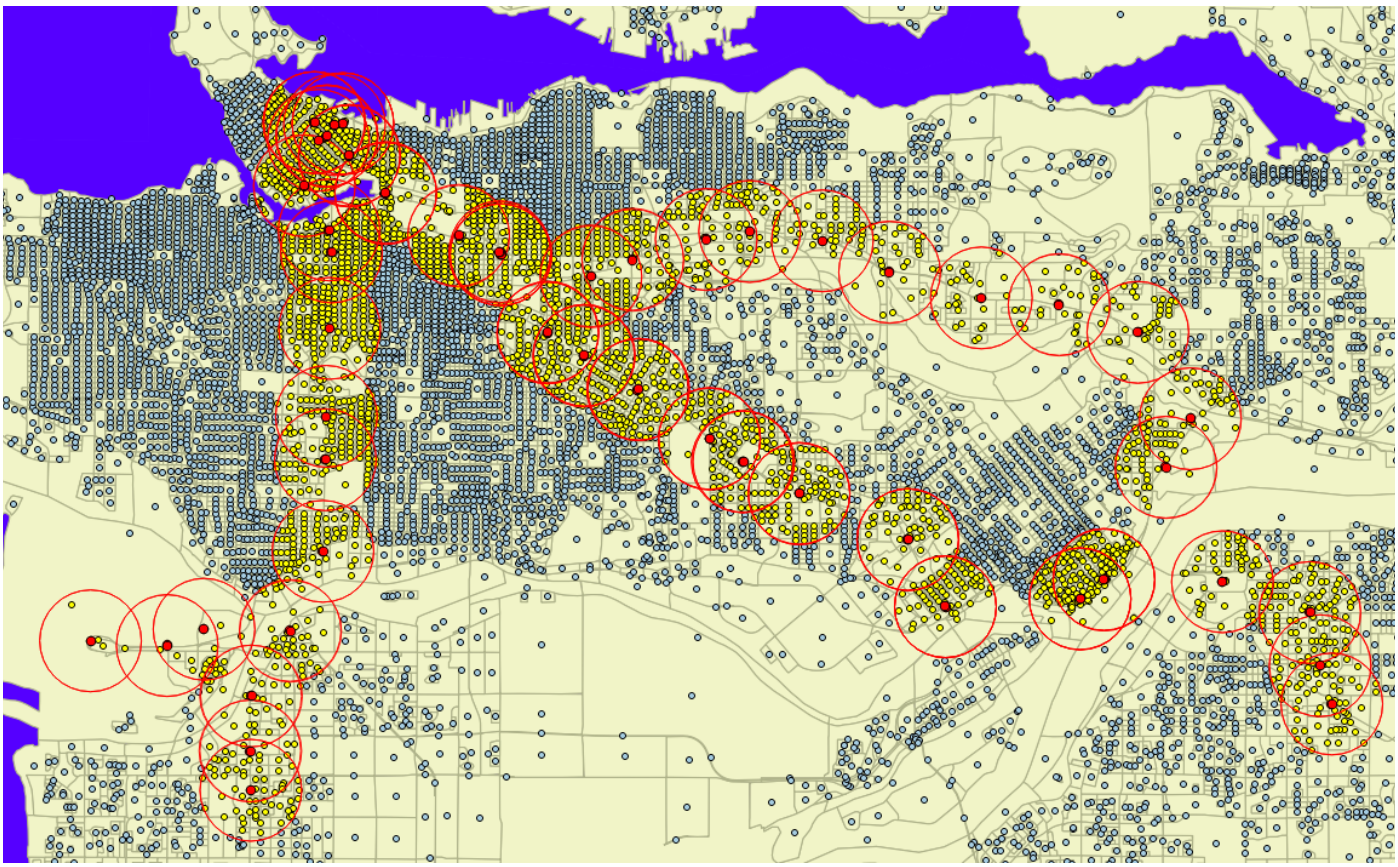


Figure 8: Example of walking distance analysis for rapid transit
This map shows one-kilometre buffers (red circles) around rapid transit stations (red points) in a portion of Metro Vancouver, along with the census dissemination block centroids (yellow points) identified as being within walking distance.

Appendix B: Rapid transit checklists for cities

Toronto

	Subway and Scarborough RT	St. Clair and Spadina streetcars	Rocket express bus	Lakeshore GO train	Other GO trains	Queensway streetcar
Separated from traffic and priority signalling	✓	✓*		✓	✓	✓
Maximum wait of 10 minutes (peak times)	✓	✓	✓			Not reliable
Maximum wait of five minutes (peak times)	✓	✓	On some routes			Not reliable
All-day, two-way service	✓	✓	✓	✓		✓
Maximum wait of 15 minutes (off-peak times)	✓	✓	✓			Not reliable
Optimal spacing of stops and stations	✓		✓	✓	✓	✓
Network connectivity	✓	✓	✓	✓	✓	
Off-board fare collection	✓	Partial**	Partial	✓	✓	Partial**
Platform-level boarding	✓	✓***		✓	✓	✓***

* Separated from traffic, but priority signalling is only partially employed.

** Only at some subway stations. The new streetcar fleet will have automated on-board fare collection, with additional off-board collection at the busiest stops.

*** The new streetcar fleet has low floors to permit platform-level boarding where platforms exist.

Montreal

	Metro	AMT commuter rail	Express bus
Separated from traffic and priority signalling	✓	✓	On some routes
Maximum wait of 10 minutes (peak times)	✓		
Maximum wait of five minutes (peak times)	✓		
All-day, two-way service	✓	On the Deux-Montagnes line	
Maximum wait of 15 minutes (off-peak times)	✓		
Optimal spacing of stops and stations	✓	✓	✓
Network connectivity	✓	✓	✓
Off-board fare collection	✓	✓	
Platform-level boarding	✓	✓	

Vancouver

	SkyTrain	B-Line bus service	West Coast Express commuter rail
Separated from traffic and priority signalling	✓		✓
Maximum wait of 10 minutes (peak times)	✓	✓	
Maximum wait of five minutes (peak times)	✓	✓	
All-day, two-way service	✓	✓	
Maximum wait of 15 minutes (off-peak times)	✓	✓	
Optimal spacing of stops and stations	✓	✓	✓
Network connectivity	✓	✓	✓
Off-board fare collection	✓		✓
Platform-level boarding	✓		✓

Ottawa and Calgary

	Calgary LRT	Calgary BRT (Route 301)	Calgary BRT (other routes)	Ottawa BRT	Ottawa O-Train LRT
Separated from traffic and priority signalling	✓			Not separated in some areas	✓
Maximum wait of 10 minutes (peak times)	✓	✓	✓	✓	N/A
Maximum wait of five minutes (peak times)	✓	✓	Some routes	✓	
All-day, two-way service	✓	✓		✓	
Maximum wait of 15 minutes (off-peak times)	✓	✓	Some routes	✓	✓
Optimal spacing of stops and stations	✓	Partial		✓	✓
Network connectivity	✓	✓	✓	✓	✓
Off-board fare collection	✓	✓	✓	✓	✓
Platform-level boarding	✓				✓

Appendix C: Full results for five Canadian cities

The figures below are for core cities, except for Vancouver and Montreal. See Appendix A for geographic details.

Rapid and express transit	Toronto	Montreal	Vancouver	Calgary	Ottawa
Length of existing rapid and express transit service per million residents	65 km	37 km	46 km	68 km	49 km
Length of rapid and express transit service opened in past 20 years	106 km	5 km	82 km	45 km	23 km
Length of rapid and express transit service opened in past 20 years per million residents	40 km	3 km	35 km	41 km	26 km
Length of rapid and express transit service opened in past 10 years per million residents	16 km	3 km	14 km	35 km	10 km
Proportion of population within 1 km of rapid and express transit service	48.2%	37.0%	28.2%	27.2%	28.2%

Rapid transit	Toronto	Montreal	Vancouver	Calgary	Ottawa
Length of existing rapid transit service per million residents	32 km	37 km	29 km	53 km	49 km
Annual rapid transit ridership per capita	133	93	52	74	104
Annual ridership per km of rapid transit (100,000 boardings per km)	42	26	18	14	21
Length of rapid transit service opened in past 20 years	18 km	5 km	44 km	29 km	23 km
Length of rapid transit service opened in past 20 years per million residents	7 km	3 km	19 km	26 km	26 km
Length of rapid transit service opened in past 10 years per million residents	3 km	3 km	9 km	20 km	10 km
Proportion of population within 1 km of rapid transit service	34.1%	37.0%	18.6%	21.3%	28.2%
Length of rapid transit infrastructure funded or under construction, per million residents	20 km	7 km	5 km	0 km	14 km

Express transit	Toronto	Montreal	Vancouver	Calgary	Ottawa
Length of existing express transit service per million residents	33 km	0 km	17 km	14 km	0 km
Length of express transit service opened in past 20 years	87 km	0 km	38 km	16 km	0 km
Length of express transit service opened in past 20 years per million residents	33 km	0 km	17 km	14 km	0 km
Length of express transit service opened in past 10 years per million residents	13 km	0 km	5 km	14 km	0 km
Proportion of population within 1 km of express transit service	19.1%	N/A	13.4%	9.5%	N/A

Endnotes

1 Vukan R. Vuchic, *Urban Transit Systems and Technology* (Hoboken, NJ: John Wiley & Sons, 2007), 521-523. Transit experts commonly define rapid transit as modes that operate on fully exclusive rights of way, with no other traffic on the alignment and no intersections or grade crossings. This definition includes both subways and light metros such as the SkyTrain. Modes with fully exclusive rights of way have the highest speed and reliability, but also come at the highest cost due to the need for underground or elevated infrastructure. The second order of transit modes are "right-of-way category B" systems, where vehicles are longitudinally separated. That means the transit vehicles do not share lanes with traffic, but they are still influenced by traffic signals, as is the case with light rail or BRT. These modes still perform much better than transit in mixed traffic, but cost significantly less than subways. Typical costs are about $300 million per kilometre for subways, and $40 million per kilometre for category B systems.

2 Ibid. Optimal spacing for LRT and BRT stops is 400 to 800 metres, and 500 to 1,000 metres for subways. This compares with 200 to 400 metres between stops for mixed-traffic buses and street cars.

3 Part of the York University Rocket runs on an exclusive busway road, akin to a true BRT route. However, since this is not true of the entire route, we have categorized it as express transit for the purposes of this analysis.

4 Population counts reflect 2011 census data.

5 More details about walking distance calculations are provided in the methodology section. Definitions of walking distance vary, with 1,000 metres being an upper bound for the distance riders will walk to access rapid transit. See: Jarrett Walker, "Basics: walking distance to transit," *Human Transit*, April 24, 2011. http://www.humantransit.org/2011/04/basics-walking-distance-to-transit.html

6 This line is only partially funded by the Government of Ontario, and will require further funding from City of Toronto to proceed. The original Scarborough LRT is fully funded by the province, and would cost $1.9 billion for a 9.9-km line.

7 Calgary has only secured $502 million in funding for the green line BRT, while the initial phases cost $802 million according to *RouteAhead*, the city's transit plan. There are also plans to eventually convert the line to LRT.

8 Note that the Scarborough route is not a new line, but replaces the existing Scarborough RT at 6.4 km.

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