MAYORS' COUNCIL
On Regional Transportation

PUBLIC MEETING AGENDA

Revised: October 21, 2019

October 25, 2019, 9:00AM to 10:15AM
TransLink, Room 427/428, 400 – 287 Nelson's Court, New Westminster, BC

Chair: Mayor Jonathan X. Coté **Vice-Chair:** Mayor Jack Froese

Note that times for each agenda item are estimates only. This meeting will be livestreamed and available afterwards on the Mayors' Council's Facebook page.

MEETING OF THE MAYORS' COUNCIL ON REGIONAL TRANSPORATION
PUBLIC MEETING MINUTES

Minutes of the Public Meeting of the Mayors' Council on Regional Transportation (Mayors' Council) held Friday, September 20, 2019 at 9:00 a.m. in Rooms 427/428, TransLink Head Office, 400 – 287 Nelson's Court, New Westminster, BC.

PRESENT:

Mayor Jonathan Coté, New Westminster, Chair
Mayor Jack Froese, Langley Township, Vice-Chair
Chief Ken Baird, Tsawwassen First Nation
Mayor Neil Belenkie, Belcarra
Mayor Malcolm Brodie, Richmond
Mayor Linda Buchanan, North Vancouver City
Councillor Craig Cameron, West Vancouver (alternate)
Mayor George Harvie, Delta
Mayor Mike Hurley, Burnaby
Mayor Mike Little, North Vancouver District
Mayor Doug McCallum, Surrey
Mayor John McEwen, Anmore
Director Jen McCutcheon, Electoral Area A
Mayor Ron McLaughlin, Lions Bay
Mayor Mike Morden, Maple Ridge
Councillor Alison Morse, Bowen Island (alternate)
Mayor Richard Stewart, Coquitlam
Mayor Val van den Broek, Langley City
Mayor Darryl Walker, White Rock
Mayor Brad West, Port Coquitlam

REGRETS:

Mayor Mary-Ann Booth, West Vancouver
Mayor Meghan Lahti, Port Moody
Mayor Kennedy Stewart, Vancouver

ALSO PRESENT:

Mike Buda, Executive Director, Mayors' Council on Regional Transportation Secretariat
Geoff Cross, Vice-President, Transportation Planning and Policy, TransLink
Kevin Desmond, Chief Executive Officer, TransLink
Andrew McCurran, Director, Strategic Planning and Policy, TransLink
Steve Vanagas, Vice President, Marketing and Public Affairs, TransLink
Dan Freeman, Senior Manager, Bus Priority Programs, TransLink

PREPARATION OF MINUTES:

Christine McLenan, Recording Secretary, Raincoast Ventures Ltd.

CALL TO ORDER

A quorum being present, the meeting was called to order at 9:01 a.m.

1. PRELIMINARY MATTERS

1.1 Adoption of Agenda

Draft Agenda for the September 20, 2019 Public Meeting of the Mayors' Council on Regional Transportation, version dated September 13, 2019.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation adopts the agenda for its Public meeting scheduled September 20, 2019, version dated September 13, 2019.

CARRIED

1.2 Adoption of the Minutes

Draft Minutes of the July 25, 2019 Public Meeting of the Mayors' Council on Regional Transportation.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation adopts the minutes of its Public meeting held July 25, 2019, as circulated.

CARRIED

2. PUBLIC DELEGATE PRESENTATIONS

Report dated September 12, 2019, from Mike Buda, Executive Director, Mayors' Council Secretariat titled "Item 2 – Public Delegate Presentations."

Isabel Kolic

Executive Director of the Heights Merchants Business Improvement Association (BIA); is concerned about the loss of prime street parking related to the announcement of plans for a Rapid Bus on Hastings Street in Burnaby; suggested this project would be detrimental to the community; and requests that parking on Hastings be restored and the associated 12 blocks be exempt from assignment to a bus line.

Roderick Louis

Referenced his submission dated September 18, 2019; requested that a motion be passed to write a letter from the Mayors' Council to the Transportation Board requesting that the Board revoke its policy for licensing ride hailing companies, and engage in public consultation with municipalities, police and groups with disabilities across BC.

Tim Collings

Piloted a two-month study in 2016 to measure personal vehicle use, walking and cycling; developed an app in conjunction with study; and requested support of a broader pilot project to bring awareness to British Columbians to alleviate traffic congestion, rising health care costs and climate change.

3. REPORT OF THE NEW MOBILITY COMMITTEE

3.1 Update on Transport 2050 Engagement Activities

Report dated September 5, 2019, from Steven Vanagas, Vice President, Marketing and Public Affairs, titled "Item 3.1 – Transport 2050: Phase 1 Engagement Report".

Steven Vanagas, Vice President, Marketing and Public Affairs, TransLink, provided an update on public engagement activities to date, which was intended to be the largest engagement within the organization. Highlights included: an activity at the PNE; Phase 1 wrap up report to be completed this fall; and Phase 2 will launch in spring 2020.

Comments were provided that the outreach was impressive and connected with people who do not traditionally connect with an engagement process.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

3.2 Micro-mobility services: Planning Guidelines

Report dated September 12, 2019, from Geoff Cross, Vice-President, Transportation Planning and Policy, titled "Item 3.2 – Micromobility Guidelines for Metro Vancouver – version 1.0".

Andrew McCurran, Director, Strategic Planning and Policy, TransLink, referred to a series of presentation slides, which highlighted: the advent of dockless bikes and scooters in the last two years through mobile apps. Benefits include lower emissions, whereas challenges include: parking that blocks right of ways and busy areas; theft and vandalism; the quality and short lifespan of vehicles; and inability to get good data. With regard to the six key areas in the Shared Micromobility Guideline, this is the first step in providing a regionally consistent approach and may be a way to provide support at the regional level and reduce barriers for smaller communities.

Discussion ensued on:

- Helpfulness of this approach in providing regional consistency and guidance
- Need to be cautious to ensure this is done right
- Need to look at challenges around right of ways and impacts to people with disabilities and the visually impaired
- Note that scooters have almost taken over bike share programs.

In response to questions, staff discussed:

- A key challenge is for those cities that have implemented dockless systems in right of ways and impacts to people with disabilities and the visually impaired
- Docked systems manage the right of ways more effectively but are more expensive to implement
- The scooters are e-scooters that travel at 30 MPH.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

3.3 Report on TransLink Tomorrow

Report dated September 12, 2019, from Geoff Cross, Vice-President, Transportation Planning and Policy, titled "Item 3.3 – TransLink Tomorrow Update".

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

4. UNFINISHED BUSINESS FROM JULY 25, 2019 MEETING

4.1 10-Year Vision Implementation: RapidBus

Report dated July 18, 2019, from Sarah Ross, Director, System Planning, titled "Item 4.1 – B-Line Update".

Daniel Freeman, Senior Manager, Bus Priority Programs, TransLink, referenced the report that was brought forward in July 2019 and highlighted: updates since July 2019, which include branding, a public launch, and commencement of significant construction activities. Changes to the scope of the project include Fraser Highway changed to 104-KGB, and Dundarave Terminus changed to Park Royal. The target to launch service is January 2020, and Marine Drive is at risk of a later launch due to the complexity of the project and delay in agreement on scope. Work is being initiated on Phase 2, which includes Newton to Scott Road and Richmond to Expo. The Speed Bus Report will be brought forward in the fall.

Discussion ensued on:

- Suggestion to change the name from "Newton/North Delta" to "Scott Road Station"
- Comment about the popularity of the double decker buses at the PNE and whether there are plans to introduce more of them
- Comment that rapid buses are a step along the line to rapid transit
- Suggestion that this is an opportunity to improve the customer experience and perception and reach areas that may not have experienced quality bus service.

In response to questions, staff discussed:

- Changes to the Rapid Bus on Fraser Highway include changes to 502 and 503 service with express service on 503; low cost transit on the corridor that would help with speed and reliability; and construction, which is expected to begin in November 2019, pending weather
- The five B-Lines have not yet been funded and would be candidates for the Phase 3 investment plan
- Though Phase 3 planning has not been done, generally $5 million is required per year for each new line related to operations with $20-$30 million for capital and infrastructure; these costs are shared with senior government
- There is consideration to put double decker buses on longer routes
- The current approach is bus transit light; if the service works well it can gradually be improved with more right of ways
- There is interest in making improvements incrementally to bus priorities to extend the time of day on busy corridors that serve a large number of bus routes
- The customer experience is very important.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

4.2 Transport 2050: Transportation Network Concept Development
Report dated July 10, 2019, from Geoff Cross, Vice-President, Transportation Planning and Policy, titled "Item 4.2 – Transport 2050 Long-Term Transportation Network Concept Development".

Discussion ensued on:
- Need to consider looking at alternate fuels related to issues around climate change
- Suggestion to have data on the public transportation impact on climate change to share with the public
- Suggestion to consider trolleys as part of the discussion
- Note that many buses are currently running without negative emissions
- Need to consider what is current providing the same service.

In response to questions, staff discussed:
- TransLink's adoption of more aggressive targets in 2018 to complete 100% renewable fuels
- Note that alternative fuels were not identified in the Mayors' Vision
- Fleet replacement needs to take into account infrastructure, fleets and route changes; options for fleet renewal are being reviewed and will be presented in the fall
- Analysis on the GHG impact and potential use of the information.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

4.3 UBC SkyTrain
Report dated July 10, 2019, from Geoff Cross, Vice-President, Transportation Planning and Policy, titled "Item 4.3 – Arbutus to UBC SkyTrain Update".

Geoff Cross, Vice-President, Transportation Planning and Policy, TransLink, referenced the circulated report and advised that teams are now being assembled that will be helping to develop the work plans. The governance structure will be launched later this month. The first round will occur in 2020.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

4.4 George Massey Crossing Project Update

Report dated June 28, 2019, from Geoff Cross, Vice-President, Transportation Planning and Policy, titled "Item 4.4 – Update on George Massey Crossing Project, Phase Two".

Geoff Cross referenced the circulated report and discussed the two timeframes, the long-term replacement of the crossing, and what can be done on an interim basis. TransLink is encouraging the Ministry of Transportation to look more broadly at connections in and out of Bridgeport.

Comments were provided on the need for the entire corridor to be considered before a decision can be made on what the best solution is at this crossing. There is need for this to be a well thought out public transit corridor.

It was MOVED and SECONDED

That the Mayors' Council on Regional Transportation receive this report.

CARRIED

5. REPORT OF TRANSLINK MANAGEMENT

Kevin Desmond, Chief Executive Officer, TransLink, reviewed a slide presentation and highlighted the following: ridership continues to grow at 4% year to date, with 1.4 million average daily boardings; HandyDART is averaging 1,000 more trips per month than planned; taxis will be utilized to meet the increased demand; the Battery-Electric Bus Fleet will save up to 100t of GHG emissions; what is notable about the Battery pilot is it is the first completely interoperable test; approval from Vancouver has been received for another six battery-operated buses; a systemwide implementation of AI technology was launched in the bus fleet; and Rail-Volution was held in Vancouver on September 1-11, 2019 with over 1,200 delegates from across Canada and the US.

Discussion ensued on:

- Appreciation expressed to organizers of Rail-Volution
- Concern about "pass ups" at Capilano College and inquiry as to whether the app can be equipped to advise riders when a bus is in "pass up" mode
- Suggestion to consider geothermal power in the capital infrastructure.

In response to questions, staff discussed:

- While indicating pass ups is technologically feasible, information cannot be provided through the app
- Note that taking a Rapid bus to BRT can be done with single priority systems
- Life expectancy of electric buses, which is the same as the existing fleet – at issue is the lifetime of the battery
- Need to look at existing rail lines as part of the T2050 discussion with federal, regional and railroad partners to determine the best way to move goods and people
- Consideration in the next generation of SkyTrains to increase to three-position bike racks
- Current information technology, which does not support texting riders' information related to space for bikes; this may be a consideration for the next innovation call
- Changes needed to infrastructure for electric buses
- Expectation that, by 2030, the entire bus fleet would be electric

- Purchase of diesel buses, which are not returnable
- TransLInk is working closely with BC Hydro; they have committed $500,000 to the project.

6. ADJOURN TO CLOSED MEETING

<u>It was MOVED and SECONDED</u>

That the Mayors' Council on Regional Transportation Public Meeting held September 20, 2019 be now adjourned to in-camera.

<u>CARRIED</u>
(10:37 a.m.)

Certified Correct:

______________________________	______________________________________
Mayor Jonathan X. Coté, Chair	Christine McLenan, Recording Secretary Raincoast Ventures Ltd.

TO: Mayors' Council on Regional Transportation

FROM: Mike Buda, Executive Director, Mayors' Council Secretariat

DATE: October 11, 2019

SUBJECT: ITEM 2 – **Public Delegate Presentations**

RECOMMENDATION:

That the Mayors' Council on Regional Transportation receive this report.

PURPOSE:

To introduce the objectives and process for hearing from public delegates.

BACKGROUND:

Public participation at meetings is valued by the Mayors' Council, and up to one hour is set aside at open meetings to receive public delegations. The Mayors' Council will only receive public delegations who intend to speak on matters that are within the authority of the Mayors' Council.

Individuals can apply to be a delegate by completing the online Application Form up until 8:00AM, two business days prior to the meeting. In situations where there isn't enough time to hear from everyone wishing to speak, the Mayors' Council encourages written submissions be sent to mayorscouncil@translink.ca.

The webpage for public delegates includes a Protocol for Public Delegates that notes:

- the Mayors' Council Chair will exercise discretion in maintaining a reasonable level of order and decorum;
- delegates and all meeting participants are reminded that different points of view are respected, and discussions are kept above the level of personal confrontation, disruptive behaviour and profanity.

DISCUSSION:

The deadline to apply to speak to the Mayors' Council is 8:00am two days prior to the meeting. At the time of this report, not all prospective speakers will have had a chance to complete applications. Accordingly, the **list of approved speakers, as well as any written submissions or presentations, will be provided on table**. Any presentations provided by delegates will also be provided to Mayors' Council members only, on table (up to 10-pages maximum).

Each delegation will be given a maximum of three minutes to address the Mayors' Council. As a general rule, there are no questions or discussion between Council and delegates. The pilot policy governing Public Delegates can be found online.

TO: Mayors' Council on Regional Transportation

FROM: Sarah Ross, Director System Planning

DATE: October 10, 2019

SUBJECT: **Item 3.1** - **Bus Delay Due to Congestion**

RECOMMENDATION

That the Mayors' Council Regional Transportation:

1. Recommend that the Mayors' Council encourage municipalities to invite TransLink staff to present to their Councils on the issue of delay to buses within their community, and the opportunities to reduce this delay;
2. Request staff to include municipal commitments to supportive transit priority when evaluating potential bus service expansion project on congested corridors for inclusion in the Phase Three Plan;
3. Receive this report and the *2019 Bus Speed and Reliability Report (draft)* and *Transit Priority Toolkit*.

PURPOSE

The purpose of this report is to raise awareness that bus delay due to congestion is a significant problem for TransLink's customers and budgets. Management is seeking support for advancing the types of interventions that can mitigate this delay that are identified in the Transit Priority Toolkit. Although work on transit priority is underway and investments are being made on some corridors and hotspots, much more must be done to reduce the financial magnitude of the problem and maintain/increase the desirability of taking transit.

BACKGROUND

The Mayors' Ten-Year Vision identified need for investment in expanded bus priority throughout Metro Vancouver. The Phase One and Phase Two Investment plans funded the first seven RapidBus corridors, a RapidBus upgrade program, and a new cost-share funding programs for Bus Speed and Reliability.

Through the RapidBus program TransLink has taken on substantial project leadership for bus priority investment on new corridors working in partnership with local governments to undertake community engagement, planning, design and construction.

The complementary Bus Speed and Reliability Infrastructure municipal funding program supports municipalities to address hotspots and smaller corridor improvements. Municipal agencies cost-share and lead those projects, with TransLink providing funding, data and technical guidance. The 2020 call for projects is currently underway, coincident with TransLink's other municipal roadway funding programs.

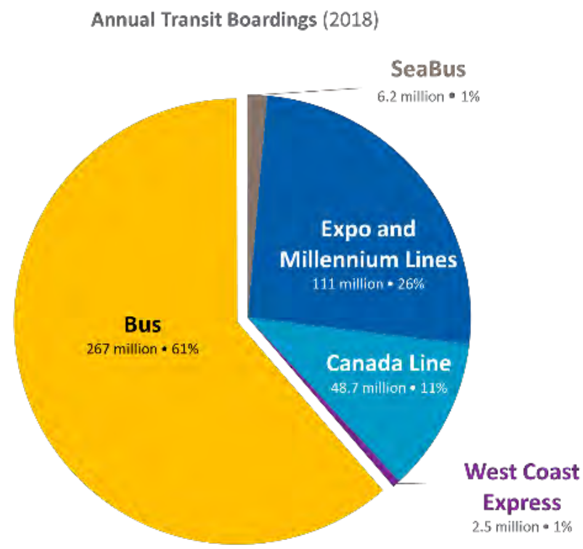
The *2019 Bus Speed and Reliability Report* (Appendix A) identifies the areas and corridors across the region where transit customers are experiencing the most delay. The *Transit Priority Toolkit* (Appendix B) identifies the potential interventions that TransLink and local agencies can use to improve the situation.

DISCUSSION

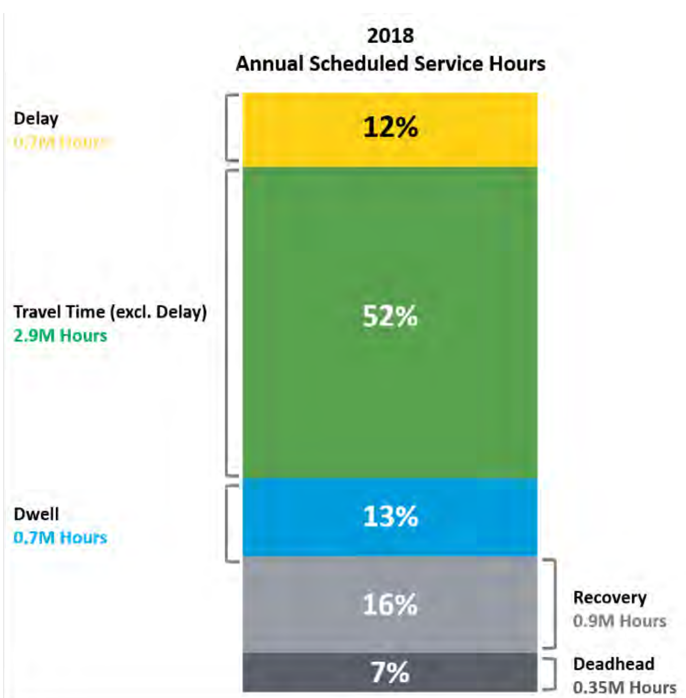
The slowing of bus service costs money and is a strategic risk to TransLink and Metro Vancouver transit service.

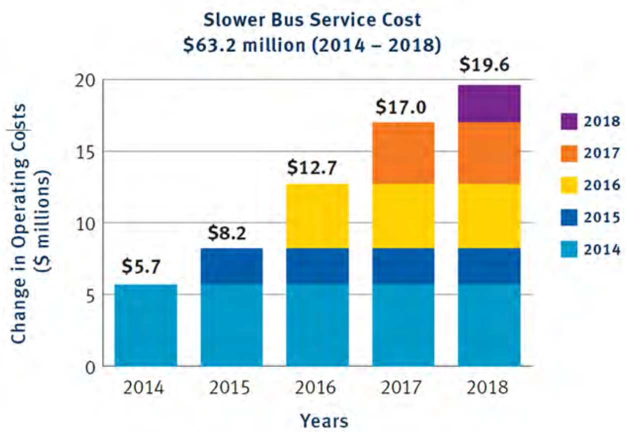
Nearly two-thirds of transit trips in Metro Vancouver are by bus. Eighty percent (80%) of the region's bus routes are slower today than they were five years ago, due in large part to increased roadway congestion and lack of sufficient bus priority.

The negative effect on customers is not only longer and less reliable journey times, but also longer waits and increased overcrowding due to bus bunching. This reduces the overall attractiveness of transit compared to driving, ride-hailing, taxi and even cycling and walking. While ridership growth remains strong, we cannot take this for granted. Any decline in ridership will impact fare revenues and the ability to fund existing service levels – a situation experienced by many transit agencies in North America.



In addition to customer impacts, slowing of bus service has a growing impact on TransLink's finances. **We estimate that over $75 million per year (nearly 700,000 annual service hours, or 12% of CMBC's bus total operating costs, are attributable to roadway delay).** A further 16% of CMBC's operating budget is recovery time spent at termini, which is required not only for operator breaks but also to ensure on-time departures. As bus travel times become more irregular, recovery time must be increased.





Operating costs resulting from slowing and less reliable bus services are growing. CMBC adjusts schedules quarterly to maintain on-time performance and ensure operator breaks in the face of growing roadway congestion, improving it on 61% of routes since 2014. **Those schedule adjustments added $2.5M - $5M each year to CMBC's annual operating costs** over that same period. This is equivalent to the cost of adding a new RapidBus line every 1-2 years.

2019 Bus Speed and Reliability Report highlights priority locations for action on bus delay

For the first time ever, we have undertaken a region-wide analysis of delay to buses and bus passengers. It shows that delay occurs across our service area. The 2019 Bus Speed and Reliability Report is an assessment of region-wide bus passenger delay. A draft version of this report is attached (Appendix A), with final revisions and layout in progress. This report:

- provides an overview of bus delay in Metro Vancouver
- identifies the 20 corridors with the highest passenger delay and assesses in detail their sources of delay
- Identifies hot-spots of delay, mapped at a sub-regional level
- Summarizes the types of tools that can help reduce delay
- outlines TransLink's role, and the need for supportive partner agency action to address this challenge to the region's transit system.

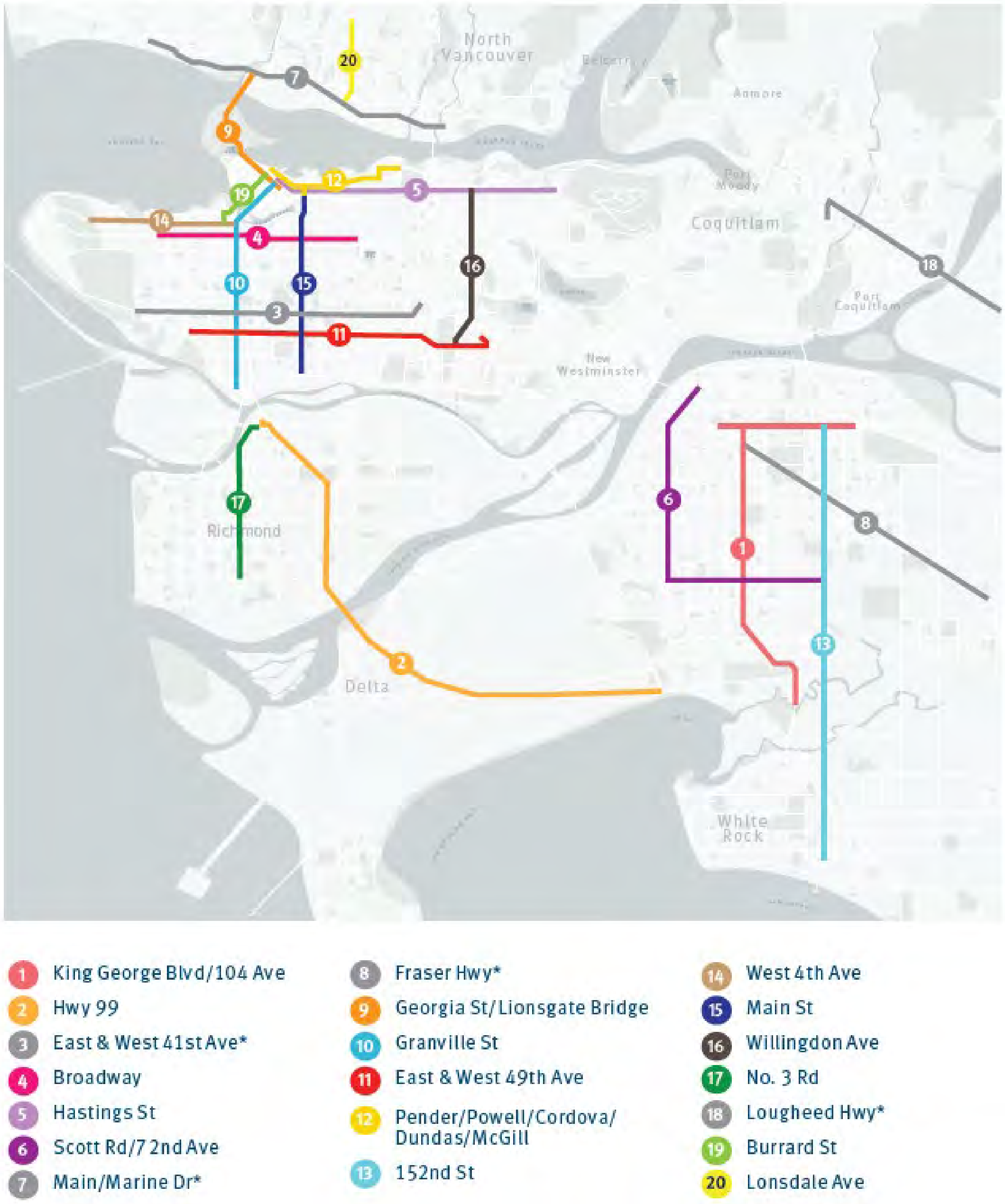
This analysis is based on a customer-focussed metric (person-hours of delay), which complements analyses of bus travel time and variability to focus on areas where the largest number of people are experiencing the most delay. This newer and more sophisticated analysis is calculated based on transit vehicle GPS data and passenger count data.

Delay is found in all subregions, a reflection of growth in bus ridership as well as roadway congestion in all communities. There is a concentration of priority corridors in the two Metro Vancouver Regional Cores (Downtown Vancouver and Downtown Surrey), as a significant number of local and regional bus routes converge in both centres.

Four of the top 20 twenty corridors will see new priority measures in place through the first round of RapidBus projects set to launch in 2020. These are expected to reduce the passenger delay on those corridors, which will be monitored through subsequent Bus Speed and Reliability reports. Corridor profiles have been developed for each of the twenty priority corridors, including a map, key characteristics of the corridor, and details of bus delay locations, severity, and causes of delay to assist in identifying potential solutions.

Delay 'hot spots' are found across the region and, in some cases, may be nearly as intense as the 20 corridors and are just more geographically constrained. Many such hot spots at key intersections, at bridge approaches, and at the entrance to transit hubs are locations where targeted interventions can make big improvements to bus speed and reliability.

Top 20 Corridors for Passenger Delay



Transit Priority Toolkit illustrates range of solutions available

The bus priority problems facing Metro Vancouver are inherently solvable, and there are a wide range of strategies suited to addressing them. We did not invent these strategies – they can be found in many other cities.

The Transit Priority Toolkit (Appendix B) is a reference guide and serves as a supplement to the 2019 Bus Speed and Reliability Report. It outlines the numerous tools available to address bus delay and provides concrete examples of their application locally and in other jurisdictions.

Typically, there are multiple strategies that could be employed to address a given source of bus delay, ranging in cost, effectiveness, complexity and visibility. In many cases, a relatively small amount of investment can make a dramatic difference to the performance of the bus service. Customers can have faster travel times and more reliable service. Reducing delay from congestion and keeping the buses moving saves both capital and operating dollars. These strategies include:

- Bus Stop and Curb Management
    - Bus Stop Placement
    - Curb Management
- Traffic Regulations
    - Movement Restrictions
- Street Design
    - Bus Stop Infrastructure
    - Turn Pockets
    - Vertical Control Devices
    - Queue Jumps
    - Transit Approach Lane
    - Peak Hour Bus Lane
    - Dedicated Bus Lane
- Signal Priority
    - Passive Signal Priority
    - Transit Signal Priority (Active)
- Transit Agency Practices and Policy
    - All Door Boarding
    - Schedule/Operator Recovery

Municipalities (or the provincial government, depending on the road) have control over critical levers for bus priority.

The critical levers for bus priority are under local control. As the transit operator TransLink has control or direct influence over some levers, such as stop location, boarding and fare payment, and route design. All other levers are under the control of municipalities and the BC Ministry of Transportation and Infrastructure through their authority over roadways. They control all tools related traffic control (e.g. turn restrictions, signal timing and prioritization), roadway infrastructure (e.g. bus bulbs), curb management (e.g. parking removal), and transit lane designations (e.g. bus or HOV lanes). Reducing the delay our bus passengers experience requires a collaborative approach and a willingness of local road authorities to advance transit priority measures.

We recognize that prioritizing transit – like any mode – requires examining trade-offs between users of the roadway. The attached documents are intended to assist municipalities in having those discussions and determining how best to reduce bus delay in the context of each community. TransLink is committed to assisting municipalities with that process. We developed tools that enable an evidence-based approach at a fine-grained level. This makes it possible to determine the respective benefits and costs of different allocations.

TransLink has begun initiatives to expand bus priority, but more is needed

The Mayors' Vision identified the need for expansion of bus priority in the region, with 12 new RapidBus corridors. Dedicated TransLink funding for bus priority was put in place through the Phase 1 and Phase 2 Investment Plans, including the delivery of 5 new RapidBus corridors and new municipal cost-share funding programs.

A first phase of bus priority expansion projects is currently underway, which will deliver over 30 lane-km of new bus priority measures by 2020. TransLink has begun awarding funding to municipalities to develop and deliver projects that help make buses faster and more reliable.

While these bus priority efforts currently underway are important, thus far they address only a small portion of identified locations and times of bus delay. More action is needed to address the scale of the problem of bus delay in Metro Vancouver.

CONCLUSION

Bus delay due to congestion is a major problem for TransLink's customers, budgets and our ability to expand. However, it is a problem for which many solutions exist, as has been demonstrated locally and globally. These solutions can deliver meaningful transit travel time and even capacity benefits relatively quickly and inexpensively, particularly when compared to larger transit infrastructure projects. Doing so saves money, enabling a greater share of future funding to go toward service expansion, rather than extra service to maintain schedules.

Greater efforts are required from all governments to improve the performance of buses on regional roadways. In particular, municipal and BC Ministry of Transportation leadership is required to more actively pursue a range of bus priority strategies and projects on the top corridors of bus delay under their jurisdiction.

The 2019 Bus Speed and Reliability Report and accompanying Transit Priority Toolkit serve as important guidance for the region and local road authorities in prioritizing efforts and identifying locally appropriate solutions. Ongoing TransLink assistance in the form of data, expertise, and funding will be necessary to support local efforts.

ATTACHMENTS

Appendix A: 2019 Bus Speed and Reliability Report (draft)
Appendix B: Transit Priority Toolkit


Bus Delay Due to Congestion
Mayors Council
Oct 25, 2019
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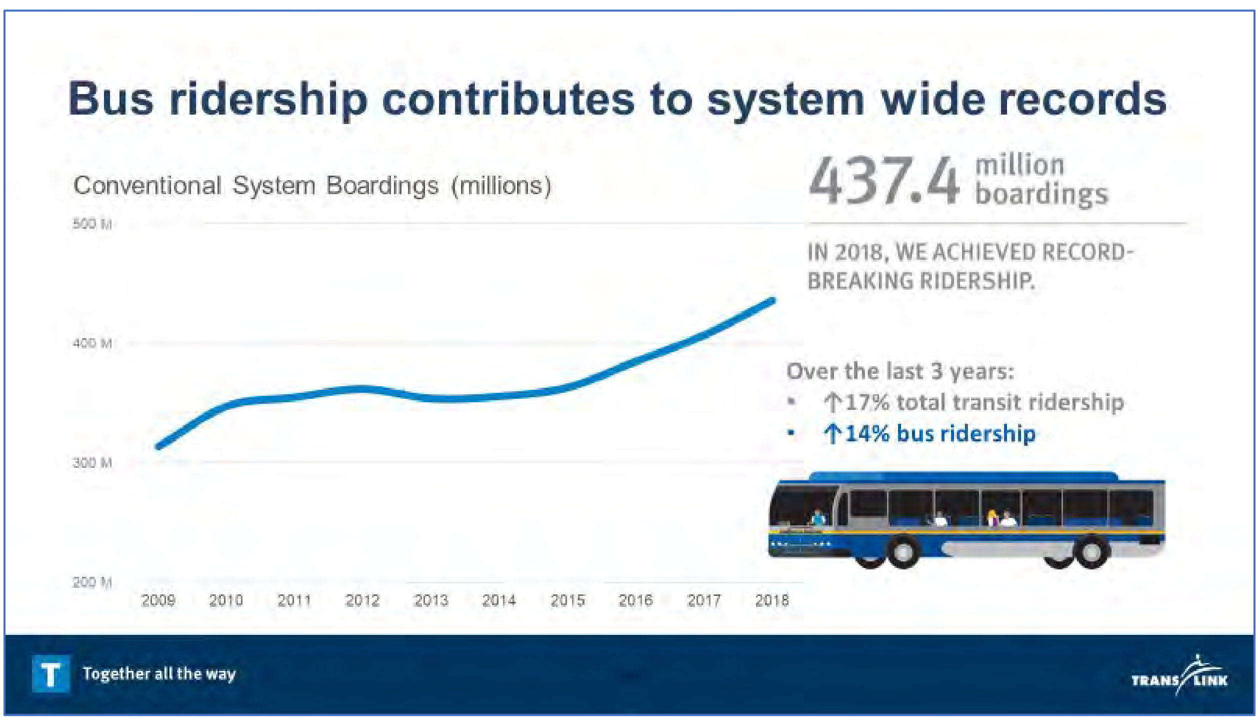
Bus ridership contributes to system wide records
Conventional System Boardings (millions)
500 M
400 M
300 M
200 M
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
437.4 million boardings
IN 2018, WE ACHIEVED RECORD-BREAKING RIDERSHIP.
Over the last 3 years:
↑17% total transit ridership
↑14% bus ridership
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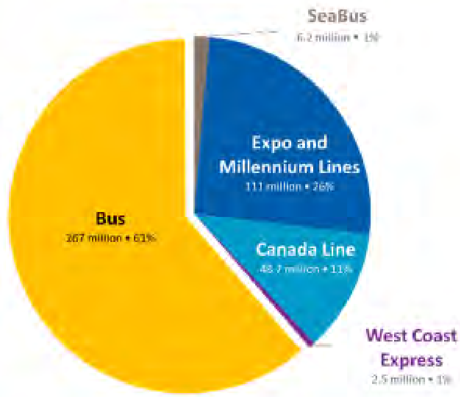
Slowing of buses is a significant risk to the region

80% of bus routes are slower than 5 years ago



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Slowing of buses is bad for customers, and <u>costly</u>

For example, if a route once took **50 minutes** to complete, and ran every **10 minutes**, it would need **5 buses**. However, if the trip slowed to **60 minutes**, then **6 buses** would be needed just to maintain service every 10 minutes.

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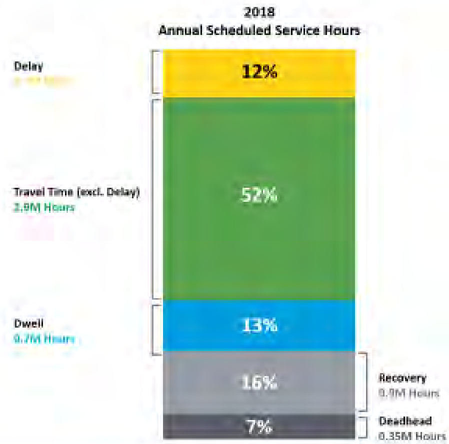
Bus delay costs TransLink > $75M / yr



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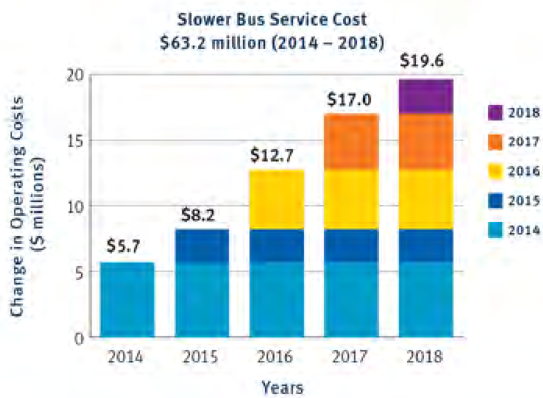
The cost of delay is growing



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First Region-Wide Analysis of Passenger Delay

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Priority Locations for Action

Top 20 Corridors for Passenger Delay

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Detailed analysis of top corridors

- Map of Delay
- Table of Facts
- Description
- Locations and classification of delay

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Delay hotspots also identified across the region

NORTHEAST SECTOR

LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
Lougheed Hwy	18
Pinetree Way	
North Road	
Wilson Ave	
David Ave	
St Johns St	

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Solutions Exist

- Transit Priority Toolkit identifies the different types of solutions, depending on local context and nature of cause of delay

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Municipalities & MOTI control critical levers

TransLink Control	OPERATIONS	Stop Relocation or Consolidation	Boarding Policy	Route Design
Municipality and MOTI Control	SIGNALS	Turn/Movement Restrictions	Queue Jumps	Transit Signal Priorities
		Bus-only Signals	Signal Phase Modification	
	INFRASTRUCTURE	Bus Platform Design	Bus Bulges	Boarding Islands
		Roadway Channelization	Parking Removal	Turn Radii Improvements
	TRANSIT LANES	Curb-side Bus Lanes	Interior/Offset Bus Lanes	Median Bus Lanes
		Contraflow Bus Lanes	Queue Bypass/Transit Approach Lanes	

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Some projects underway, but more needed

- TransLink provides **data**, **expertise** & **funding** for bus priority
- Competitive funds for:
  - Capital Projects
  - Operating Plans
  - Pilot Projects
  - Project Development
  - Capacity Building
- Partnerships needed with municipalities & BC MOTI

Together all the way

Recommendation

1. Receive this report and the 2019 Bus Speed and Reliability Report and Transit Priority Toolkit.

2. Encourage municipalities to invite TransLink staff to present to their Councils on the issue of delay to buses within their community, and the opportunities to reduce this delay.

3. Include municipal commitments to supportive transit priority when evaluating potential bus service expansion project on congested corridors for inclusion in the Phase 3 Investment Plan.

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2019 Bus Speed and Reliability Report

translink.ca

2019 Bus Speed and Reliability Report

Executive Messages

A Message from the CEO of TransLink

Buses are the workhorse of our transit network and they play a critical role in our people moving business. Our buses travel over 324,000 kilometres on an average weekday, equivalent to driving around the earth more than eight times within a 24-hour period. With robust population growth, a strong economy, and booming transit ridership, the quality of life in Metro Vancouver hinges on our ability to transport people as efficiently and in as green a way as possible. In 2018 alone, over 262 million residents and visitors to the area boarded TransLink buses, representing the largest single year increase of 8% in ridership. Our buses are instrumental in creating connections to employment, education, healthcare, and the people and places that matter the most.

It's for these reasons that TransLink and the Mayors' Council have worked closely to secure substantial increases to bus service in the 10-Year Vision. This transit expansion plan calls for a much-needed 25% increase in bus service and to extend coverage into 10 new service areas. However, new fleet and service increases are only part of the solution – the region faces considerable traffic congestion issues, hindering the performance of the bus network. As much as possible, we want to avoid having our buses weave in and out of, and being delayed, by traffic.

We must keep our buses moving to maximize the investments we're pouring into the transit system. And, there's only so much TransLink can do on its own – regional collaboration will be key to implementing the kinds of bold transit priority programs that will enable us to continue making buses an attractive option for the public. Together, we know that all our hard work increasing access to transit and improving the region's road network will yield a bus service that is fast, reliable, and meets the needs of Metro Vancouver residents.

Sincerely,

Kevin Desmond,
Chief Executive Officer
TransLink

A Message from the President and General Manager of Coast Mountain Bus Company

Our employees, from bus operators and mechanics, to schedulers, work tirelessly to provide a bus service that is fast, efficient and reliable for customers across Metro Vancouver. And, with an average of 20 million boardings per month, buses are the most widely used transit service in the region. In fact, our buses move over 260 million people through 23 communities annually. With the approval of the 10-Year Vision, there has been an unprecedented effort to increase bus service across the region, addressing years of pent-up demand. However, we find ourselves spending time trying to maintain bus speeds, rather than using these resources to increase service levels.

We've been experiencing a steady and consistent decline in bus speeds, especially in dense urban areas. 80% of bus routes are slower today than they were five years ago due to the negative effects of congestion and lack of transit priority in critical areas. As a result, each year, we devote around 50,000 hours or more than $5 million, trying to maintain the current speed of our buses. As the region's congestion increases, we'll need new transit priority measures to help buses cut through traffic and improve the customer experience.

Launching in January 2020, our RapidBus program will provide an example of the exceptional service that transit priority can provide. These upgrades can include changing intersection infrastructure, prioritizing traffic signals, invoking turn restrictions, and introducing dedicated bus lanes to improve speed and reliability. This report will provide an overview of the top 20 corridors in most need of improvements across the region. Our services have a big impact on the region, and we'll need help from all our partners to achieve the kind of experience our customers deserve.

Sincerely,

Michael McDaniel
President and General Manager,
Coast Mountain Bus Company

INTRODUCTION

Bus delay due to congestion is a significant, but solvable, regional transit problem.

Transit service is critical to access and mobility in Metro Vancouver.

Metro Vancouver residents board buses 931,000 times every weekday. Transit helps Metro Vancouver residents reach the things that are important to life and liveliness: work, school, shopping, services, and social gatherings.

In contrast to most North American metropolitan areas, transit ridership is growing in Metro Vancouver. Last year TransLink set a record for ridership by providing 437 million boardings.

Buses are the workhorses of transit service.

Buses serve the overwhelming majority of all transit boardings in Metro Vancouver. Almost two-thirds of transit journeys (261 million each year) are by bus.

And almost three-quarters of transit journeys—travel from origin to destination, including transfers—include a bus connection to another mode such as SkyTrain or SeaBus.

Bus ridership is also the fastest growing segment of ridership in Metro Vancouver. Of all modes of travel, bus ridership grew by the largest percentage (8%) and largest numerical value (19.9 million daily boardings) in 2018. In fact, bus ridership has been trending upward for a long time. Over the past three years, bus ridership has grown by more than 14%, or nearly 37 million boardings per year.

TransLink and Coast Mountain Bus Company work hard to provide frequent and reliable service.

Metro Vancouver residents rely on transit to get them to their destinations on time. Frequent and reliable bus service allows Metro Vancouver residents to plan their travel around their lives, rather than plan their lives around their travel.

TransLink added 3.7% more bus service in 2018 compared to 2017, to improve reliability and reduce overcrowding on 53 bus routes. Part of the reliability improvements include adjusting schedules to improve accuracy. As traffic congestion increases, for example, we change our predictions of how long the bus will take to travel from one stop to the next. On-time performance is a measure of the percent of buses arriving at their destinations on-time. Since 2014, on-time performance has improved on over half (61%) of bus routes despite traffic congestion causing slower speeds. Those improvements benefitted two-thirds of customers (67%).

However, traffic greatly impacts customer experience and operating costs.

Traffic affects more than motorists—it slows down people on buses, too. As buses slow, TransLink must put more buses on the street to maintain the same levels of service.

80% of bus routes are slower today than they were five years ago. Traffic has the largest effect on heavily-used bus routes on busy streets. As many as 85% of customers—or 250 million journeys—were affected by slower service in 2018. The negative effect on customers is not only longer and less reliable journey times, but also longer waits and increased overcrowding due to bus bunching. This reduces the overall attractiveness of transit as a mode choice. While ridership growth remains strong, we cannot take this for granted. Any decline in ridership will affect fare revenues and the ability to fund existing service levels – a situation experienced by many transit agencies in North America.

In addition to customer impacts, slowing of bus service has a growing impact on TransLink's finances. We estimate that over $75 million per year (700,000 annual service hours), or 12% of CMBC's bus total operating costs, are attributable to roadway delay. A further 16% of CMBC's operating costs is recovery time spent at termini, which is required not only for operator breaks but also to ensure on-time departures. As bus travel times become more irregular, recovery time must also be increased.

Operating costs resulting from slowing and less reliable bus services are growing. CMBC adjusts schedules quarterly to maintain on-time performance in the face of growing roadway congestion, improving it on 61% of routes since 2014. Those schedule adjustments added $2.5M - $5M each year to CMBC's annual operating costs over that same period. This is equivalent to the cost of adding a new RapidBus line every 1-2 years.

These are solvable problems.

Fortunately, there are many tools to improve travel time and reliability for buses.

Some tools are within TransLink's control, such as the distance between bus stops and boarding policies. However, most tools are within municipal or provincial control. Changes to traffic signals, intersection and roadway design, and management of curb-side uses require municipal or provincial approval, if not leadership.

TransLink has begun initiatives to expand bus priority, particularly through the RapidBus Program which is funding and delivering a first wave of improvements in 2020. TransLink is also making available $14.6 million over four years to municipalities to fund bus speed and reliability improvements on their streets.

To unlock the capacity of our roads, TransLink and agencies that control roadways and traffic signals must work together.

HOW TO USE THIS DOCUMENT

This report informs the public and their elected leaders about where delays have the greatest affect on bus service and what to do about it.

This report explores

1. The causes and effects of delay on buses.
2. The strategies available to TransLink, municipalities and the BC Ministry of Transportation and Infrastructure (hereafter BC MOTI) to improve bus speed and reliability.
3. Specific, actionable, and effective improvements that TransLink can help fund through the Bus Speed and Reliability Program.

Part 1 begins by establishing the Context.

This section describes the importance of fast, reliable bus service to Metro Vancouver. It also provides an overview of the strategies commonly used by transit agencies and cities to improve speed and reliability of bus service.

Part 2 offers a description of Challenges to providing fast, reliable bus service.

This section describes many of the common challenges faced by TransLink, municipalities and BC MOTI. It then details how TransLink has prioritized those challenges by identifying the top 20 corridors generating the greatest delay to customers.

Part 3 offers Next Steps.

This section describes how TransLink, municipalities and BC MOTI are partnering to deliver bus priority on some of the top corridors of passenger delay as part of the RapidBus Program. It then describes opportunities for TransLink, municipalities and BC MOTI to share the costs of bus priority improvements elsewhere, including the top 20 corridors causing the greatest delay to customers.

The Appendix of this report offers Case Studies of tools used to improve bus speed and reliability in Metro Vancouver and elsewhere.

The appendix also includes **Corridor Profiles** and **Sub-region Highlights** offering detailed maps and descriptions of locations and causes of delay.

Glossary

Term	Definition
Boarding	Every time a passenger enters a bus, train or SeaBus. Transfers are counted as additional boardings.
Bus Speed and Reliability Program	Cost-share funding program for municipalities to plan, design and construct bus priority.
Delay	Excess time spent traveling between bus stops.
Dwell	Time spent at a bus stop to allow customers to get on and off the bus.
Journey	A complete transit trip, regardless of the number of transfers.
On-time Performance	The percent of trips that arrive at their destination at the time scheduled.
Passenger Load	The number of people on a bus at any given time.
Person-hours of Delay	The total amount of excess time spent in transit for all passengers on the bus.
RapidBus	Rapid-service bus operating at least every 10 minutes, with bus priority and enhanced passenger amenities.
Reliability	Difference between scheduled and actual travel time. Reliability measures how accurately bus schedules match actual driving conditions.
Ridership	The total number of people who use transit. Typically reported for an average weekday or entire year.
Speed	The distance covered in a given amount of time. Most people think about their experience on transit in terms of travel time, but speed is a useful metric for comparing performance of buses traveling different distances.
Travel Time	Time spent traveling between locations (e.g. terminus, stops).
Variability	Range of travel times observed for a given route, direction, segment, and time of day. High variability results in either poorer reliability or lower cost-efficiency of service delivery.

Further discussion of these terms and methodologies can be found in the Appendix.

Part 1: Context

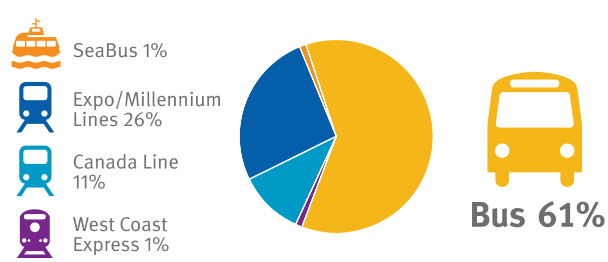
IMPORTANCE OF TRANSIT SERVICE

Bus service is critical to access and mobility in Metro Vancouver. Delay caused by traffic greatly affects the cost and quality of this service.

Metro Vancouver residents board buses over 931,000 times every weekday. Transit helps Metro Vancouver residents reach the things that are important to life and liveliness: work, school, shopping, services, and social gatherings.

In contrast to most North American metropolitan areas, transit ridership is growing in Metro Vancouver. Last year TransLink set a record for ridership by providing 437.4 million boardings.

Nearly two-thirds of transit trips in Metro Vancouver are by bus



Buses are the workhorse of transit service in Metro Vancouver.

Buses serve an overwhelming majority of transit customers in Metro Vancouver. Nearly two-thirds of transit journeys (261 million boardings each year) are by bus. And almost three-quarters of all transit boardings—travel from origin to destination, including transfers—include a bus connection to another mode such as SkyTrain or SeaBus.

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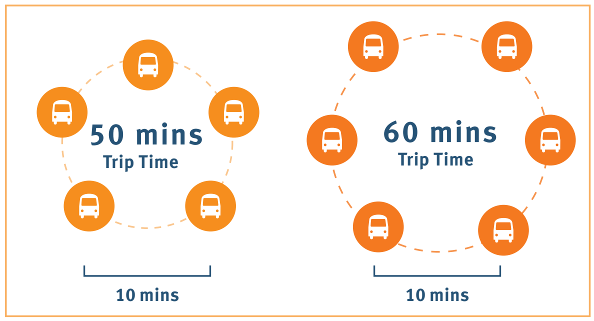
On-time performance is a measure of the percent of buses arriving at their destinations on-time. Since 2014, on-time performance has improved on most (61%) bus routes. Two-thirds of transit customers (67%) have benefitted from those schedule improvements. These improvements have occurred despite increasing traffic causing slower speeds.

Traffic greatly affects customer experience and operating costs.

Traffic affects more than motorists—it slows down people on buses, too. As buses slow, TransLink must put more buses on the street to maintain the same levels of service.

*For example, if a route once took **50 minutes** to complete, and ran every **10 minutes**, it would need **5 buses**. However, if the trip slowed to **60 minutes**, then **6 buses** would be needed to maintain service every **10 minutes**.*



80% of bus routes are slower today than they were five years ago. Traffic has the largest effect on heavily-used bus routes on busy streets.

As many as 85% of customers—or 250 million journeys —were affected by slower service in 2018 compared to 2014.

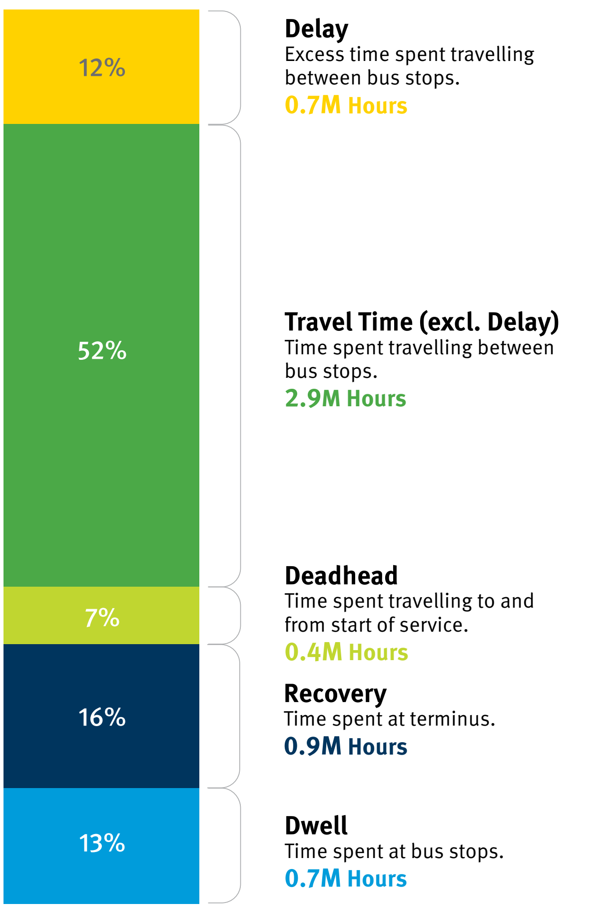
The negative effect on customers is not only longer and less reliable travel times, but also longer waits and increased overcrowding due to bus bunching. This reduces the overall attractiveness of transit compared to driving, ride-hailing, taxi and even cycling and walking. While ridership growth remains strong, we cannot take this for granted. Any decline in ridership would impact fare revenues and the ability to fund existing service levels – a situation experienced by many transit agencies in North America.

In addition to customer impacts, slowing of bus service has a growing impact on TransLink's finances. We estimate that over $75 million per year (nearly 700,00 annual service hours), or 12% of CMBC's bus total operating costs, are attributable to roadway delay. A further 16% of CMBC's operating costs is recovery time spent at termini, which is required not only for operator breaks but also to ensure on-time departures. As bus travel times become more irregular, recovery time must also be increased.

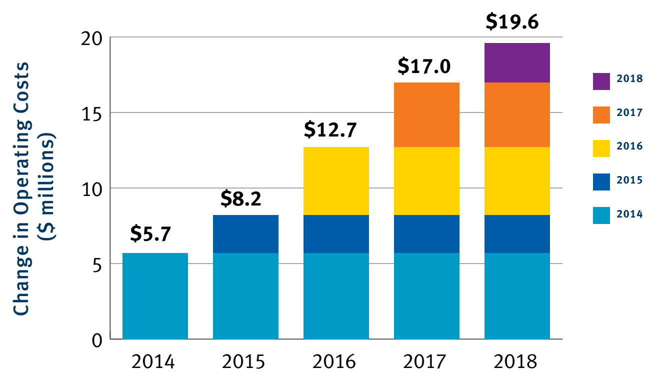
Each year, TransLink adds $2.5M - $5M of service to offset the impacts of traffic.

Operating costs resulting from slowing and less reliable bus services are growing. Unless bus speeds improve, these costs carry forward into all future years. Since 2014, annual operating costs have increased by $19.6 million to offset impacts of traffic, leading to $63 million spent in the last five-year period. For the same amount of money, we could introduce a new RapidBus line every 1 – 2 years!

2018 Annual Scheduled Service Hours
5.5M Hours



Slower Bus Service Cost
$63.2 million (2104 – 2018)



CMBC adjusts schedules quarterly to maintain on-time performance in the face of growing roadway congestion. Simply put, TransLink cannot respond to slower service by adjusting schedules alone. To control costs TransLink must also protect buses from traffic congestion.

IMPORTANCE OF SPEED AND RELIABILITY

Providing fast and reliable bus service ensures our transportation network is sustainable, equitable and efficient.

Fast, reliable service makes transit an attractive travel choice compared to driving.

Traffic congestion affects our quality of life, health, safety, and regional economy. When people choose to take transit rather than driving, they help reduce the number of cars on the road and greenhouse gas emissions in the air. More people choose to take transit when they can count on it to get them where they need to go in a reasonable time.

Therefore, providing fast and reliable bus service supports goals of providing safer streets, reducing the number and share of automobile journeys, and reducing greenhouse gas emissions and the effects of climate change.

Fast, reliable bus service improves access and mobility, and equity.

When travel is fast and reliable, people can make more journeys more often. They are better able to access goods and services, participate in civic and social life, and the economy. Bus riders in Metro Vancouver have a higher share of women, seniors, and lower income residents compared to the regional average. Access and mobility improvements are particularly important to support their equal participation in society.

Providing for fast, reliable bus service is consistent with the goals outlined Metro Vancouver's Regional Growth Strategy to create healthy, sustainable and complete communities.

Transit is also among the most efficient and effective use of limited resources.

Transit is among the most efficient and effective use of limited resources such as space on the roadway and natural resources. Transit carries large numbers of people through roads and intersections in a small space and short amount of time. It makes efficient use of fuel and energy.

Providing fast, reliable transit service supports goals of managing limited resources and providing taxpayers with efficient services.

Fast, reliable service improves efficiency and effectiveness of public funds.

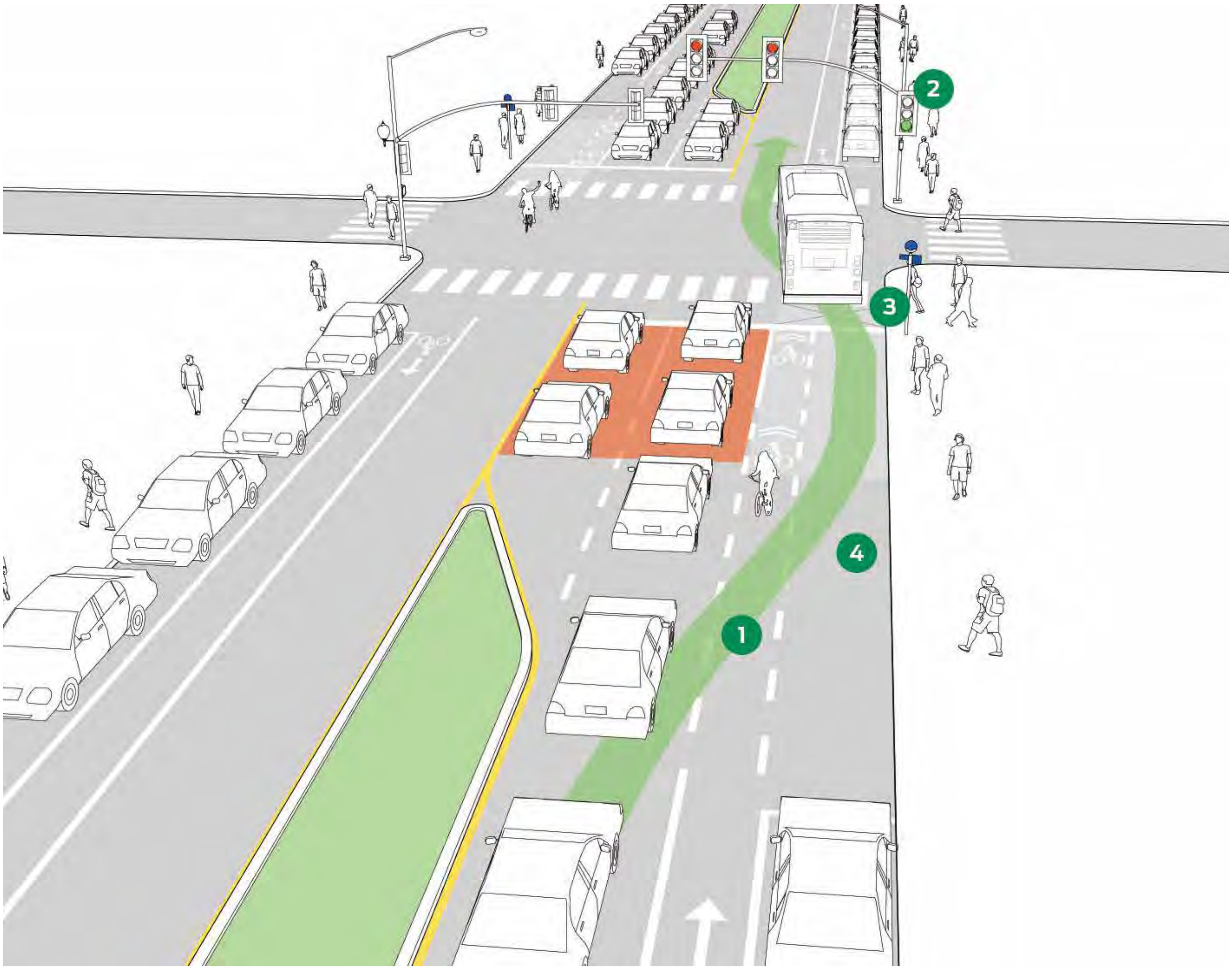
As buses slow, TransLink must put more buses on the street to maintain the same levels of service. Conversely, as buses get faster and more reliable, TransLink can provide the same level of service with fewer buses or increase the level of service with no additional cost.

Providing fast, reliable transit service supports goals of delivering efficient and effective services to tax payers.

> "Metro Vancouver has an opportunity and a vision to achieve what humanity aspires to on a global basis – the highest quality of life embracing cultural vitality, economic prosperity, social justice and compassion, all nurtured in and by a beautiful and healthy natural environment."
>
> Metro Vancouver Regional Growth Strategy (2011)

TOOLS TO IMPROVE SPEED AND RELIABILITY

There are many tools to improve speed and reliability of bus service.



Fortunately, there are many tools to improve travel time and reliability for buses. These are often the same tools used to improve comfort, safety, and travel time for motorists, bicyclists, or pedestrians.

They include:

- Management of traffic movements and curb uses.
- Provision of special infrastructure on the roadway, at intersections, and at bus stops.
- Dedication of lanes to protect transit customers from the impacts of traffic.
- Changes to design and operation of traffic signals.
- Changes to the operations and route of buses.

TRANSIT PRIORITY TOOLKIT

TransLink has released a Transit Priority Toolkit as a companion to this document. The Transit Priority Toolkit provides examples of transit priority measures commonly used to address specific sources of delay. It also includes a summary of benefits, challenges, costs, considerations, alternative strategies, and case studies from across North America.

STRATEGY	CONGESTION: INTERSECTION	CONGESTION: ROADWAY	DELAY: SIGNAL	DELAY: RIGHT TURN	DELAY: LEFT TURN	OPERATIONS: ACCESS TO BUS STOP	OPERATIONS: LEAVING BUS STOP	OPERATIONS: DWELL TIME	OPERATIONS: INSUFFICIENT RUNNING TIME	SAFETY: PEDESTRIANS	SAFETY: CYCLISTS	SAFETY: MOTORISTS	COST	COORDINATION
A. Bus Stop and Curb Management														
A1. Bus Stop Placement	★		★			★★★	★★	★	★	★★	★★		$–$$	Medium/ High
A2. Curb Management		★				★★	★	★		★	★	★	$–$$	Medium
B. Traffic Regulations														
B1. Movement Restrictions	★★★		★	★★★	★★★		★★		★★	★	★	★★	$–$$$$	Medium/ High
C. Street Design														
C1. Bus Stop Infrastucture						★★	★★	★★★		★★★	★★★		$–$$$	Low
C2. Turn Pockets	★		★★	★	★							★★	$–$$	Medium
C3. Vertical Control Devices		★★★				★★	★		★★	★★★	★★★	★	$	Medium
C4. Queue Jumps	★★★		★★★						★★				$–$$	Medium
C5. Transit Approach Lane	★★★		★★★						★★				$	Medium
C6. Peak-Hour Bus Lane	★★	★★		★★	★★	★★	★★	★★	★★★		★	★★	$$–$$$$	High
C7. Dedicated Bus Lane	★★★	★★★		★★★	★★★	★★★	★★★	★★★	★★★		★	★★	$$–$$$$	High
D. Signal Priority														
D1. Passive Signal Priority	★★	★	★★						★★	★	★	★★	$–$$	Medium
D2. Transit Signal Priority (Active)	★★★		★★★	★★★	★★★				★★★				$$–$$$$	High
E. TransLink Practices and Policy														
E1. All-Door Boarding								★★★	★★	★				Low
E2. Schedule/Operator Recovery									★★★					Low

SPECIFIC CHALLENGES

$ UNDER $50K
$$ $50,000 - $100K
$$$ $100,000 - $250K
$$$$ OVER $250K

Benefits: ★ LOW ★★ MEDIUM ★★★ HIGH

Most tools to improve speed and reliability are not under TransLink's control.

TransLink has control over some of these tools.

TransLink has control or direct influence over operating considerations such as stop location, boarding and fare payment policies, and route design. TransLink can adjust stop location and boarding and fare payment policies to reduce the amount of time buses spend at bus stops picking up and dropping off customers. TransLink can also adjust route design to avoid delay on slow streets or commonly congested intersections.

These tools have their limits. For example, changes to stop locations and route designs are usually subject to public comment and municipal approval.

However, most tools—and the most *effective* tools—are under municipal and BC MOTI control.

Changes to traffic signals, intersection and roadway design and infrastructure, and management of lanes require municipal or provincial approval, if not political leadership.

The tools to provide faster, more reliable bus service range in terms of cost, effectiveness, complexity, and visibility. In general, tools that are effective and inexpensive are more politically sensitive because they require an explicit trade-off between users of the roadway. For example, converting general travel lanes or parking lanes into bus lanes is a fast, effective, and inexpensive way to improve bus service; however, the explicit reallocation of space from one user to another often arouses opposition.

TransLink Control	OPERATIONS	Stop Relocation or Consolidation	Boarding Policy	Route Design
Municipality and MOTI Control	SIGNALS	Turn/Movement Restrictions	Queue Jumps	Transit Signal Priorities
		Bus-only Signals	Signal Phase Modification	
	INFRASTRUCTURE	Bus Platform Design	Bus Bulges	Boarding Islands
		Roadway Channelization	Parking Removal	Turn Radii Improvements
	TRANSIT LANES	Curb-side Bus Lanes	Interior/Offset Bus Lanes	Median Bus Lanes
		Contraflow Bus Lanes	Queue Bypass/Transit Approach Lanes	

CURRENT DYNAMIC

Collaboration between TransLink, municipalities and BC MOTI is critical for successful bus priority.

TransLink, municipalities and BC MOTI each offer unique skills, expertise, tools, and resources when planning bus priority.

As the manager of Metro Vancouver's integrated regional transit network, TransLink has enormous amounts of data to identify where, when, and by how much buses are slowing down. TransLink also has specialized staff with the transit operations and design expertise to identify causes of delay and potential solutions. Finally, TransLink also provides funding resources to municipalities to design and deliver projects that make buses faster and more reliable. TransLink will award $14.6 million over four years for planning, design, and implementation of transit priority measures through the Bus Speed & Reliability funding program. This is on top of the funding for bus priority for RapidBus corridors.

Municipal and provincial agencies offer their own skills, expertise, tools, and resources for bus priority. Municipal and provincial agencies have information about traffic volumes, and other roadway activity such as parking usage. Municipal and provincial agencies have specialized staff with transportation and traffic signal operation and design expertise to identify causes of delay and potential solutions. Municipal and provincial agencies have local knowledge of conditions, including previous and planned initiatives. Municipal and provincial agencies develop and manage budgets for maintaining and upgrading their roadways. Most importantly, municipal and provincial agencies have the *authority* to change signals and roadways.

Multi-agency partnerships are required for progress on bus priority.

Although on-street transit priority improvement projects can be done cost-effectively and quickly, they are not easy to accomplish due to their multi-agency nature. Planning, collaboration, and political will are key prerequisites for successful completion of transit priority improvement projects. But no single agency on its own successfully deliver any such projects.

As the transit agency, TransLink lacks the authority to unilaterally make changes to roadways and signals. And yet while municipal and provincial agencies do have that authority, they have not typically undertaken bus priority planning on their roadways, perhaps feeling a lack of expertise and authority on transit matters.

Recently that has started that change, as TransLink, the Province, and some Metro Vancouver municipalities have begun planning and collaborating on bus priority efforts. That collaboration has been aided by dedicated TransLink funding, and development of data analytics and visualizations on bus delays.

Data helps leaders make more informed decisions about trade-offs.

Providing priority to transit often requires trade-offs relative to available capacity or delays for other (less efficient modes) or in relation to parking and access etc. Those decisions can be difficult, particularly if they cause impacts to some members of the public. Leaders at municipalities and BC MOTI who have authority over roadway design and signal operations have not historically had much access to bus performance data to inform their decision-making about transit priority. That is now changing.

This report provides data about where, when, and how much traffic affects buses across Metro Vancouver. This report uses TransLink's bus performance and passenger delay data from across the region to aid the discussion within municipal and provincial agencies and with the public about where transit priority improvements may be most beneficial to the most travelers.

PART 2 - CHALLENGES

COMMON CHALLENGES TO PROVIDING FAST, RELIABLE BUS SERVICE

Customer-focused metrics identify areas of greatest passenger delay.

Most municipalities and BC MOTI face similar challenges to providing fast, reliable bus service.

Although each city has unique characteristics, the design and function of streets is generally similar everywhere. Most cities must balance competing demands for limited space on public roadways and sidewalks, including space for walking, cycling, taxis, goods movement, loading zones, cars, parking, and transit. Similarly, BC MOTI must balance competing demands for limited space on provincially managed highways that travel within and across Metro Vancouver. These competing demands for public rights-of-way create challenges to providing fast, reliable bus service.

Sometimes transit priority improvements have benefits to other users of the roadway, such as when widening projects add bus or HOV lanes. But where it is not possible or practical to increase the capacity of the roadway or intersection, transit improvements are more likely to require cities and BC MOTI to make trade-offs with other modes in allocation of road space.

Like municipalities and BC MOTI, TransLink has a multimodal mandate.

TransLink plans for, funds, and supports walking, cycling, goods movement, and infrastructure for general traffic on the major road network. We seek to do so in a way that meets regional needs and that sustains local businesses and communities. We share an interest in balancing the many uses of roadways.

TransLink recognizes the need to examine roadway space allocation trade-offs in a local context, which often includes discussions with the community. TransLink is committed to supporting municipalities and BC MOTI with that process, to address bus delay with locally appropriate solutions.

Many cities have been successful at providing fast, reliable bus service.

Faced with competing demands from different users, most cities carefully balance support for existing travel behavior with changes to encourage desired behavior. For example, most cities have some experience reallocating road space to provide safer facilities for cycling or walking.

The same can be done to protect people on transit from congestion. Cities across the globe, including several in Metro Vancouver, have successfully reallocated space on the roadway or time in the traffic signal cycle to improve the speed and reliability travel for people on the bus. This is often done in recognition of the fact that transit riders already make up a major share of the people moving through major corridors.

ANALYTICAL APPROACH TO IDENTIFYING NEEDS

TransLink can calculate the amount of time our customers spend delayed by traffic.	We collect multiple sources of data from onboard the bus GPS units, Compass readers, and automated passenger counters (APC) for each route. For example, each bus generates approximately 20,000 electronic records per day. **That adds up to more than 28 million records per day, system-wide.**
TransLink uses the customer-focused metric—Person-hours of Delay—to identify needs for transit priority.	We can calculate a comparison between average travel time to fastest travel time for a route, direction, segment, and time of day. We then take this difference and multiply by the average number of people on the bus for the route, direction, segment, and time of day.

The figure on the following page provides a high-level explanation of person hours of delay and how TransLink applies this metric. A more detailed breakdown of the process and methodology is described in the Appendix under Corridor Profiles.

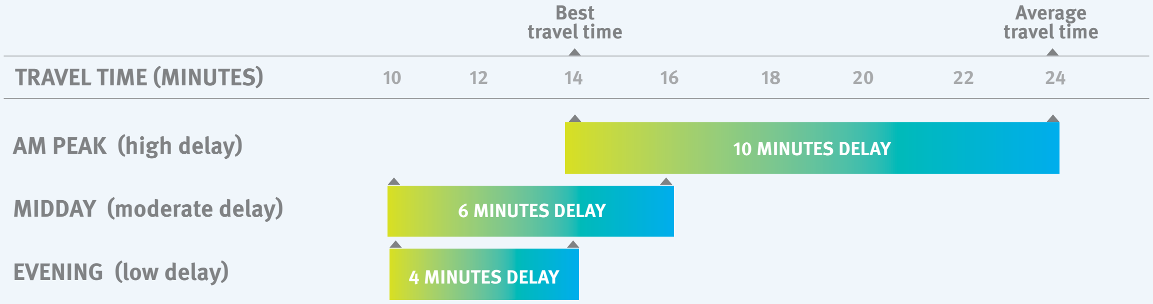
TransLink has identified corridors that generate the most delay for our customers.

The priority needs for transit priority are on the twenty corridors that generate the most passenger-hours of delay. These priority corridors are geographically distributed. Metro Vancouver is unique for having high transit demand throughout the region. High transit ridership is not limited to the urban core; it extends well into and between the town centers and suburbs. Many of these corridors affect multiple sub-regions, as they serve both local and cross-regional bus routes.

The delay at these locations affects not just the passengers in the corridor, but those who live and travel by transit outside of the corridors.

For example, both the West Georgia and Powell/Dundas/McGill corridors are used by North Shore residents with regular daily bus commutes across the bridges and into Vancouver. Portions of Hastings St are managed by Vancouver and BC MOTI, but can affect Burnaby residents the most, and vice versa.

The time it takes to travel by bus along a corridor changes depending on time of day.



Delay varies by time of day... and effects different amounts of people throughout the day.

Time of day	Travel time range	Average delay (minutes)	Number of passengers	Total number of passengers who experienced a delay
8:00am–8:15am	14–24 MINUTES	10	50, 70, 60	180
8:15am–8:30am	14–20 MINUTES	6	50, 35	85
8:30am–8:45am	14–20 MINUTES	6	60, 40, 50	150

TransLink has identified locations that generate the greatest amount of delay for our customers.

Using a customer-focused metric— **Person-hours of Delay (PHD)** — TransLink can identify needs for transit priority.

HOW IS PHD CALCULATED?

PHD is the average delay multiplyed by the number of passengers who experinced it.

For accuracy, TransLink makes this calculation in **15-minute increments** during the day.

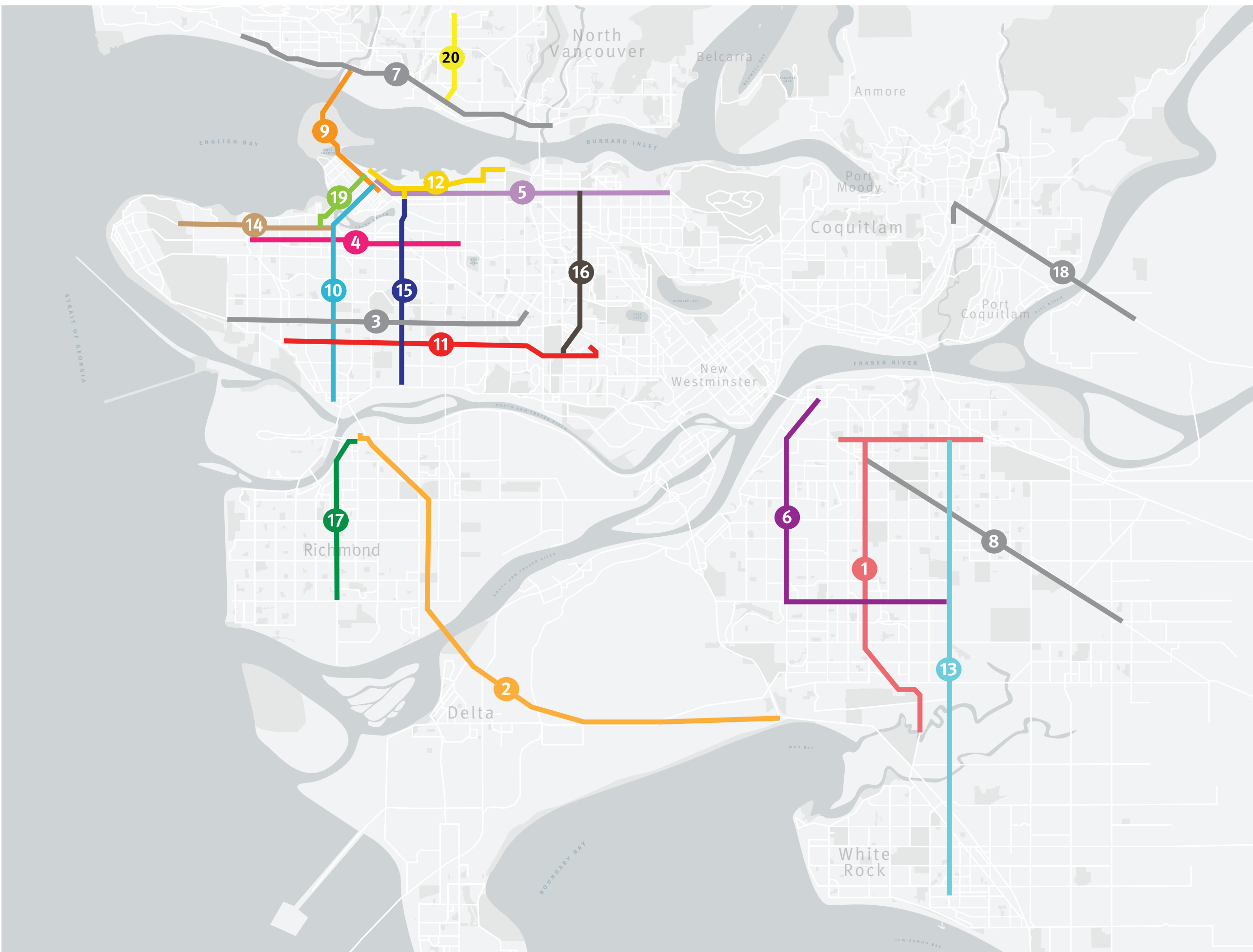
8:00am–8:15am	10 X 180 =	30 hours
8:15am–8:30am	6 X 85 =	8.5 hours
8:30am–8:45am	6 X 150 =	15 hours

We add the passenger-hours of delay for **each 15-minute increment** together to get total person-hours of delay or PHD for a whole day.

RANKED PRIORITIES

Top 20 corridors contributing to person-hours of delay in the region.

TransLink has identified twenty corridors that generate the most passenger-hours of delay. They are ranked in by severity of passenger delay. In some cases, we divide long streets into smaller corridors based on the primary sections of delay (e.g. Broadway only from Commercial to Alma). In other cases, we combine two or more streets based on dominant transit routes and customer travel patterns (e.g. King George Blvd/104 Av, Scott Rd/72 Ave).



- 1 King George Blvd /104th Ave
- 2 Hwy 99
- 3 41st Ave
- 4 Broadway
- 5 Hastings St
- 6 Scott Rd/ 72nd Ave
- 7 Main/Marine Dr
- 8 Fraser Hwy
- 9 Georgia St/Lionsgate Bridge
- 10 Granville St
- 11 49th Ave
- 12 Pender/Powell/Cordova/ Dundas/McGill
- 13 152nd St
- 14 West 4th Ave
- 15 Main St
- 16 Willingdon Ave
- 17 No. 3 Rd
- 18 Lougheed Hwy
- 19 Burrard St
- 20 Lonsdale Ave

The table below summarizes some of the statistics for each corridor. A deeper analysis of each corridor is provided in Appendix, including detailed bus speed and variability maps, corridor description and key facts, and location-specific causes of delay. Corridor profiles are not provided for 41st Ave, Main/Marine Dr, Fraser Hwy or Lougheed Hwy corridors due to the ongoing RapidBus program investments.

Top 20 corridors contributing to person-hours of delay in the region

Rank/ Corridor	Municipality or BC MOTI	Adjacent and Affected Municipalities	Routes Impacted	Average Daily Ridership Affected	Percentage of Total Bus Ridership	Average Person-Hours of Delay
1 King George Blvd/104 Ave	Surrey	Delta, White Rock, Langley City, Langley Township	96, 314, 320, 321, 326, 329, 337, 345, 393, 394, 501, 502, 503	61,300	6.7%	872
2 Hwy 99	Ministry of Transportation, Richmond	Delta, Surrey, White Rock	311, 351, 352, 354, 601, 602, 603, 604, 620	15,900	1.7%	772
3 41st Ave	Vancouver	UBC, Richmond	41, 43, 480	35,400	3.8%	642
4 Broadway	Vancouver	UBC	8, 9, 14, 16, 17, 99	148,100	15.9%	641
5 Hastings St	Vancouver, Burnaby	Port Moody, Coquitlam, Port Coquitlam, North Vancouver (District)	3, 8, 14, 16, 20, 28, 95, 129, 130, 131, 132, 134, 160	162,500	17.4%	583
6 Scott Rd/ 72 Ave	Surrey, Delta	Richmond	96, 301, 310, 311, 312, 314, 319, 322, 324,329, 335, 341, 342, 391, 393, 640	72,500	7.8%	535
7 Main/Marine Dr	West Vancouver, City of North Vancouver, District of North Vancouver, Province of BC	Vancouver, UBC	228, 231, 232, 236, 239, 240, 241, 242, 247, 250, 251, 252, 253, 254, 255, 256, 257, 258	51,000	5.5%	511
8 Fraser Hwy	Surrey, City of Langley, Township of Langley, Province of BC		320, 345, 395, 501, 502, 503	28,100	3.8%	486
9 W Georgia St/ Lions Gate Bridge	Vancouver, Province of BC	North Vancouver (District), North Vancouver (City), West Vancouver, UBC	240, 241, 242, 246, 247, 250, 253, 254, 257, 258	33,300	3.6%	481
10 Granville St	Vancouver		4, 7, 10, 14, 16, 17, 20, 50	126,300	13.5%	449

Rank/ Corridor	Municipality or BC MOTI	Adjacent and Affected Municipalities	Routes Impacted	Average Daily Ridership Affected	Percentage of Total Bus Ridership	Average Person-Hours of Delay
11 49th Ave/ Imperial	Vancouver, Burnaby	Richmond	49, 430	35,300	5.4%	436
12 Pender/ Powell/ Cordova/ Dundas/ McGilll	Vancouver	District of North Vancouver	4, 5, 7, 10, 17, 19, 22, 209, 210, 211, 214	100,000	10.7%	405
13 152 St	Surrey	White Rock, Delta, Langley Township, Langley City, Richmond	320, 321 335, 341, 345, 351, 354, 363, 375, 394, 531	43,400	4.3%	378
14 W 4th Ave	Vancouver, UBC	West Vancouver	4, 7, 32, 42, 44, 84, 258	42,400	4.5%	303
15 Main St	Vancouver		3, 8, 19, 22 (off-peak)	55,500	5.9%	284
16 Willingdon Ave	Burnaby	Vancouver, New Westminster, North Vancouver (District)	25, 110, 123, 125, 130	52,800	5.7%	261
17 No 3 Rd	Richmond	Burnaby, Vancouver, New Westminster	301, 401, 402, 403, 404, 405 406, 407, 408, 410, 414, 416, 430	66,900	7.2%	248
18 Lougheed Hwy	Coquitlam, Port Coquitlam, Maple Ridge, Pitt Meadows, Province of BC	Burnaby, Mission	159, 160, 170, 172, 189, 701, 722, 791	19,200	2.1%	171
19 Burrard St	Vancouver	Burnaby, UBC, West Vancouver	2, 5, 32, 44, 95, 258	65,000	7.0%	162
20 Lonsdale Ave	City of North Vancouver, District of North Vancouver	Vancouver, West Vancouver	228, 229, 230, 232, 239, 241	22,400	2.4%	144

PART 3 - NEXT STEPS

TransLink has begun initiatives to expand bus priority.

The Mayors Vision identified the need for expansion of bus priority in the region, with 12 new RapidBus corridors. Dedicated TransLink funding for bus priority was put in place through the Phase One and Phase Two Investment Plans, including the delivery of seven new RapidBus corridors, a RapidBus upgrade program, and a new municipal cost-share funding program for Bus Speed and Reliability.

A first wave of bus priority expansion projects is currently underway, delivered through two TransLink programs:

- the **RapidBus Program** for larger investments in a few key corridors
- the **Bus Speed and Reliability Program** for funding municipalities to develop and deliver hotspot treatments and smaller corridor improvements.

RAPIDBUS PROGAM

TransLink's RapidBus program introduces express service with transit priority to major transit corridors across the region.

Mayors' 10 Year Vision calls for a network of RapidBus corridors

In 2014, the Mayors' Council 10-Year Vision for Metro Vancouver Transit and Transportation identified a dozen new bus corridors for "B-Line or Better" service. Building on the success of previous limited stop B-Lines, the Phase One Investment Plan funded the first five routes for implementation. The Phase Two Investment Plan funded two additional routes.

In implementing Phase One of the investment plan, several further improvements were made beyond the existing B-Line brand features. These routes will provide all-day fast, very frequent service, seven days a week. They will also feature enhanced customer amenities, including improved accessibility and real-time next-bus information at each stop. And critically, they will feature bus priority to ensure the services are fast and reliable. In recognition of the improved service and amenity features, the "B-Line or Better" routes have been rebranded as "RapidBus".

The first five RapidBus routes will be launching in 2020 as well as an upgrade to the Fraser Hwy corridor.

Route #	Route Name	Corridor Rank for Passenger Delay	Notes
R1	**King George Blvd RapidBus**	**1**	**Upgraded 96 B-Line**
R2	**Marine Dr RapidBus**	**7**	**New route**
R3	**Lougheed Hwy RapidBus**	**18**	**New route**
R4	**41st Ave RapidBus**	**3**	**New route**
R5	**Hastings St RapidBus**	**5**	**Upgraded 95 B-Line**
503	*Fraser Hwy Express*	*8*	*Upgraded*

RapidBus service along five corridors is planned for launch in 2020. This will include three new routes and upgraded service along two existing B-Line corridors. Service increases and cost-effective bus priority improvements will also be made to the Fraser Hwy corridor, in advance of rail transit expansion there.

These corridors are all among the top 20 for person-delay in the region based on current conditions. Through the RapidBus program, bus priority measures developed and agreed upon in partnership with local municipalities and BC MOTI will roll out across the three new corridors and Fraser Hwy by 2020.

Planning has also commenced on the next two funded RapidBus corridors (Scott Rd, and Richmond to Expo Line). Bus priority improvements will form an important part of those projects as well.

The first wave of RapidBus projects will deliver over 30 lane-km of new bus priority measures.

The first wave of RapidBus projects will deliver one of the largest one-time expansions of arterial bus priority in Metro Vancouver's history.This consists of significant amount of new bus priority lanes, as well as other transit priority measures including:

- 21 lane-kms of all-day bus-only or business access & transit (BAT) lanes.
- 2 lane-kms of peak period bus-only lanes.
- 3.5 lane-kms of High Occupancy Vehicle (HOV) lanes.
- 4.5 lane-kms of parking restricted travel lanes
- 7 bus queue jump lanes.
- 3 bus-only turning lanes.
- 4 additional traffic signals.
- 5 intersection changes to reduce multi-modal friction.

These new transit priority measures are anticipated to improve speed and reliability for not only the RapidBus lines, but also more than 30 other buses routes that travel along those corridors. TransLink along with municipal and BC MOTI partners will monitor the effectiveness of these measures and seek to enhance them as needed.

BUS SPEED & RELIABILITY COST-SHARING PROGRAM

TransLink will award $14.6 million over four years to municipalities to make buses faster and more reliable.

TransLink created a dedicated bus priority fund for municipalities, enabled by the Phase One and Two Investment Plans. Over four years, TransLink will award $14.6 million through a cost-share funding program to municipalities to develop and deliver projects that help make buses faster and more reliable. This program augments TransLink's other existing municipal cost-share funding programs.

Funds from this program are distributed on a competitive basis. Priority is given to projects that are most effective at reducing person-hours of delay. The corridors listed in this document have the highest potential for receiving funding.

Competitively allocated ***Bus Speed and Reliability*** *funds*

$ Millions

2019	$ 1.525
2020	$ 3.725
2021	$ 4.15
2022	$ 5.25
Total	$ 14.625

TransLink will award funds for a variety of projects.

The ultimate goal of the Bus Speed and Reliability Program is to improve the design and operation of roadways and intersections to benefit customers on the bus. To achieve that goal, TransLink will award funds for a variety of projects including:

- **Capital Projects and Operating Plans** that make buses faster and more reliable.
- **Pilot Projects** to measure the effects of new designs or operating plans to inform future decisions about permanent changes.
- **Project Development** to examine known bottlenecks and develop conceptual designs for future funding.
- **Capacity Building** so that local jurisdictions have the knowledge, skills, and tools to plan and deliver projects in a quick and cost-effective manner.

Projects from the inaugural year of the program are already showing measurable benefits.

The first year of the program began with dispersing $1.5 million for the 2019 cycle. Municipalities that received funding include Burnaby, Delta, North Vancouver City, North Vancouver District, Richmond, Surrey, and Vancouver.

MONITORING AND REPORTING

This report points to the insufficiency of current bus priority efforts and the need for ongoing monitoring and action.

Current bus priority efforts only address a small portion of delay across the region.

While these bus priority efforts currently underway through the RapidBus and Bus Speed and Reliability programs are important, thus far they address only a small number of the twenty top priority corridors identified in this report. Further, even on those corridors current efforts do not address all locations and times of bus delay identified through this report.

The need is also increasing, with bus delays worsening as congestion grows. Clearly, more action is needed to address the scale of the problem of bus delay in Metro Vancouver and reverse current trends.

Ongoing monitoring and reporting of bus speed and reliability will support sustained commitment to action.

As the Metro Vancouver's first detailed analysis of region-wide bus delay, this report provides transportation professionals, the public, and their elected leaders with critical information about where delays delays have the greatest affect on bus service today. It further provides guidance about what to do about it.

Continued monitoring and reporting of bus delay will be essential in tracking both improving and deteriorating conditions over time. Regular reporting on bus delay will guide ongoing TransLink, municipal and BC MOTI efforts to ensure that they are focussed on the areas of greatest need.

Appendix

Case Studies, Corridor Profiles and Subregional Highlights

Appendix

Case Studies

Case studies indicate that the most successful transit prioritizations appear in cities that have established a clear policy on transit improvements and have a strategic plan in place for implementation.

Defining the need for priority and determining where it can be implemented is central to the development of a strategic program.

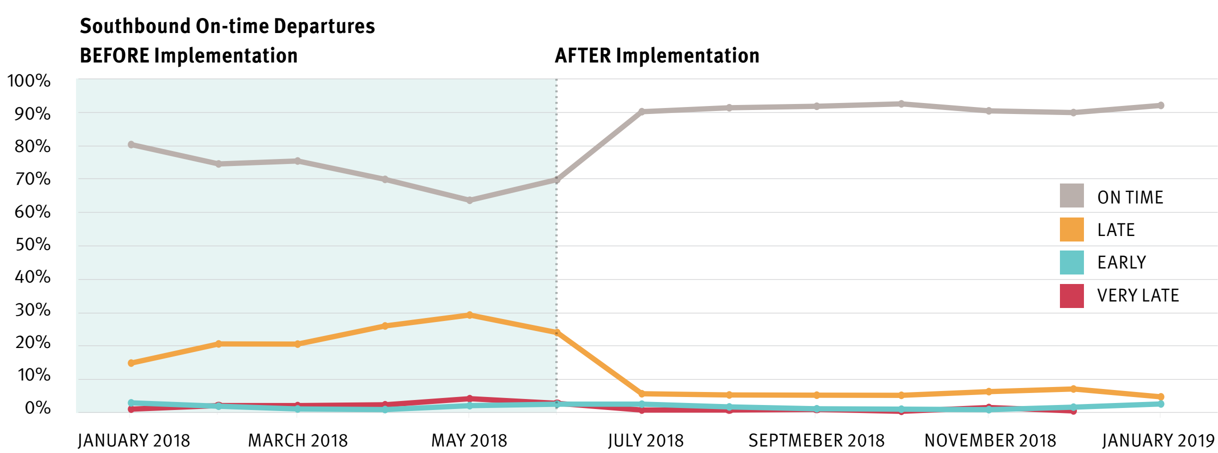
SCHEDULING AND LAYOVERS

Route 20 Downtown Layover Pilot (Vancouver, BC)

For many routes operating in downtown Vancouver, the layover of the route occurs only at the terminal, often outside of downtown. This is due to the current lack of sufficient space in downtown Vancouver, where buses may hold in place for a few minutes before starting the next trip. Consequently, inbound buses must immediately start the proceeding outbound trip with no recovery time built in the schedule to make up for any unanticipated delays.

In summer 2018, the City of Vancouver and TransLink began a pilot project on Route 20. By removing four metered parking spaces, the existing bus stop on the southwest corner of Richards St and Georgia St was extended approximately 25 meters to provide space for two articulated trolley buses to rest at the same time. Initial results include significant reduction in bus bunching (down 50 – 85%) and improved on-time departures (up 13 – 34%).

Change in on-time performance for southbound trip departures before (Jan 1 - Jun 24) and after (Jun 25 - Sept 14) implementation of Route 20 Downtown Vancouver Layover



BUS BULGES (BUS BULB-OUT STOPS)

Temporary boarding island (New York City)

Temporary Bulb-Outs: New York, Portland, and Los Angeles

Bus bulbs and islands improve reliability by placing the bus stop adjacent to a travel lane. Buses can stop in the travel lane and no longer need to merge back into moving traffic. There are numerous examples of bus bulges in Metro Vancouver, such as on Marine Drive in West Vancouver and on Main St in Vancouver. While bus bulges are normally constructed as an extension of the sidewalk using concrete, recently several North American cities including New York, Portland, and Los Angeles have installed plastic modular bulb-out stops. These modular bus stops allow cities and transit agencies to improve bus stops quickly and cheaply. The modular bulb-outs are wheel-chair accessible. They also can be assembled into a boarding island to accommodate a bike lane passing behind the transit stop, a design standard for multi-modal streets.

TRANSIT ONLY LANES AND QUEUE JUMPS

Bus-only lane in Everett, Massachusetts

Everett Pilot Peak Hour Bus Lane

Everett, Massachusetts's bus-only lane pilot has become a model for other cities on quick fixes to improve bus service. Everett, a working-class city just outside Boston, has high transit ridership, with over 10,000 riders a day traveling on the routes that serve the Broadway corridor.

For a week in December 2016, the city coned off a parking lane on Broadway for the morning rush hour to pilot a curb-running bus lane. Since the parking restriction was temporary for the pilot, public outreach was initially limited to flyers announcing and explaining the demonstration project.

The results of the pilot were encouraging. Immediately, passengers noticed the improvements, with travel times decreasing by 4 to 8 minutes on the 1-mile (1.6 km) pilot area. Everett made the bus lanes permanent in spring of the following year, following public support during the pilot. The Everett pilot bus lanes showed that sometimes the best public outreach is by doing a demonstration project.

Soon after, the City of Boston began piloting bus lanes in Roslindale by removing on-street parking during the morning peak hours. Like in Everett, the short demonstration period was met with positive feedback, and the bus lanes were quickly made permanent. Several other cities in the Greater Boston region including Cambridge and Arlington have undertaken similar demonstration projects.

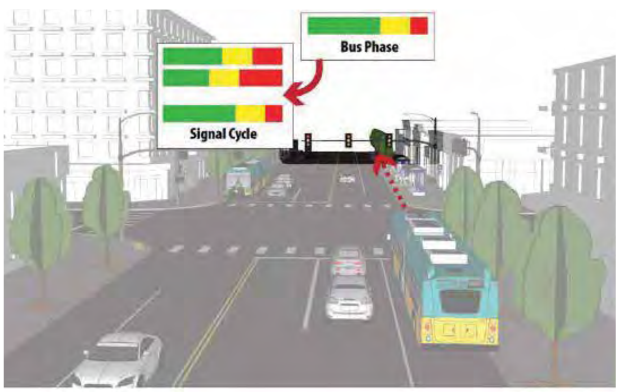
New York Select Bus Service

New York's Select Bus Service uses a combination of pre-paid boarding, stop consolidation, red transit-only lanes (either all day or at peak hours), queue jump lanes, and signal priority to improve travel speeds on some of the city's busiest bus corridors. Buses in some areas still operate in mixed traffic due to constraints in the right-of-way or due to political concerns.

Select Bus Service started on a Bronx crosstown route in 2008. In 2010, Select Bus Service began on the M15, which operates primarily on Second and First Avenues, a couplet of two one-way spines in Manhattan. First and Second Avenues feature peak-hour dedicated transit lanes for most of the day with a brief window in the afternoon that allows for commercial deliveries to use the curb bus lane. For other portions of the route, the M15 SBS continues to operate in mixed traffic, including in some highly congested areas of the Financial District and the Lower East Side. In this section, signal priority was installed. The transit priority features and the off-board fare payment system resulted in a reduction of end-to-end-travel time from 81 minutes on the predecessor route to 69 minutes, a savings of 12 minutes. Of this, 5 minutes can be attributed to transit-priority features, while the other was due to off-board fare payment systems reducing dwells at stops.

QUEUE JUMPS WITH ADVANCE BUS SIGNAL IN SEATTLE

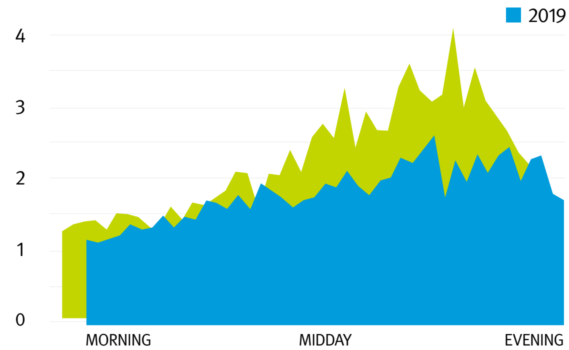
Bus-only signal phase (King County Metro)



Seattle Department of Transportation (SDOT) and King County Metro Transit have been installing queue jumps with a leading bus interval to allow for buses to re-enter traffic before general traffic. Recently, SDOT and King County Metro converted an under-utilized center-turn lane to install a queue jump at a congested intersection, South Rainier Ave at Dearborn Ave. The time savings is up to 90 seconds per trip and has improved reliability along one of the busiest local bus routes. Queue jumps with leading bus intervals have been installed at other congested chokepoints, including at highway entrances, bridges, and major intersections in downtown Seattle.

TRAFFIC SIGNAL IMPROVEMENTS

Change in runtime 2018 to 2019 at Scott Rd & 84th Ave (minutes)



Left Turn Signal at Scott Rd/84 Ave, Delta, BC

In June 2019, the city of Delta installed a left turn signal northbound at Scott Rd & 84 Ave where transit buses were experiencing waits of up to 4 minutes to make the single left turn. Immediately after the change in signal operation, buses saved almost 2 minutes in travel time. Installation of this left turn signal also benefits other road users completing their left turn highlighting the mutual benefits that signal improvements can achieve.

TRANSIT SIGNAL PRIORITY

King County Metro RapidRide, Seattle, WA

The back-bone of Seattle's transit network is its bus system. RapidRide services are King County Metro's premium routes that have limited stops, high frequency, and transit priority features at key points on their corridors. King County Metro and SDOT have been working to install improvements across the network for both RapidRide and local services. In 2014, transit-only lanes and signal priority were installed on the RapidRide E Line, a 20 km route that operates from downtown Seattle to Aurora Village, just north of the city's border. Signal priority was introduced at 20 intersections along the route and found that 1.8 minutes was saved due to transit priority per trip. The total time savings with all transit priority features, which included transit-only lanes, prepaid boardings, and queue jumps, was 5.2 to 8.8 minutes.

STOP CONSOLIDATION

Société de transport de Montreal (Montreal, QC)

In 2015, a study from McGill University analyzed potential bus stop consolidation on the Société de transport de Montreal (STM) using a simpler methodology. The study assumed a removal of 23% of bus stops while only reducing service area by 1%. 75 bus routes would be able to operate with one fewer bus and reduce running times by 2% system wide.

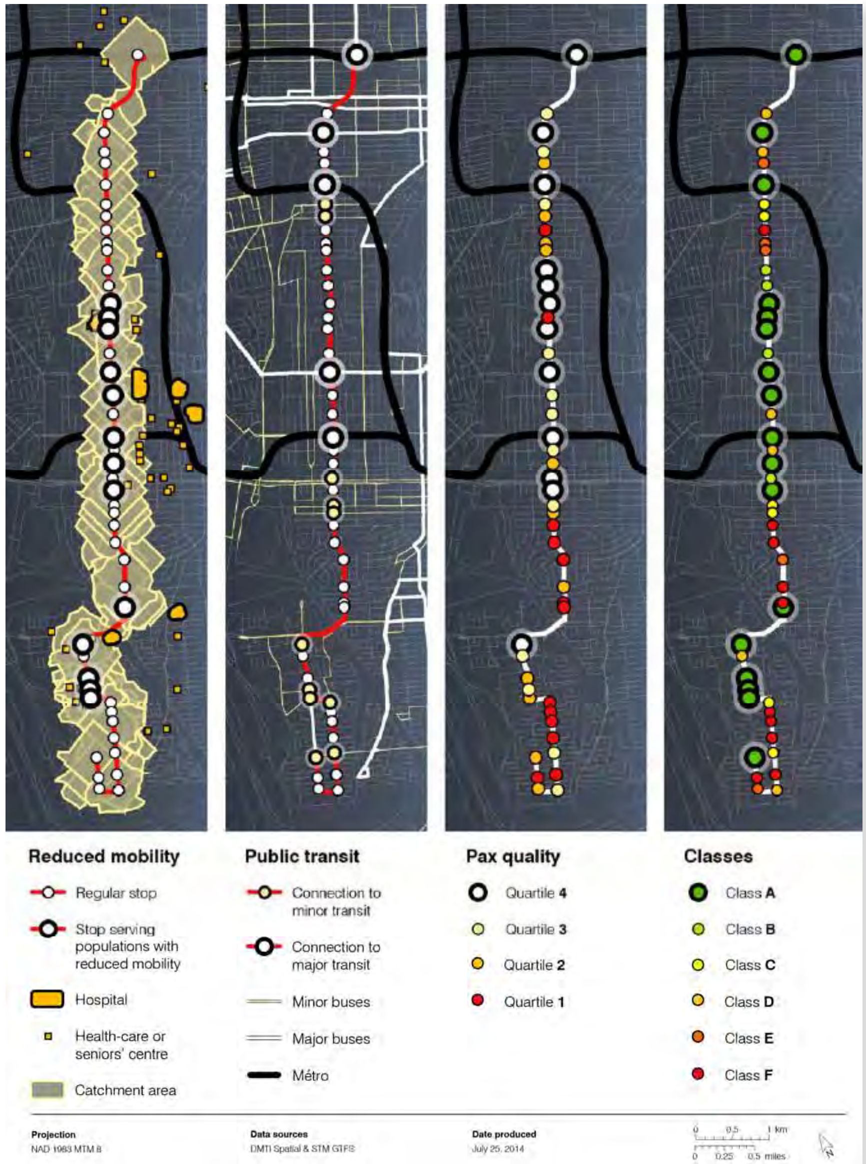


Figure 3: Stewart & El-Geneidy, "Don't Stop Just Yet!: A simple, effective, and socially responsible approach to bus-stop consolidation," 2015. http://tram.mcgill.ca/Research/Publications/Bus_stop_consolidation_Montreal.pdf

Muni Forward (San Francisco, CA)

Muni Forward is a comprehensive re-design of the Muni network that is currently being rolled out. Muni Forward includes service frequency increases and installing transit priority treatments along major corridors. The plan also includes stop consolidation, a politically challenging endeavor in San Francisco, because combining existing stops can sometimes meet resistance where people want the shortest possible walk. San Francisco has the second slowest buses in the United States, partially contributed to by the close stop spacing, which in some parts of the city has buses stop every block. Although the time savings for removing a single stop might seem negligible, when accumulating the time savings across an entire route, the impact can be significant. Stop consolidations were accompanied with service increases.

Main St MAX (Kansas City, MO)

In some cities, the implementation of a rapid bus service has allowed for stop consolidation. Kansas City introduced in 2005 the Main St MAX, a high-frequency rapid bus service. While some transit priority features were implemented, such as peak hour bus lanes and signal priority, a large part of the time savings was due to stops being farther apart (approximately every 400 m). Ridership on the corridor increased by 50% within two years of introduction of the new service. Passengers found that it was worth the extra walk for higher frequency service on Main St MAX as well as the passenger amenities at bus stops. Parallel local service continued until 2011, when the KCATA conducted a Comprehensive Service Analysis. The service analysis found that most passengers taking local routes boarded at shared MAX stops and were only taking the local service if a local bus arrived first. A passenger survey confirmed that passengers preferred to walk farther if the service was faster. With the service changes defined in the Comprehensive Service Analysis, local service was eliminated along the corridor, and the service hours were re-invested in increased MAX service.

Corridor Profiles

ANALYTICAL APPROACH TO IDENTIFYING NEEDS

Extensive data provides insights about bus performance, including speed, variability, reliability, and delay to customers.

Buses generate enormous amounts of information

Each bus generates approximately 20,000 electronic records per day. That adds up to more than 28 million records per day, systemwide. These records include information about the time of day, location of the bus, and number of customers getting on or off the bus at each stop.

TransLink uses that data to gain insights about bus performance and make service improvements such as increasing frequency or fleet size to address overcrowding or updating bus schedules to accurately reflect roadway conditions.

TransLink can also use this data to calculate the amount of time our customers spend delayed by traffic. This process is described in more detail below.

Speed and Travel Time

Each bus is equipped with a GPS unit which records the time and location of the bus every few seconds. TransLink uses this information to calculate how much time buses spend at each bus stop and traveling between bus stops.

Bus speed and travel time is calculated by comparing GPS records for each bus and the amount of time that passed between those records.

TransLink calculates speed and travel time between bus stops by comparing the departure time from one bus stop until the arrival time at the next bus stop. The amount of time at bus stops—or *dwell time*—is not included in this calculation. Therefore, any variability in travel times are attributable to roadway conditions.

Variability and Reliability

Variability and reliability are distinct but related concepts. *Variability* is the range of observed travel times for a given time and location. Reliability is the ability for TransLink to schedule service accurately. When transit travel time varies greatly, it is more difficult to provide reliable and cost-effective schedules.

Example: Imagine that a bus travels between Points A and B. At 3:30 PM, the travel time between A and B varies greatly—sometimes it takes 2 minutes to get there; other times almost 10 minutes. How can TransLink schedule this service accurately and cost-effectively? If TransLink sets the schedule for the bus based on a travel time of 8 minutes, some buses will arrive early and sit there wasting time (but staying on schedule) and some buses will be late, delaying customers on board and keeping others waiting.

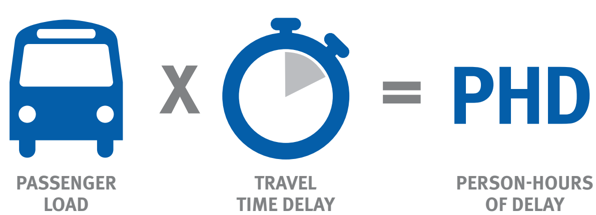
Ridership and Passenger-Load

Buses are also equipped with Automated Passenger Counter (APC) sensors in the doorways to count the number of customers getting on or off at each stop. TransLink uses this data to monitor the total number of customers that use each bus—or ridership—as well as the volume of customer activity at each stop. It can also be used to calculate the number of customers on the bus—or *passenger load*— in between stops.

Delay and Passenger-hours of Delay

Delay is the amount of excess time each bus spends traveling due to external factors such as traffic congestion, signal timing, and so on. It does not include the dwell time the bus spends loading and unloading passengers. Excess travel time is estimated by comparing average of travel times to minimum travel time for each route, direction, segment, and time of day. Extreme outliers and journeys that are not completed (e.g. due to mechanical failure) are filtered out of the analysis. Delay is a measurement of efficient use of limited resources—namely, vehicles and labor.

Passenger-hours of delay are calculated by multiplying the passenger load by delay for each route, segment, and time of day. The passengers-hours of delay is then summed across all segments in a corridor to calculate passenger hours of delay for an entire corridor. Passenger-hours of delay is a measurement of how much delay affects transit customers.



ELEMENTS OF CORRIDOR PROFILES

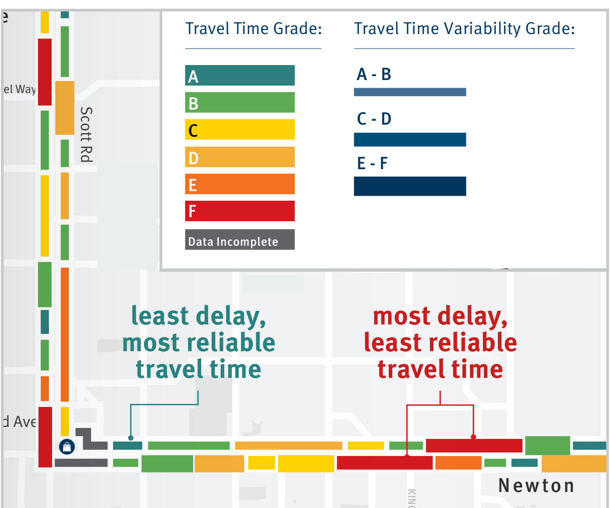
The top corridors generating the most delay for customers are examined in greater detail.

Each corridor profile contains the same elements: a map, table of quick facts, corridor description, and a table of the locations of common causes of transit delay. This report does not detail Main/Marine Dr., Lougheed Hwy, 41st Ave, or Fraser Hwy due to the ongoing RapidBus program investments.

Each corridor profile also includes its significance to the city, sub-region, or region, and key challenges to providing faster, more reliable bus service.

The information about specific locations of delay is based on operator input; direct observations; or an assessment of data, roadway design, geometry, and operations, and experience with similar circumstances.

Maps of bus speed and variability



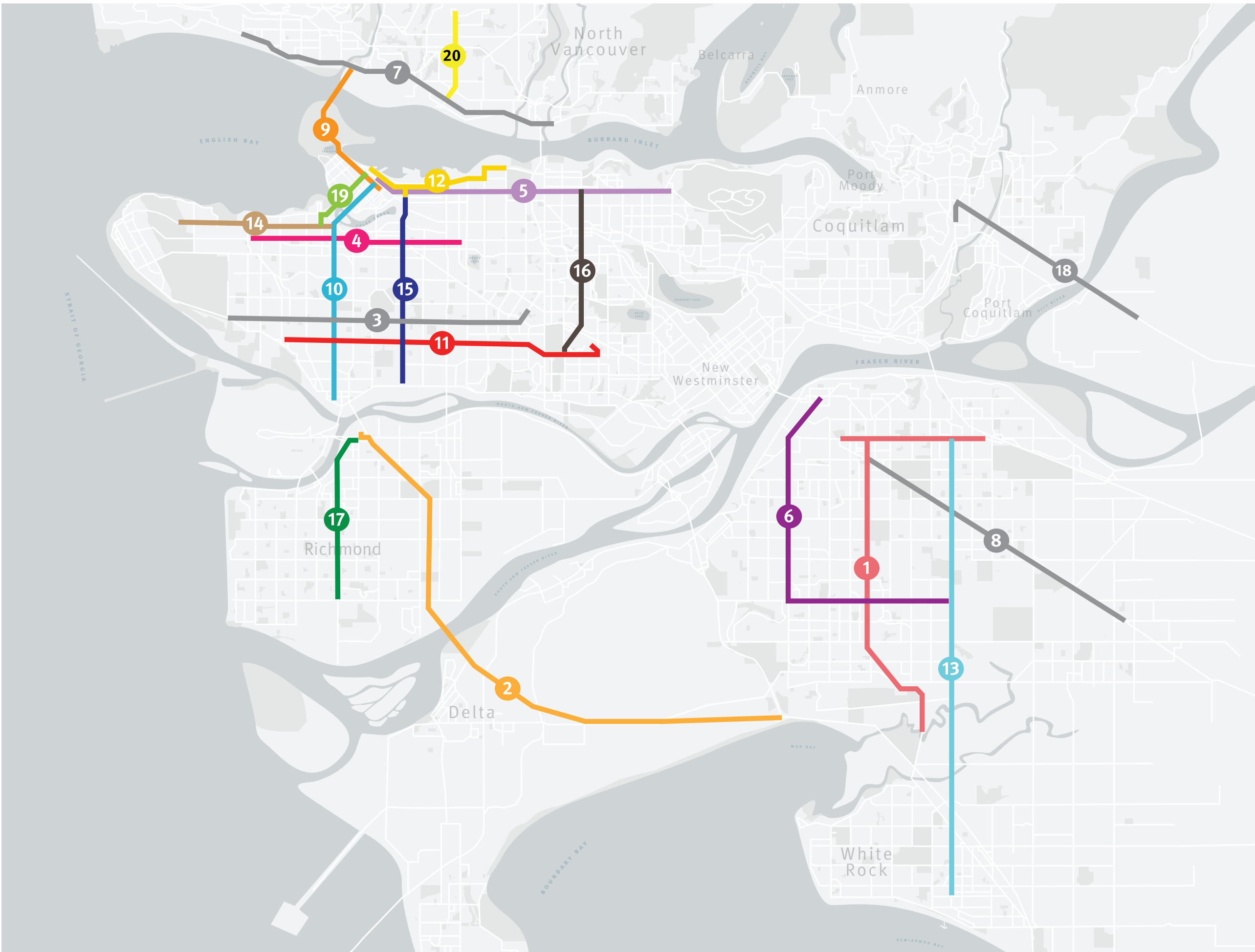
Maps illustrate bus speed (with colour) and variability (with thickness of line) between stops during the PM peak. Red represents the most critical areas of delay and thicker lines represent the least reliable of travel times.

Corridors are identified as potential candidates by analyzing **3 attributes of transit service quality**. In the analysis, a corridor is defined as a single segment or set of contiguous segments over which a common set of bus routes operate.

The 3 attributes of transit service quality are measured as:

1. **Travel Time** is estimated as the ratio of the average bus travel time on a corridor to a reference, or baseline, travel time. This ratio captures the amount of delay for a transit vehicle compared to the reference travel time.
2. **Reliability** is estimated as the ratio of the standard deviation of bus travel time on a corridor to a reference standard deviation. This measure captures the variability of bus service, with a lower value indicating less variation in the travel times. Both passengers and transit operators are negatively affected by variability in travel times.
3. **Passenger-Hours of Delay (PHD)** captures the amount of delay for bus passengers. This is calculated by using the travel time delay and multiplying it by the number of passengers on the bus. Bus vehicle delay is calculated as the difference between the actual travel time and the reference, or baseline, travel time.

Top 20 Corridors



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19 Burrard St
20 Lonsdale Ave

1 KING GEORGE BLVD/104 AVE

Corridor Description

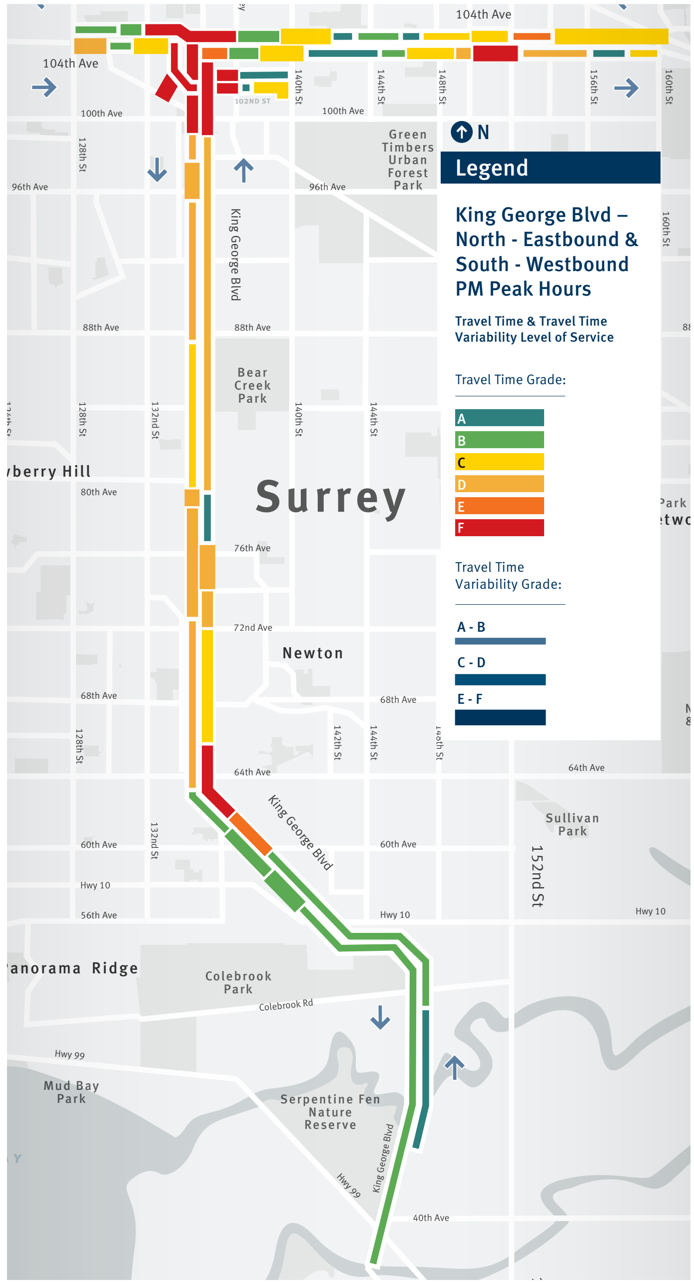
- The 96 B-Line links King George Blvd and 104 Ave as a single, continuous transit corridor. Segments of this corridor are served by other local bus lines.
- **Combined frequency of 13 – 15 buses/hour throughout the corridor.**
- This corridor connects Surrey's most populated urban town centers to key destinations such as downtown Surrey, City Hall, Surrey Memorial Hospital, SFU, and the Expo SkyTrain.
- At the heart of this corridor is Surrey Central Station where many of the busiest routes in Surrey and Langley originate or pass through. This area is a regional target for future growth. Bus access is—and will continue to be—critical.

Significance

- **More than 18% of bus journeys in Surrey begin on this corridor.** The performance of this corridor affects more than 44,000 transit customers each weekday.
- **Delays on this corridor affect the entire sub-region.** Delays affect transit between Surrey Central and Guildford, Newton, Fleetwood, South Surrey, Cloverdale, as well as the City of Langley and Township of Langley.
- **Transit priority has paid off.** Ridership on the 96 B-Line has more than doubled since its launch in 2013. To improve speed and reliability, the City of Surrey installed queue jumps and lane dedications on King George Blvd. In addition, TransLink introduced all-door boarding on the 96 B-Line in 2018 to reduce the amount of time spent boarding customers at bus stops.

Key Challenges

- Segments of King George Blvd and 104 Ave are narrow and constrained by development on either side.



Quick Facts *based on an average weekday within this corridor*

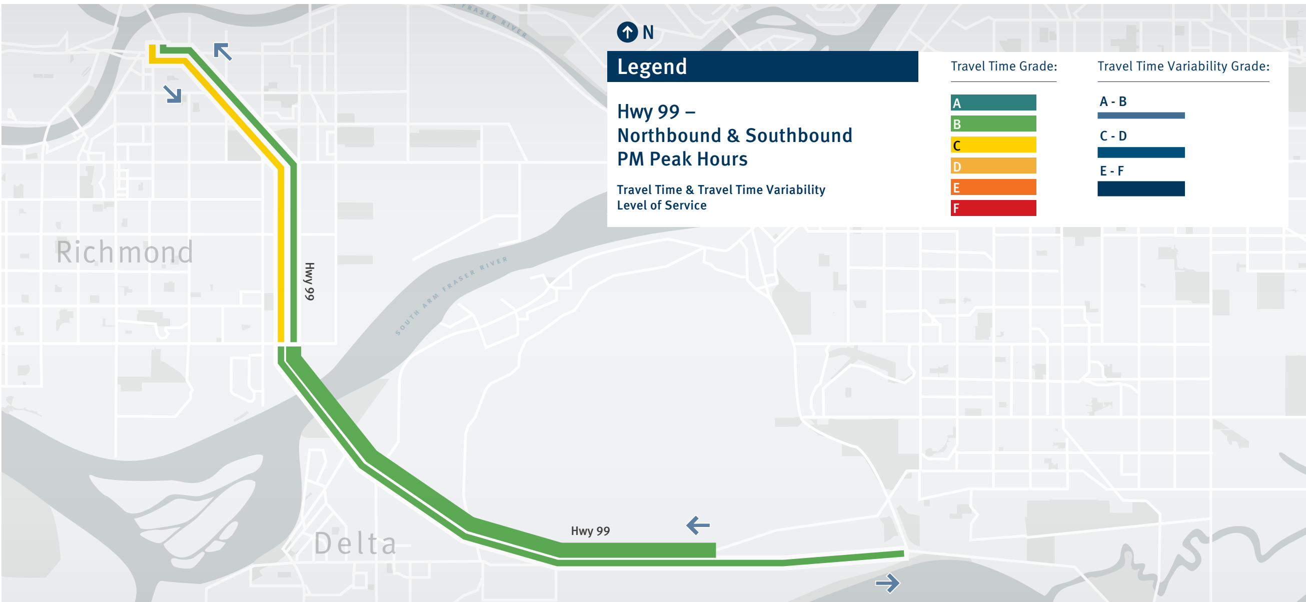
Length	19 km
Routes	96, 314, 320, 321, 326, 329, 337, 345, 393, 394, 501, 502, 503
Total Ridership *(all bus routes on corridor)*	61,300
Boardings/Alightings *(on corridor)*	23,500 / 24,100
Person-hours of Delay	872
Bus-hours of Delay	156

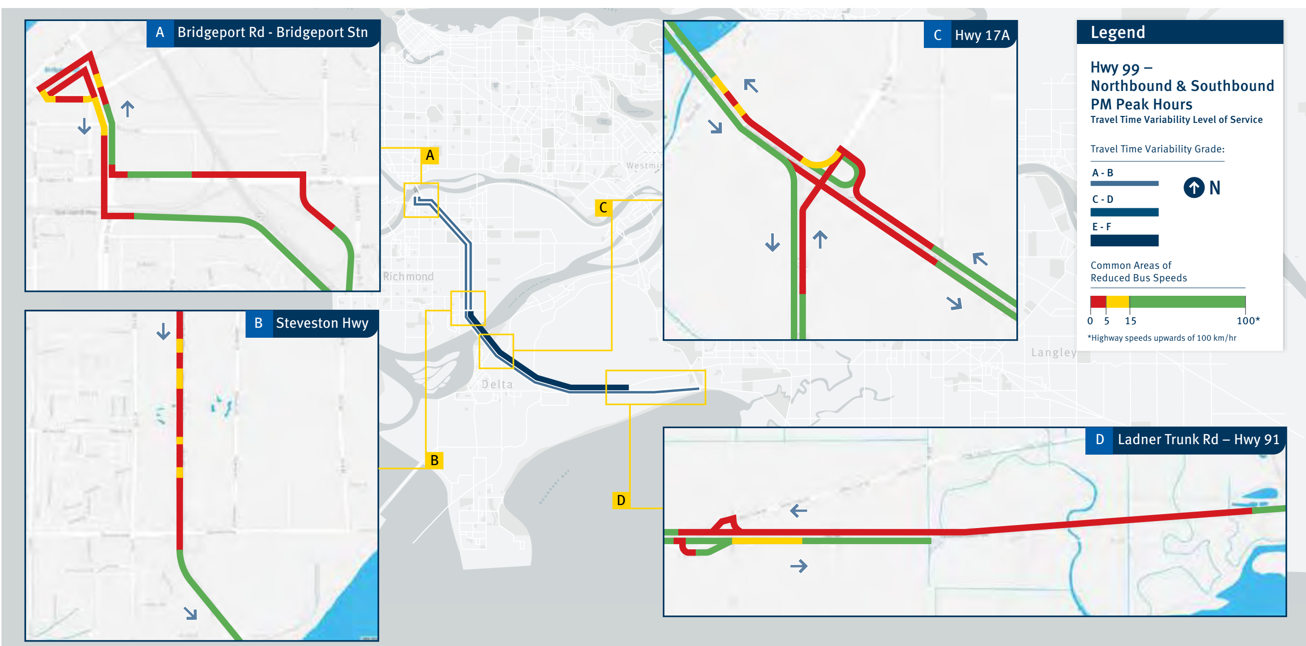
1 KING GEORGE BLVD/104 AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• SB King George Blvd at 72 Ave • NB King George Blvd at Old Yale Rd • NB King George Blvd at 102 Ave • NB King George Blvd at 104 Ave
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• NB King George Blvd at 88 Ave • NB/SB King George Blvd at 76 Ave
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB King George Blvd at 64 Ave • SB King George Blvd at 68 Ave • NB/SB King George Blvd at 72 Ave • SB King George Blvd at 80 Ave • SB King George Blvd at 84 Ave • SB King George Blvd from 98A Ave to Fraser Hwy • SB/NB University Dr surrounding Surrey Central Station • EB 104 Ave from 152 St to 156 St
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• EB Old Yale Rd in the 13500 Block includes bus stops at both nearside and farside of intersection

2 HWY 99





Quick Facts *based on an average weekday within this corridor*	
Length	24.4 km
Routes	311, 351, 352, 354, 601, 602, 603, 604, 620
Total Ridership *(all bus routes on corridor)*	15,900
Boardings/Alightings *(on corridor)*	7,400 / 7,600
Person-hours of Delay	772
Bus-hours of Delay	23

2 HWY 99

Corridor Description

- Hwy 99 is part of the Frequent Transit Network, connecting the Canada Line's Bridgeport Station to South Delta, North Delta, South Surrey, White Rock and Tsawwassen Ferry Terminal. Transit connections include Ladner Exchange, South Surrey Park & Ride and Scottsdale Exchange.
- Bus services on Hwy 99 have high average speeds, but are subject to high variability – with trips taking between 30 to 55 mins during peak periods. This is despite having bus-on shoulder lanes for much of the corridor.
- **Additional analysis was undertaken for this corridor due to its unique nature as a highway with speeds of upwards of 100km/hr and stop-to-stop spacing between 8 and 11 kilometres.** Localized delays analysis was undertaken to identify bottleneck sites between stops. This analysis, shows on a second map, represents common areas where bus speeds are recorded below 5 km/hr based on data received from bus GPS.
- **Combined 36 buses/hour.**

Significance

- **620 Tsawwassen Ferry/Bridgeport Station** experienced the largest numerical and percentage growth in Ladner/South Delta/Tsawwassen by 130,000 annual boardings (+15.3%).

Key Challenges

- Authorized use of HOV lanes by vehicles not meeting minimum occupancy requirements.
- Commercial vehicle operations during peak travel times.
- Conflicts between bus on shoulder lanes and merging traffic at exit and entry ramps.

Location of Common Causes of Transit Delay

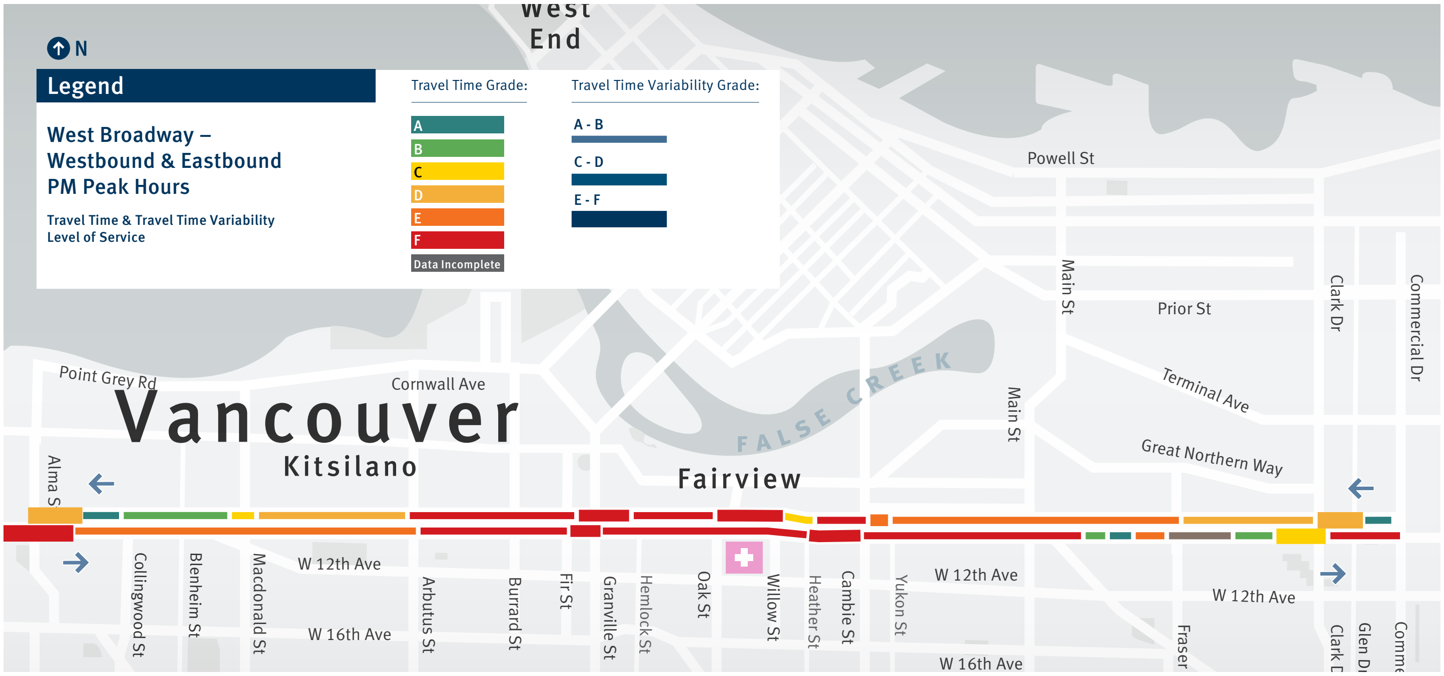
Issue	Key Locations
Delay to buses caused by motorists turning right	
Delays experienced by buses at offramps.	• SB Hwy 99 at Steveston Hwy • NB Hwy 99 off-ramp at Steveston Hwy • NB Hwy 99 off-ramp at Bridgeport Rd
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a "green wave." When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• EB/WB on Bridgeport between No 4 Rd and Bridgeport Station to connect Bridgeport Station to Hwy 99

2 HWY 99

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB/SB Hwy 99 between Ladner Trunk Rd and Hwy 91 • NB Hwy 99 off-ramp at Hwy 17A • SB Great Canadian Way between Bridgeport Rd Station and Sea Island Way to access Hwy 99 • NB Hwy 99 mixed traffic in HOV lane • WB Hwy 17A at 60 Ave approaching Hwy 99 • EB Hwy 17A at Hwy 99
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights. This affects transit customers at a few locations.	• Access to/from Ladner Exchange • SB Hwy 99 egress from Matthews Exchange
Delay to buses cause by HOV or bus-only lane violations	
Posted lane restrictions are not observed by unauthorized vehicles.	• SB Hwy 99 at Massey Tunnel

4 BROADWAY



Quick Facts *based on an average weekday within this corridor*	
Length	8.6 km
Routes	8, 9, 14, 16, 17, 99
Total Ridership *(all bus routes on corridor)*	148,100
Boardings/Alightings *(on corridor)*	81,400 / 82,600
Person-hours of Delay	641
Bus-hours of Delay	267

Corridor Description

- Broadway corridor connects north-south commercial streets and surrounding neighborhoods to key destinations like Vancouver City Hall, UBC, Vancouver General Hospital, and the Expo, Millennium and Canada Lines.
- Second largest employment corridor in British Columbia after the downtown Vancouver business district.

Significance

- **Broadway is a well-served and well-utilized transit corridor.**
  - 99 B-Line is the most heavily used bus route in Canada and the United States, serving almost 56,000 boardings per day.
  - A bus every 2 – 3 minutes during peak hours.
- **Performance of the Broadway corridor has an enormous impact on regionwide transit service.**
  - More than 15% of Vancouver bus boardings start in this corridor.
  - 50% of east-west person-throughput is on the bus.

Key Challenges

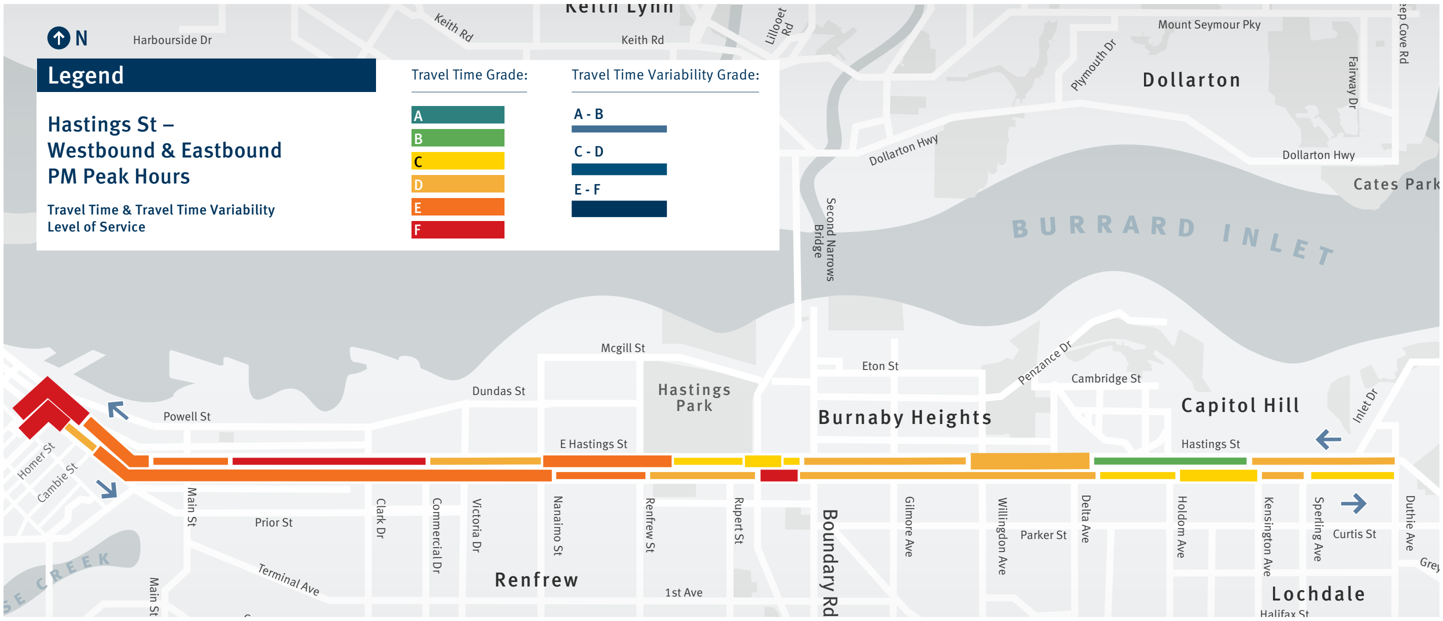
- Bus service will continue to be important leading up to, during, and after rail extension. During construction of the subway, bus service will play a critical role in maintaining access to key destinations and reducing automobile journeys through this corridor.
- The construction of the planned Broadway Subway will result in localized delays in the segment between Arbutus St and Main St. Broadway west of Arbutus St will continue to carry large numbers of bus riders after the Broadway Subway is complete.

4 BROADWAY

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
Where left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane. Where buses make left turns, lack of turn signals, short turn phases, or difficulty accessing turn lanes can lead to longer travel times and less reliable service.	• EB/WB Broadway from Arbutus St to Alma St
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• WB Broadway at Alma St • EB Broadway at Commercial Dr
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• EB/WB Broadway at Kingsway • EB/WB Broadway at Main St • EB/WB Broadway at Cambie St • WB Broadway at Hemlock St • EB Broadway at Granville St • EB Broadway at Arbutus St
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a "green wave." When traffic signals are uncoordinated or not timed for bus speeds, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• Between major intersections (e.g. Main St to Cambie St, Cambie St to Oak St, Oak St to Granville St, Granville St to Arbutus St)
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• Throughout the corridor, especially between Arbutus St and Kingsway midday and weekends
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• Throughout the corridor, e.g. EB Broadway between Ontario St and Prince Edward St

5 HASTINGS ST



Quick Facts *based on an average weekday within this corridor*	
Length	13 km
Routes	3, 8, 14, 16, 20, 28, 95, 129, 130, 131, 132, 134, 160
Total Ridership *(all bus routes on corridor)*	162,500
Boardings/Alightings *(on corridor)*	43,500 / 48,700
Person-hours of Delay	583
Bus-hours of Delay	218

Corridor Description

- Major journey generators:
  - Two SFU campuses (Burnaby Mountain and Downtown Vancouver)
  - Downtown Vancouver
  - Neighborhoods and commercial districts in between.
- This is the northernmost continuous east-west arterial across Vancouver, Burnaby, and a direct connection to Barnet Hwy (extending further east to Port Moody, Coquitlam, Port Coquitlam, Maple Ridge, Pitt Meadows, and beyond) and Hwy 1 (extending to the City of North Vancouver, District of North Vancouver). As such, Hastings is both a major commuting corridor and a connection to neighborhood-oriented goods and services.
- Many local bus routes serve segments of the corridor, continuing to other locations. This results in very high frequency of service and access to a broader range of destinations, including the Northeast Sector and North Shore.
- Both standard and trolley buses use this corridor. This leads to issues with trolley buses being unable to pass or reroute due to unforeseen delays.

Significance

- **Hastings is a well-served and well-utilized transit corridor.**
  - 95 B-Line and 130 are the first and second most heavily used bus routes in Burnaby, respectively.
  - Bus routes on this corridor combine to provide 23 buses/hour or a bus arriving roughly every 2 - 2.5 minutes during peak hours.
- **Performance of the Hastings corridor has an enormous impact on regionwide transit service.**
  - More than 7.4% of Vancouver and Burnaby buses begin or end in this corridor.
  - 15.7% of all Metro Vancouver customers traveling by bus use a bus that travels on the Hastings corridor. In other words, one in seven people traveling by bus in Metro Vancouver is affected by the performance of Hastings.

5 HASTINGS ST

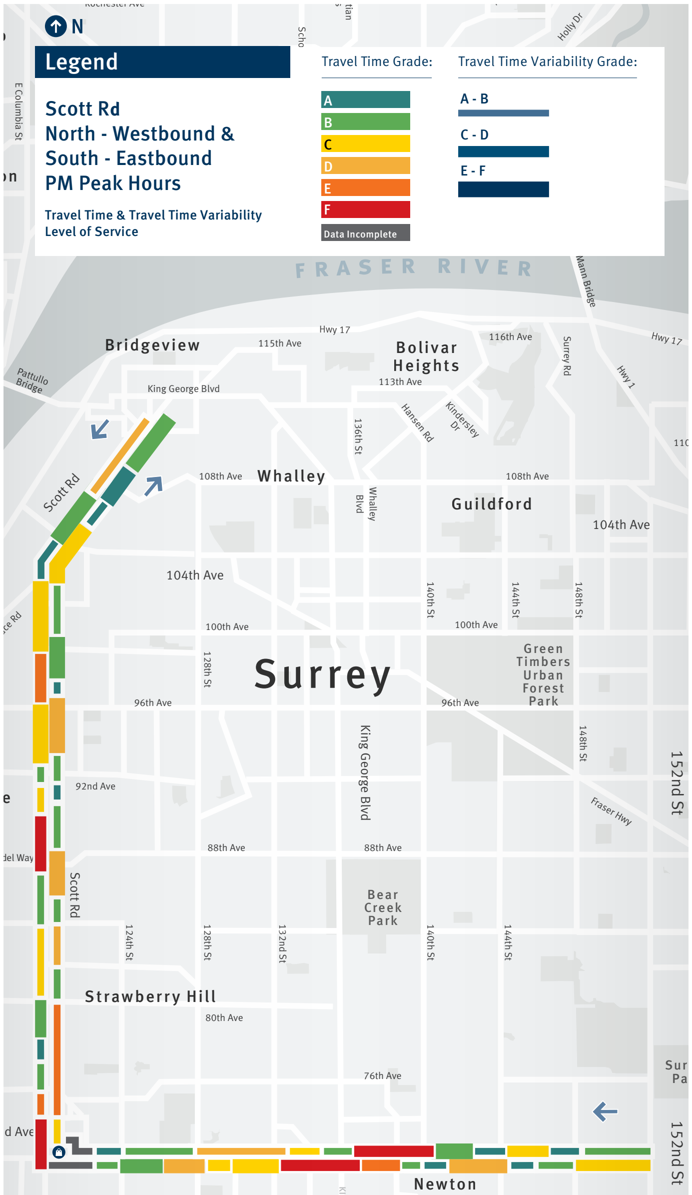
Key Challenges

- **Bottleneck at Hwy 1 affects the entire corridor.** Westbound Hastings between Boundary and Hwy 1 is a critical bottleneck to the North Shore (130) and Downtown Vancouver. Lines 95 and 130 occasionally must undertake significant multi-block detours to avoid congestion on Hastings in this segment.
- Unauthorized use of HOV lanes by vehicles not meeting minimum occupancy requirements.
- **Transit priority is paying off.** Extending the hours of bus-only lanes by 30-minutes in the morning and 60-minutes in the evening has had significant benefits to transit travel time. However, the weekends as well as midday and early afternoon continues to be a source of significant delay for thousands of transit customers traveling to, from, through, and within this corridor.

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• EB/WB Hastings St at Nanaimo St • WB Hastings St at Cambie St
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• WB Hastings St at Granville St
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• WB Hastings St at Cassiar Connector • EB Hastings St at Granville St • EB/WB Hastings St at Nanaimo St • Buses turning right at NB Granville St at Hastings St • Buses turning right at WB Hastings St at Seymour St
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a "green wave." When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• EB/WB Hastings from Main St to Seymour St
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• WB Hastings from Boundary Rd to Cassiar Connector • EB Hastings from Kootenay St to Boundary Rd • EB Hastings from Clark Dr to Nanaimo St • EB Hastings from Carrall St to Boundary Rd • EB/WB Hastings from Boundary Rd to Duthie Ave • WB Hastings from Carrall St to end of line

6 SCOTT RD/72 AVE



Quick Facts *based on an average weekday within this corridor*

Length	16 km
Routes	96 (at Newton Exchange), 301, 310, 311, 312, 314, 319, 322, 324, 329, 341, 342, 355, 391, 393, 640
Total Ridership *(all bus routes on corridor)*	72,500
Boardings/Alightings *(on corridor)*	13,700 / 16,200
Person-hours of Delay	535
Bus-hours of Delay	112

Corridor Description

- Line 319 serves Scott Rd and 72 Ave as a single, continuous transit corridor. Several other bus routes serve smaller segments of this corridor.
- Bus routes on this corridor combine to offer 10 – 17 buses/peak hour.
- Corridor links Newton, Strawberry Hill, North Delta and provides connections to shopping centers, Kwantlen, Scott Road Station and bus exchanges.

Significance

- **Significant growth and overcrowding.**
  - Line 319 is the 11th most heavily used bus line in Metro Vancouver.
  - In 2018, Line 319 experienced the second largest numerical growth of all bus routes in the network, adding 1.2 million annual boardings (+23.6%).
- **Future RapidBus corridor.**
  - Funded through the Phase Two Investment Plan. Planning for this line will be undertaken jointly with Delta and Surrey.

Key Challenges

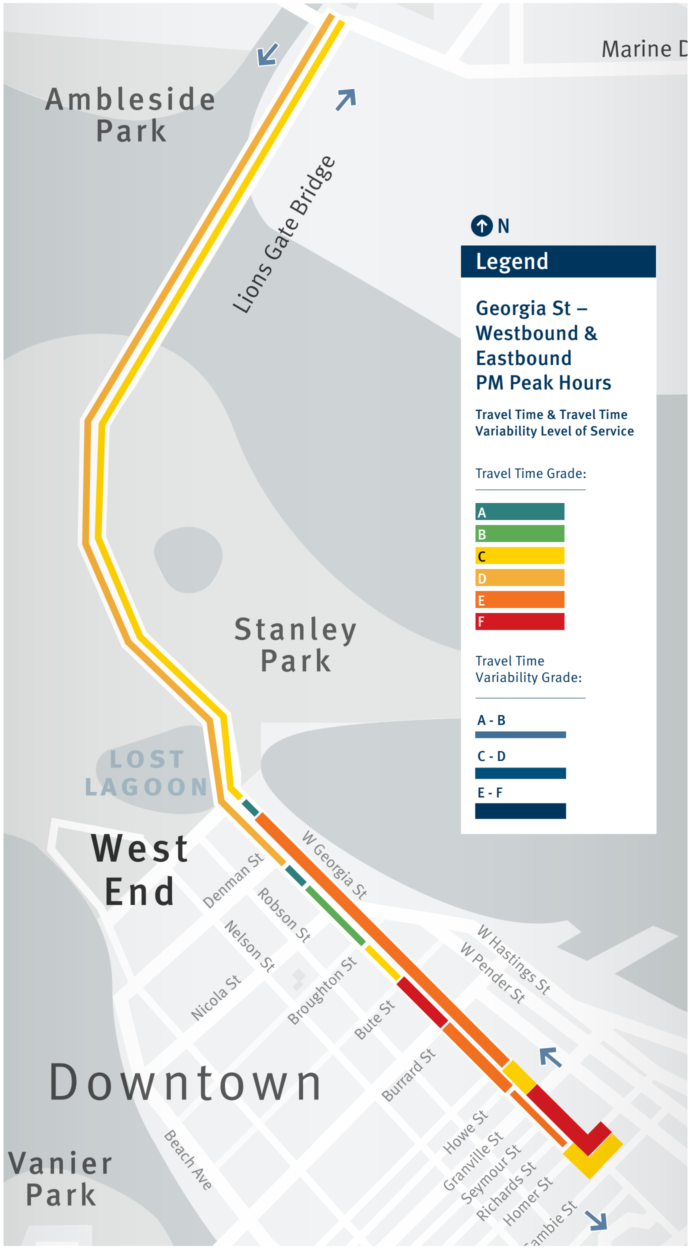
- Scott Rd and 72 Ave are both narrow streets.
- Scott Rd is characterized by malls and businesses with large parking lots and multiple driveways.
- The street network east and west of Scott Rd is somewhat discontinuous and as a result, the intersections at the main cross streets have substantial turn movements, resulting in wider intersections and longer traffic signals.

6 SCOTT RD/72 AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• SB 122 St at 72 Ave
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• SB Scott Rd at Mall Access to Scottsdale Exchange Bus Loop • SB 122 St at 72 Ave • NB 137 St at 72 Ave
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• SB Scott Rd from 92 Ave to 88 Ave • SB Scott Rd at 74a
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• EB/WB 72 Ave from 120 St to Newton Exchange • EB/WB 72 Ave at 128 St • EB/WB 72 Ave at 132 St • NB Scott Rd at 74 Ave • NB Scott Rd at 80 Ave • NB Scott Rd at 84 Ave • NB/SB Scott Rd at 86 Ave • NB/SB Scott Rd at Nordel • SB Scott Rd at 92 Ave • NB/SB Scott Rd at 96 Ave
Delay to buses caused by re-entering traffic from bus stop	
Bus stop design can affect how quickly and easily buses are able to pull into and out of bus stops. This impacts on travel time and reliability.	• SB Scott Rd from 96 Ave to Nordel
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• Throughout corridor • SB Scott Rd at 96 Ave (nearside stop)

9 W GEORGIA ST/LIONS GATE BRIDGE



Quick Facts *based on an average weekday within this corridor*	
Length	6.6 km
Routes	240, 241, 242, 246, 247, 250, 253, 254, 257, 258
Total Ridership *(all bus routes on corridor)*	33,200
Boardings/Alightings *(on corridor)*	14,400 / 15,800
Person-hours of Delay	481
Bus-hours of Delay	77

Corridor Description

- Georgia St and the Lions Gate Bridge provide key bus service connections between downtown and the North Shore.
- Bus routes on this corridor combine to offer 15-35 buses/hour at peak times throughout most of the corridor.
- Many of the bus routes between Vancouver and the North Shore exhibited double-digit growth in 2018 (e.g. Line 240 grew by 12.7%; Line 257 grew by 16.7%).

Significance

- **One out of every three to five people traveling this corridor are on the bus.** Depending on time of day and direction, 20 – 33% of people traveling on the Lions Gate Bridge and W Georgia St are traveling by bus, generating less than 1% of the vehicle traffic.

Key Challenges

- Bus priority and parking restrictions are currently time limited. WB Bus and HOV 3+ lane operates from 3-7pm; however high demand for services outside of traditional peak periods, such as during special events, leaves buses vulnerable to delay.
- Increasing presence of electric vehicles in Bus and HOV 3+ lane.

9 W GEORGIA ST/LIONS GATE BRIDGE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• WB W Georgia St St at Denman St (AM)
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• EB W Georgia St at Denman St • EB W Georgia St at Howe St • EB W Georgia St at Burrard St • EB W Georgia St at Granville St • WB W Georgia St at Burrard St • WB W Georgia St at Bute St • WB W Georgia St at Cardero St

10 GRANVILLE ST

Quick Facts *based on an average weekday within this corridor*

Length	9.7, km
Routes	4, 7, 10, 14, 16, 17, 20, 50, 480
Total Ridership *(all bus routes on corridor)*	126,300
Boardings/Alightings *(on corridor)*	31,700 / 31,900
Person-hours of Delay	449
Bus-hours of Delay	143

Corridor Description

- **Major north-south transportation corridor.** Granville St is the extension of Hwy 99 and the westernmost north-south arterial, continuing south of Vancouver to Sea Island, Vancouver International Airport, and Richmond.
- **Major retail.** South Granville is an uptown shopping area with street-facing retail, on-street parking, high numbers of pedestrians, several key east-west cycling routes, and traffic signals at nearly every cross street.

Significance

- **Frequent corridor.** South of Broadway, bus every 5 minutes in the AM peak; within downtown Vancouver, 35 – 55 buses/hour (southbound and northbound, respectively).
- **7% of bus journeys in Vancouver begin or end on this corridor.**

Key Challenges

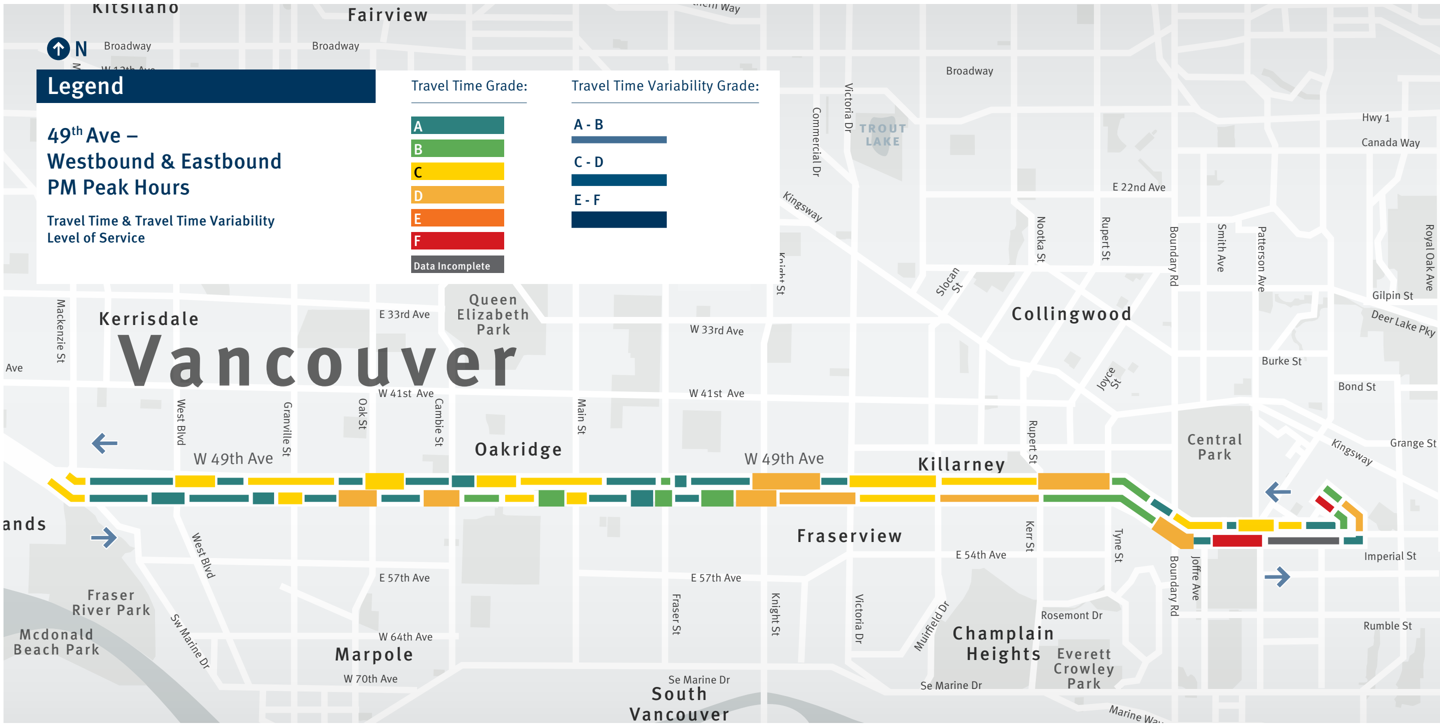
- Delays occur most in the commercial areas of Marpole, South Granville and Downtown.
- Trolley buses must follow each other and are unable to pass or reroute if unforeseen delays occur.
- High volumes of boardings, alightings, and transfers to SkyTrain downtown result in slower bus speeds.

10 GRANVILLE ST

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• NB Granville St from W 62nd Ave to W 57th Ave (turning restrictions only during AM Peak)
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• NB Granville St at King Edward Ave (GP cars turning right delay bus movement)
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a “green wave.” When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• NB/SB Granville St at W 70th Ave • NB/SB Granville St at W 41st Ave delay due to high east-west traffic crossing. • NB/SB Granville St at King Edward Ave delays from GP traffic turning left onto KE, reduces lane capacity) • NB Granville St at Park Dr has reduced signal timing due to SB advance left turn phase.
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB/SB Granville St from W 16th Ave to Granville St Bridge • NB Granville St from W 71st Ave to W 64th Ave
Delay to buses caused by re-entering traffic from bus stop	
Bus stop design can affect how quickly and easily buses are able to pull into and out of bus stops. This impacts on travel time and reliability.	• NB Granville St from W 71st Ave to W 64th Ave
Pedestrian Access/Safety	
High pedestrian demand activates crosswalk.	• NB Granville St at King Edward Ave (neighbourhood schools increase pedestrian activity after 14:00)
Delay to buses cause by HOV or bus-only lane violations	
Posted lane restrictions are not observed by unauthorized vehicles.	• NB/SB Granville Mall between Hastings St and Smithe St used by unauthorized vehicles.

11 49TH AVE



Quick Facts	*based on an average weekday within this corridor*
Length	10.8 km
Routes	49, 430
Total Ridership *(all bus routes on corridor)*	35,300
Boardings/Alightings *(on corridor)*	30,300 / 29,000
Person-hours of Delay	436
Bus-hours of Delay	101

Corridor Description

- 49th Ave is served by Lines 49, and 430, connecting the Expo and Canada Line, Langara, and UBC, as well as multiple elementary and secondary schools, and local destinations across South Vancouver and Southwest Burnaby.
  - These lines combine to provide 12 - 15 buses/hour.

Significance

- **Route 49 is a major transit corridor,** served by the second busiest bus route in the region behind the 99 B-Line with 9.3 million annual boardings.
  - **More than 17% growth of annual boardings on 49 Metrotown Station/UBC** from 2017 to 2018. The largest numerical growth in the entire bus network by 1,366,000 annual boardings.
  - 5.7% of bus journeys in Vancouver and Burnaby begin on 49th Ave corridor.

Key Challenges

- Narrow corridor.
- Heavy demand for left and right turns at intersections.

11 49TH AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane. The resulting congestion affects buses at several locations on 49th Ave.	• EB/WB 49th Ave at Granville St • EB/WB 49th Ave at Main St • EB/WB 49th Ave at Fraser St • EB/WB 49th Ave at Victoria Dr • WB 49th Ave at Kerr St • EB/WB 49th Ave at Boundary Rd
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules. Delay at left-turns affects buses at a few locations on 49th Ave.	• EB/WB Imperial St at Willingdon Ave • SB Dunbar St at SW Marine Dr
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase. The resulting congestion affects buses at a few locations on 49th Ave.	• WB 49th Ave at Cambie St • EB/WB 49th Ave at Oak St
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a “green wave.” When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules. Delay caused by traffic signal coordination affects buses primarily in two long segments.	• EB 49th Ave from Oak St to Main St • WB 49th Ave from Main St to Alberta St
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• WB 49th Ave from Arlington St to Tyne St • WB 49th Ave from Victoria Dr to Knight Dr • WB 49th Ave from McKinnon St to Kerr St • EB 49th Ave from Fraser St to Knight St • EB 49th Ave from Arlington St to Boundary Rd • EB 49th Ave from Marguerite St to Granville St • EB 49th Ave from Argyle St to Victoria Dr • EB/WB 49th Ave at Knight St • EB 49th Ave from Vivian St to Kerr St

11 49TH AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses caused by re-entering traffic from bus stop	
Bus stop design can affect how quickly and easily buses are able to pull into and out of bus stops. The resulting impacts on travel time and reliability are observed at a few locations on 49th Ave.	• WB 49th Ave at Blenheim St • WB 49th Ave from Macdonald St to Dunbar St
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• EB 49th Ave at Fredrick St and Fraser St • WB 49th Ave at Chester St and Fraser St • WB 49th Ave at Victoria Dr

12 PENDER/POWELL/CORDOVA/DUNDAS/MCGILL

Quick Facts *based on an average weekday within this corridor*	
Length	8.6 km
Routes	4, 5, 7, 10, 17, 19, 22, 209, 210, 211, 214
Total Ridership *(all bus routes on corridor)*	100,000
Boardings/Alightings *(on corridor)*	11,700 / 19,500
Person-hours of Delay	405
Bus-hours of Delay	137

Corridor Description

- Critical connection between North Shore, East Vancouver neighborhoods, and Downtown Vancouver.
- Shares corridors with commercial traffic related to Port of Vancouver and Hwy 1 access.

Significance

- **10% of bus riders in Metro Vancouver use a bus that travels on this corridor.** In other words, one in ten bus riders in Metro Vancouver is affected by the performance of this corridor.
- Affects 7,760 people traveling to or from the North Shore each weekday.

Key Challenges

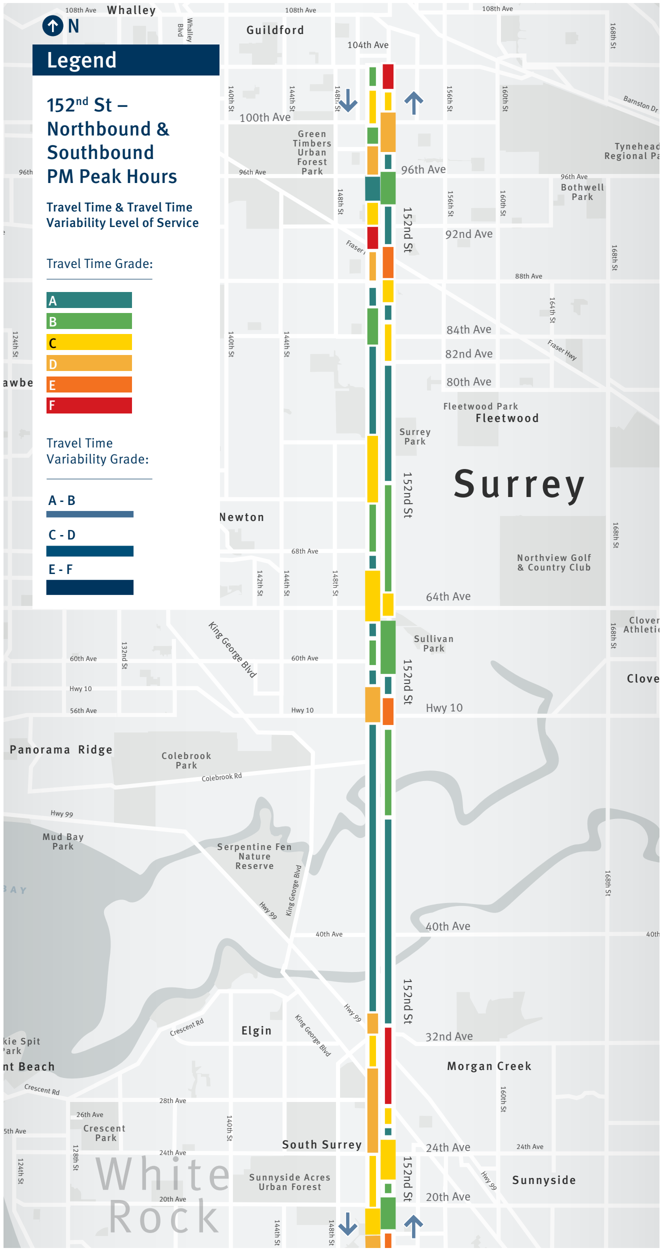
- This corridor is composed of many streets, most of them are narrow streets, two lanes in each direction with on-street parking most of the day and no turn lanes.
- **Transit travel time doubles during rush hour.** Major bottleneck is between Powell/Clark and Nanaimo/Dundas during afternoon rush hours. Travel time for transit customers through this segment increase from about 6 minutes (midday) to more than 12.5 minutes (PM peak).

12 PENDER/POWELL/CORDOVA/DUNDAS/MCGILL

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• EB W Georgia St to Pender St • EB Pender St at Main St • WB Powell St at Main St • EB Dundas St at Nanaimo St
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• EB Pender St at Burrard St • WB Pender St at Main St
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• WB Pender St from Bute St to W Georgia St, especially during PM peak • From EB Powell St at Clark Dr to McGill St at Renfrew St
Delay to buses cause by HOV or bus-only lane violations	
Posted lane restrictions are not observed by unauthorized vehicles.	• EB/WB Pender St from Cambie St to Seymour St • Delay to through-movements of buses due to unauthorized vehicles making left or right-turns from EB Pender St onto NB/SB Granville St.
Overhead trolley wire	
Trolley buses are unable to pass one another due to lack of bypass wire.	• WB W Cordova St at Main St

13 152ND ST



Corridor Description

- Connecting **the regional town centre of Guilford to White Rock**. 152nd St is one of 2 major north-south connectors between north and south Surrey.
- **Combined frequency of 6-19 buses/hour throughout the corridor,** with the highest frequencies at the merger of transit services in the Semiahmoo Town Centre.

Significance

- More than 17% of people traveling by bus in Surrey and White Rock travel on this corridor.
- Half of the routes along this corridor received service improvements in 2018.
- Delays along the southern portion of this corridor affect services on Hwy 99 that connect the Semiahmoo peninsula to the Canada Line.

Key Challenges

- Three quarters of the routes in the South of Fraser had double digit percentage ridership growth in 2018 (40/53 routes). This is a large increase for any bus route, let alone multiple bus routes, and it surpassed the regionwide bus growth rate of 8.0%.
- This corridor has a narrow roadway that carries heavy vehicle volumes as one of the few contiguous north-south roadways in Surrey, and key connections to Hwy 1 and Hwy 99. It also sees significant turn volumes at major intersections.

Quick Facts *based on an average weekday within this corridor*

Length	18 km
Routes	320, 321, 335, 341, 345, 351, 354, 363, 375, 394, 531
Total Ridership *(all bus routes on corridor)*	43,500
Boardings/Alightings *(on corridor)*	6,600 / 5,800
Person-hours of Delay	378
Bus-hours of Delay	69

13 152ND ST

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• NB 152nd St at 18th Ave
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• NB 152nd St from 101 to 104th Ave
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB/SB 152nd St at King George Blvd • NB/SB 152nd St at 32nd Ave • NB/SB 152nd St at 64th Ave • NB 152nd St at 68th Ave • NB 152nd St from 82 Ave to 88th Ave • SB 152nd St from Fraser Hwy to 88th Ave • NB 152nd St at 94th Ave (AM) • NB 152nd St at 96th Ave • SB 152nd St from 104th Ave to 96th Ave
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights. This affects transit customers at a few locations.	• NB/SB 152nd St between Fraser Hwy and 96th Ave

14 WEST 4TH AVE

Quick Facts *based on an average weekday within this corridor*	
Length	7.4 km
Routes	4, 7, 32, 42, 44, 84, 258
Total Ridership *(all bus routes on corridor)*	42,400
Boardings/Alightings *(on corridor)*	11,990 / 11,480
Person-hours of Delay	303
Bus-hours of Delay	63

Corridor Description

- West 4th Ave connects Dunbar, Kitsilano and West Point Grey with Downtown, and UBC. It also provides transit connections to Canada and Millennium Lines.
- **Bus routes provide a combined 20-24 buses/hour** along the corridor.

Significance

- **8.8% of customers traveling by bus in Vancouver use buses that travel through this corridor.** In other words, about one in twelve bus riders in Vancouver are affected by the performance of this corridor.

Key Challenges

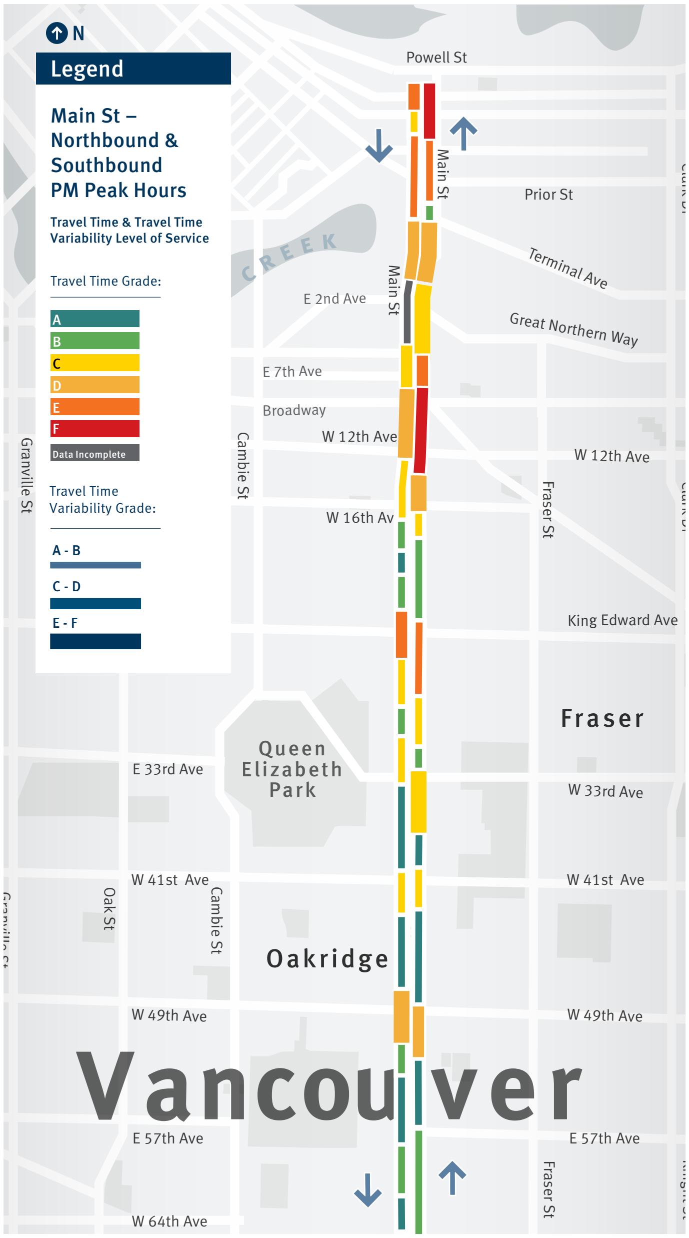
- The corridor has extensive commercial areas featuring on-street parking, higher densities of traffic signals, and pedestrian activity, all of which contribute to localized congestion. These activities and associated bus delays are particularly high on weekends.
- Portions of West 4th Ave have six lanes; but the two median lanes are often taken up by left turns, and the curb lanes by parking; this means buses pulling out of stops are sometimes trapped by vehicles using the one practical through lane – one out from the curb.

14 WEST 4TH AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• Throughout the corridor • WB 4th Ave at Alma St • WB 4th Ave from Vine St (Safeway) to Balsam St • EB/WB 4th Ave at Macdonald St
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• Throughout the corridor • EB 4th Ave from Balsam St to Vine St (Safeway)
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit. Parallel parking movements exacerbate roadway congestion.	• Throughout the corridor • NB Fir St from bus loop to 4th Ave • WB 4th Ave from Fir St to Burrard St
Delay to buses caused by re-entering traffic from bus stop	
Bus stop design can affect how quickly and easily buses are able to pull into and out of bus stops. This impacts on travel time and reliability.	• EB 4th Ave at Burrard St • EB 4th Ave at Maple St • EB/WB 4th Ave at Alma St • EB/WB 4th Ave at Bayswater St • EB/WB 4th Ave at Trafalgar St • EB/WB 4th Ave at Balsam St • EB/WB 4th Ave at Vine St • EB/WB 4th Ave at Arbutus St • WB 4th Ave at Collingwood St • WB 2nd Ave at Main St
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• WB 2nd Ave at Cambie St and Ash St • EB 4th Ave at Collingwood St and Waterloo St

15 MAIN ST



Quick Facts *based on an average weekday within this corridor*

Length	8 km
Routes	3, 8, 19, 22 (off-peak)
Total Ridership *(all bus routes on corridor)*	55,500
Boardings/Alightings *(on corridor)*	25,500 / 23,600
Person-hours of Delay	284
Bus-hours of Delay	105

Corridor Description

- Main St connects several Vancouver commercial areas including Downtown East and Mount Pleasant, Little Mountain, and South Vancouver.
- Major north-south connection between Downtown Vancouver/Chinatown, the Expo Line, and South Vancouver.
- Bus lines combine to offer 9 buses/hour south of Broadway and 24-28 buses/hour north of Broadway where multiple trolley routes converge.
- Many of the bus stops along this corridor already benefit from curb bulges, which reduces the need for buses to leave and re-enter traffic.

Significance

- 7.3% of bus journeys in Vancouver begin in this corridor.
- Performance of this corridor affects more than 11% of bus riders in the City of Vancouver.

Key Challenges

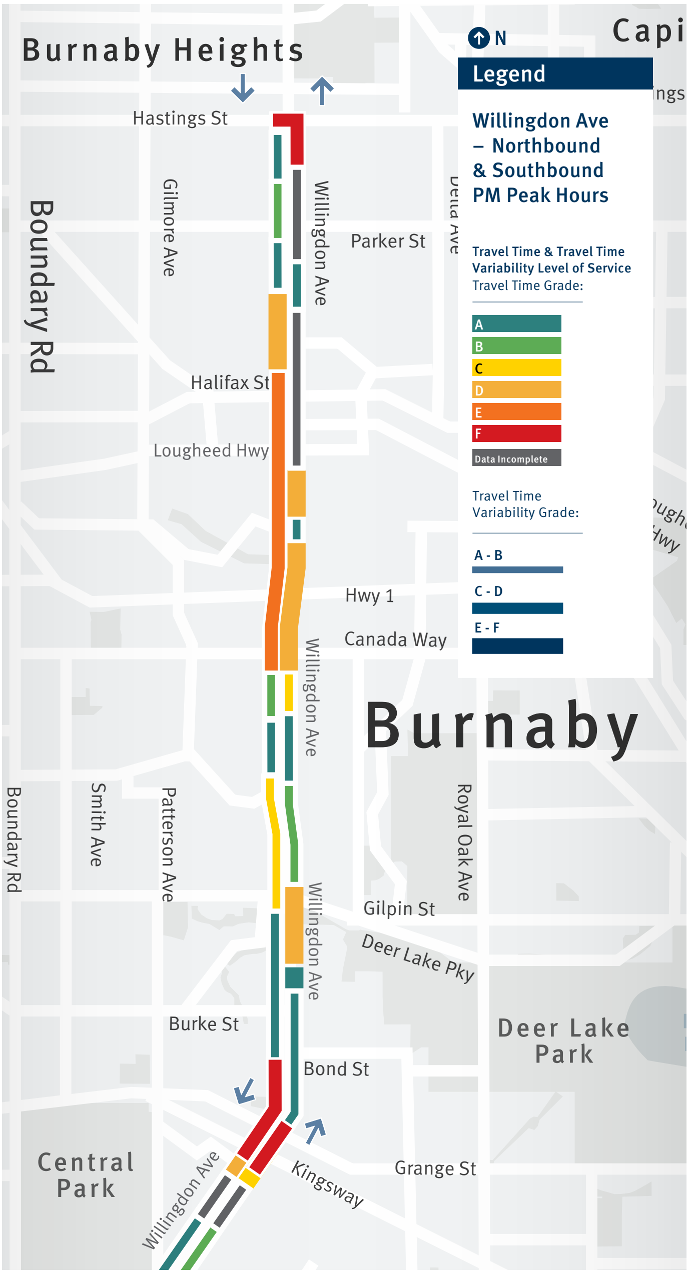
- North of Broadway, transit vehicles face high vehicle volumes and congestion, particularly at Terminal and at the Georgia St Viaducts.
- The corridor is served by multiple, high-frequency trolley routes. As these buses cannot pass each other, delays experienced can have ripple effects.

15 MAIN ST

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• EB Marine Dr at Main St • NB Main St at 49th Ave • NB Main St at Pender St • NB Main St at Hastings St
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• NB/SB Main St at 49th Ave • NB Main St at 33rd Ave • NB Main St at King Edward Ave • NB Main St at 12th Ave • NB Main St at Broadway • NB Main St at Terminal Ave
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a "green wave." When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• Pedestrian-activated signals do not appear to be in sync with adjacent signals
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB Main St from 16th Ave to 8th Ave • NB Main St from 2nd Ave to Terminal Ave • NB Main St from Prior St to Union St
Delay to buses caused by re-entering traffic from bus stop	
Bus stop design can affect how quickly and easily buses are able to pull into and out of bus stops. This impacts on travel time and reliability.	• NB Main St at 28th • NB Main St from Broadway Ave to 5th Ave
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• NB/SB Main St at Terminal Ave and National Ave • NB Main St at 5th Ave and 6th Ave
Overhead Trolley Wire	
Lack of passing wire to allow trolley buses to pass one another at stops	• NB/SB Main St St between Kingsway and Hastings St

16 WILLINGDON AVE



Corridor Description

- This key north-south Burnaby corridor connects Burnaby Heights to Metrotown, via Brentwood and BCIT.
- **Combined frequencies of 20-27 buses/hour**

Significance

- Line 130 has the 2nd highest boardings in Burnaby; Line 25 has the 5th most boardings in Burnaby.
- **9.7% of all bus journeys in Burnaby begin on the Willingdon corridor.**

Key Challenges

- Traffic signal coordination.
- Increasing presence of electric vehicles in Bus and HOV 3+ lane.

Quick Facts *based on an average weekday within this corridor*

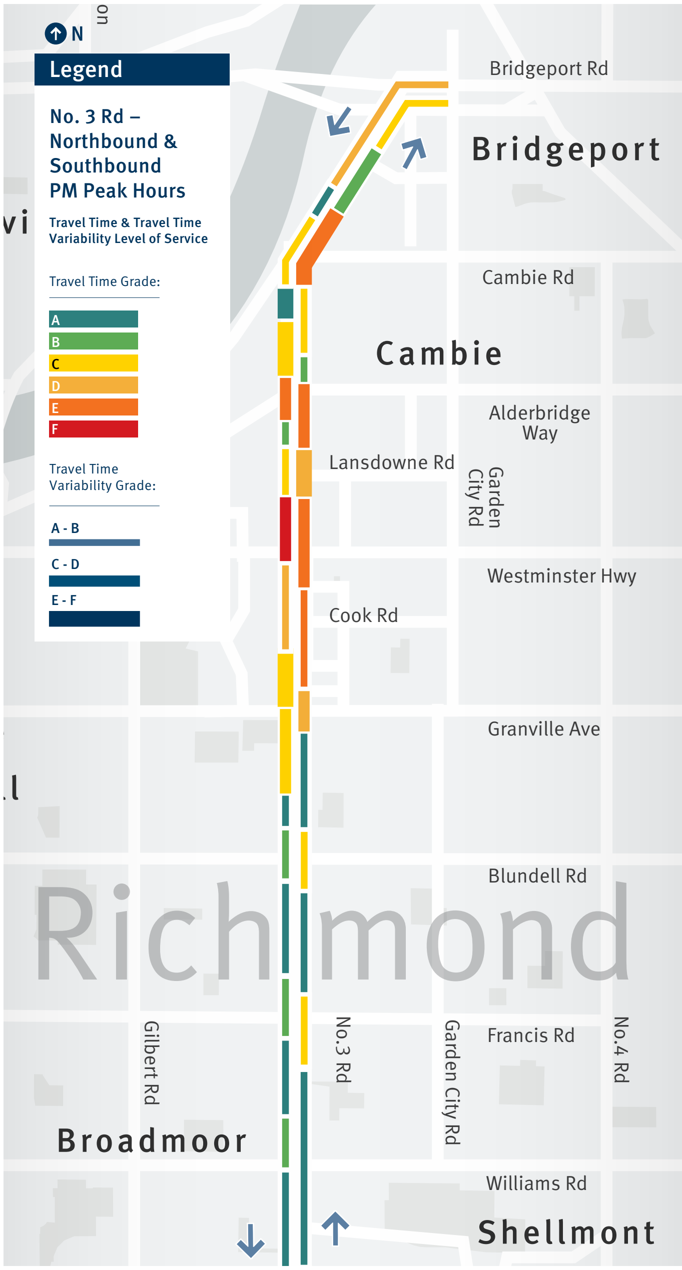
Length	6.6 km
Routes	19, 25, 110, 123, 125, 130, 146, 147
Total Ridership *(all bus routes on corridor)*	52,800
Boardings/Alightings *(on corridor)*	10,000 / 10,000
Person-hours of Delay	261
Bus-hours of Delay	92

16 WILLINGDON AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• NB/SB Willingdon Ave at Goard Way • NB/SB Willingdon Ave at Dawson St • NB/SB Willingdon Ave at Parker St
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• NB Willingdon Ave at Hastings St
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• SB Willingdon Ave at Halifax St • SB Willingdon Ave at Kingsway • SB Willingdon Ave at Parker St • NB/SB Willingdon Ave at Lougheed Hwy
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a "green wave." When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• NB/SB Willingdon Ave at Francis St • NB/SB Willingdon Ave at Union St • NB/SB Willingdon Ave at William St • NB/SB Willingdon Ave at Kitchener St
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB/SB Willingdon Ave from Canada Way to Lougheed Hwy
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• NB/SB Willingdon at Lougheed Hwy

17 NO 3 RD



Quick Facts *based on an average weekday within this corridor*

Length	6.8 km
Routes	401, 402, 403, 404, 405, 406, 407, 408, 410, 414, 416, 430
Total Ridership *(all bus routes on corridor)*	66,900
Boardings/Alightings *(on corridor)*	13,000 / 13,000
Person-hours of Delay	248
Bus-hours of Delay	88

Corridor Description

- No 3 Rd is the key north-south corridor and connects Richmond city centre to several commercial areas, as well as to other neighbourhoods across Richmond.
- Provides local bus connections to the Canada Line, Kwantlen Polytechnic University, and Richmond City Hall.

Significance

- Almost a quarter of all bus journeys in Richmond begin on this corridor.
- Combined over **61 buses/hour** at Bridgeport Station during the peak.
- Nearly **10% growth in boardings** on route 403 in 2018.

Key Challenges

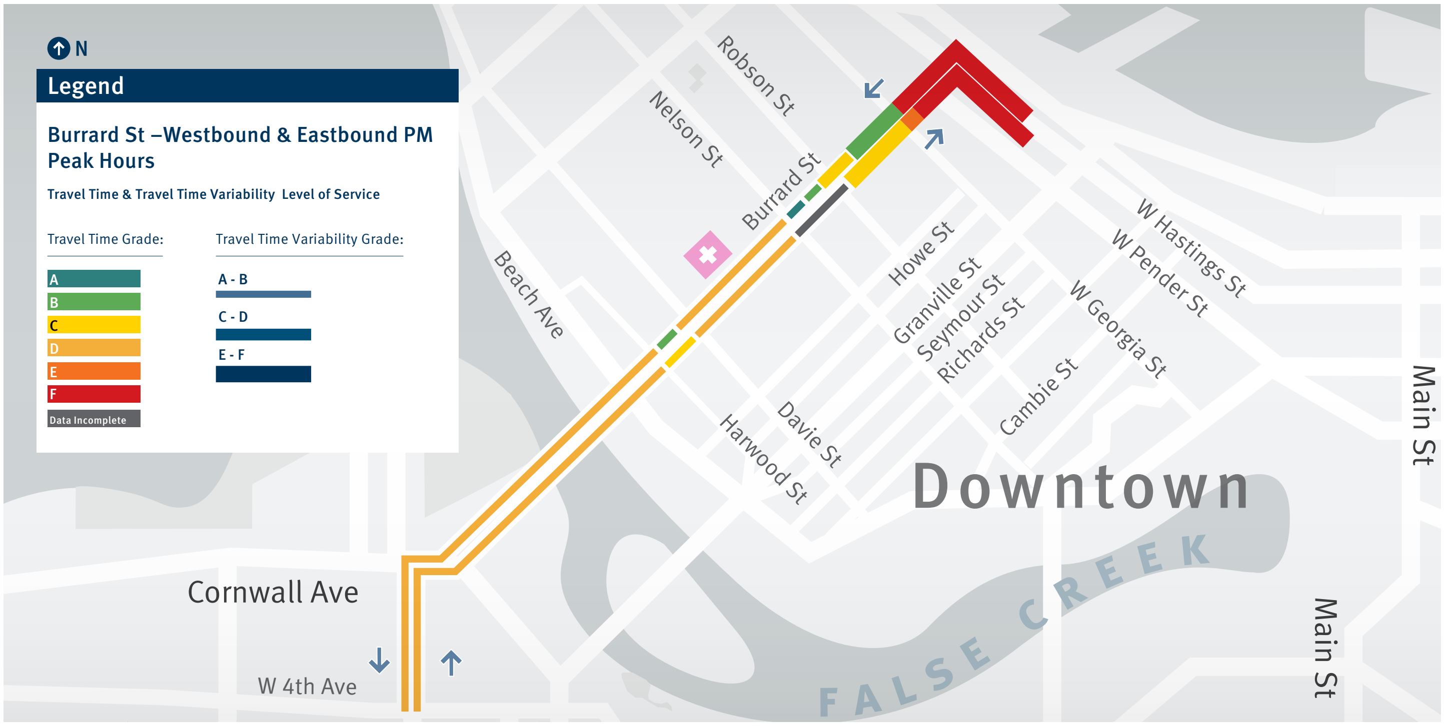
- Eventual addition of Canada Line station at Capstan Way could place additional pressure on curbside management and traffic signal timing.
- No 3 Rd is characterized by significant commercial areas between Bridgeport Rd and Granville Ave.

17 NO 3 RD

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• SB/NB No 3 Rd from Granville Ave to Capstan Way • SB No 3 Rd at Cambie Rd • SB No 3 Rd at Granville Ave • NB No 3 Rd between Cambie and Capstan Way
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• SB No 3 Rd at Steveston Hwy
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB No 3 Rd at Francis Rd • NB No 3 Rd at Blundell Rd • NB No 3 Rd from Park Rd to Alderbridge Way • SB No 3 Rd at Westminster Hwy
Delay to buses caused by location of or short spacing between bus stops	
Location of—and spacing between—bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights. This affects transit customers at a few locations.	• SB No 3 Rd between Anderson Rd. and Granville Ave. • SB No 3 Rd at Browngate Rd.
Curb Management	
Vehicles illegally stopping in curb lane to drop off passengers.	• NB No 3 Rd at Richmond-Brighouse Station • NB No 3 Rd at Lansdowne Rd • NB No. 3 Rd between Browngate Rd and Cambie Rd

19 BURRARD ST



Quick Facts *based on an average weekday within this corridor*	
Length	3.3 km
Routes	2, 5, 32, 44, 95, 258
Total Ridership *(all bus routes on corridor)*	65,000
Boardings/Alightings *(on corridor)*	16,700 / 13,500
Person-hours of Delay	162
Bus-hours of Delay	54

Corridor Description

- Key destinations include the Expo Line, St. Paul's Hospital, Vancouver Art Gallery, Robson St, Davie Village and Kits Point. Primary bridge access from Downtown Vancouver to west side of Vancouver.
- High employment density attributed to central business district.
- **Combined 17-34 buses/hour.**

Significance

- **Key transit corridor in Downtown Vancouver towards UBC.** Also Vancouver terminus of connection from Downtown Vancouver to SFU via Hastings.
- **This corridor has a significant impact on transit throughout Vancouver and the metropolitan area**
  - 7.0% of bus journeys in Metro Vancouver use a bus that travels on this corridor.

Key Challenges

- Significant demand on existing roadway as a connection to Burrard St bridge.
- Significant delay and variability around Burrard Station due to many competing uses of roadway, including curb parking. Particularly acute north of Georgia St.

19 BURRARD ST

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• EB Robson St at Burrard St
Delay to buses turning left	
Transit customers must often wait several traffic light cycles for their bus to make a left-turn at an intersection. This greatly affects average customer travel time and reliability of schedules.	• NB Burrard St at Dunsmuir St
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• SB Burrard St at Harwood St • NB Burrard St from Davie St to Pender St
Delay to buses caused by uncoordinated traffic signals	
When traffic signals are coordinated for transit, transit customers travel through intersections on a "green wave." When traffic signals are uncoordinated, transit customers may get stopped at red lights at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• NB Burrard St at Pender St
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• NB Burrard St from Davie St to Hastings St • SB Burrard St from Hastings St to Harwood St

20 LONSDALE AVE

Corridor Description

- Major and historic north-south transit and commercial corridor for the City of North Vancouver.
- Bus service provides connections from SeaBus and bus exchange at foot of Lonsdale to rest of the City and District of North Vancouver, including Capilano University and important regional recreation destinations on the North Shore.
- **9 – 16 buses/hour.**

Significance

- More than 22% of bus journeys in the City of North Vancouver begin on the Lonsdale corridor.

Key Challenges

- Lonsdale has significant parallel parking allocation, with day time duration limits of 1 hour. This contributes to delay in the curb lane as general traffic wait for others to complete parking maneuvers.
- Some parking zones are temporarily dedicated to commercial loading zones.
- Significantly poor travel times converging to and from Hwy 1 connections.

Quick Facts *based on an average weekday within this corridor*	
Length	4 km
Routes	228, 229, 230, 232, 239, 241
Total Ridership *(all bus routes on corridor)*	22,400
Boardings/Alightings *(on corridor)*	4,300 / 4,600
Person-hours of Delay	144
Bus-hours of Delay	26

20 LONSDALE AVE

Location of Common Causes of Transit Delay

Issue	Key Locations
Delay to buses causes by motorists turning left	
When left-turns are permitted at intersections without left-turn lanes, a single automobile can block a full travel lane.	• NB Lonsdale Ave left turn of bus on to Queens
Delay to buses caused by motorists turning right	
In most places, right-turning motorists must wait for pedestrians to cross the street before turning. Where pedestrian activity is high, a single right-turning motorist can block a full travel lane for an entire green phase.	• SB Lonsdale Ave at 23rd St • SB Lonsdale Ave at 19th St • SB Lonsdale Ave at 15th St • NB/SB Lonsdale Ave at 13th St • NB Lonsdale Ave at 11th St • SB Lonsdale Ave at 8th St W • SB Lonsdale Ave at 3rd St • NB Lonsdale Ave between 19th and 20th • SB Lonsdale Ave at Queens Rd
Delay to buses caused by roadway congestion	
Roadway congestion—or *traffic*—affects transit customers more acutely than other travelers on the roadway. Transit customers are not able to select an alternative path of travel. Congestion also increases all other types of delay, e.g. left-turns, right-turns, access/exit from bus stops. Management of the roadway and curb can provide more capacity for all modes, including transit.	• SB Lonsdale Ave from 29th St to 13th St • NB Lonsdale Ave from 1st St to 29th St • NB/SB Lonsdale Ave between 23rd St and 27th St (crossing Hwy 1)
Delay to buses caused by re-entering traffic from bus stop	
Bus stop design can affect how quickly and easily buses are able to pull into and out of bus stops. This impacts on travel time and reliability.	• NB Lonsdale Ave at 17th St • SB Lonsdale Ave at 19th St
Delay to buses caused by pedestrian movements	
When pedestrian crossings are unsignalized and/or uncoordinated with traffic signals, transit customers may get stopped at consecutive intersections. This greatly affects customer travel time and reliability of schedules.	• NB/SB unsignalized crosswalks along Lonsdale Ave from 1st St to 4th St
Delay to buses caused by location of bus stops	
Location of bus stops can lead to extra acceleration and deceleration time and increase the likelihood of encountering delay re-entering traffic or at traffic lights.	• NB Lonsdale Ave at 23rd St near-side bus stop south of Hwy 1

Sub-Regional Highlights

Opportunities to improve transit travel time exist throughout the network.

The preceding section provides a quantitative ranking of the top corridors across the region where transit customers are delayed the most. There however exists, within each sub-region, other priority corridors and hotspots where travel times can be improved and transit customer delays may be reduced through transit priority treatments.

To provide a view-focused identification and ranking of priority corridors and hotspots within each region, this appendix provides sub-regional maps highlighting problem areas. These maps illustrate the passenger-hour of delay metric, so a combination of bus speeds and ridership. It is important to remember that there are many areas outside of the top 20 list that would benefit from strategic approaches. These may be areas of increased delay and could benefit from strategies to mitigate potential problems developing in the future.

Spot improvements can have a significant benefit to travel time, reliability, and customer experience

Delay 'hot-spots' are found across the region and, in some cases, may be nearly as intense as the 20 corridors and are just more geographically constrained. Many such hot spots at key intersections, at bridge approaches, and at the entrance to transit hubs are locations where targeted interventions can make big improvements to bus speed and reliability.

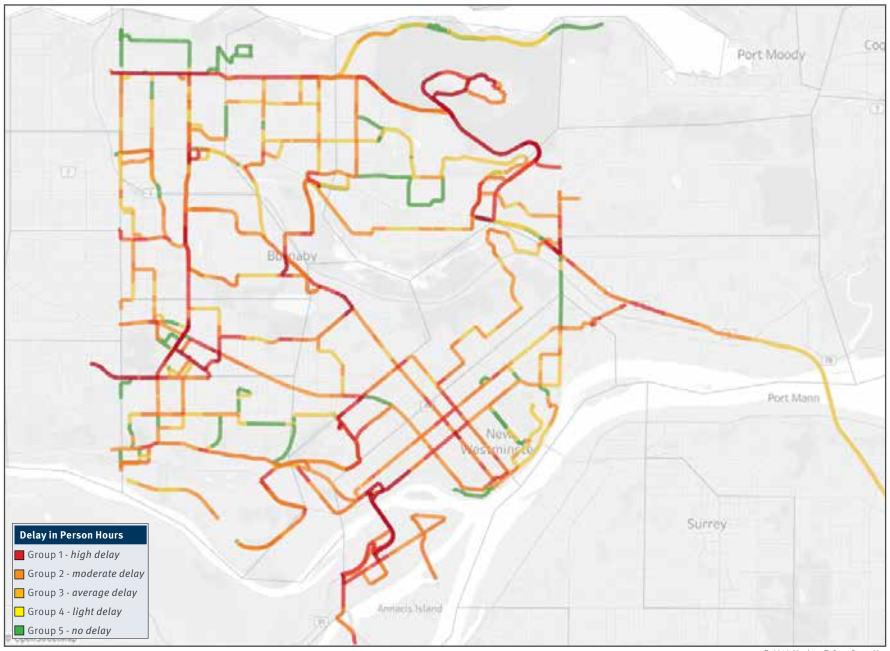
For example, by adding a single left-turn signal on Scott Rd at 84 Ave in spring of 2019, Delta reduced travel time for bus riders at that location by almost 2 minutes during the PM peak. That equates to about a 4% reduction in travel time for customers traveling the full length of the bus route which benefits both Surrey and Delta residents. This is detailed in the case study section.

TransLink has mapped passenger-hours of delay for each sub-region in Metro Vancouver

Passenger-hours of delay is calculated for each segment of the regional roadway using September to December 2018 data. This data has been mapped in quintiles. Each subregional map includes top corridors of delay, as well as other locations of high delay within the subregion.

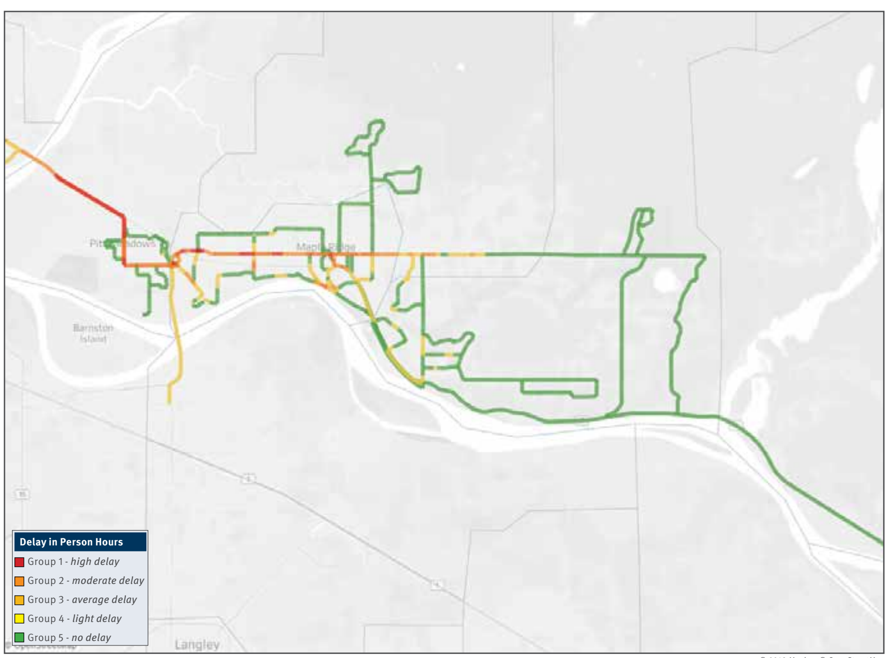
Passenger-hours of delay is calculated by using the travel time delay and multiplying it by the number of passengers on the bus. Bus vehicle delay is calculated as the difference between the actual travel time and the reference, or baseline, travel time. The calculations exclude the time spent at a bus stop to allow customers to get on and off the bus (dwell), to focus on roadway-related delay.

BURNABY/NEW WESTMINSTER



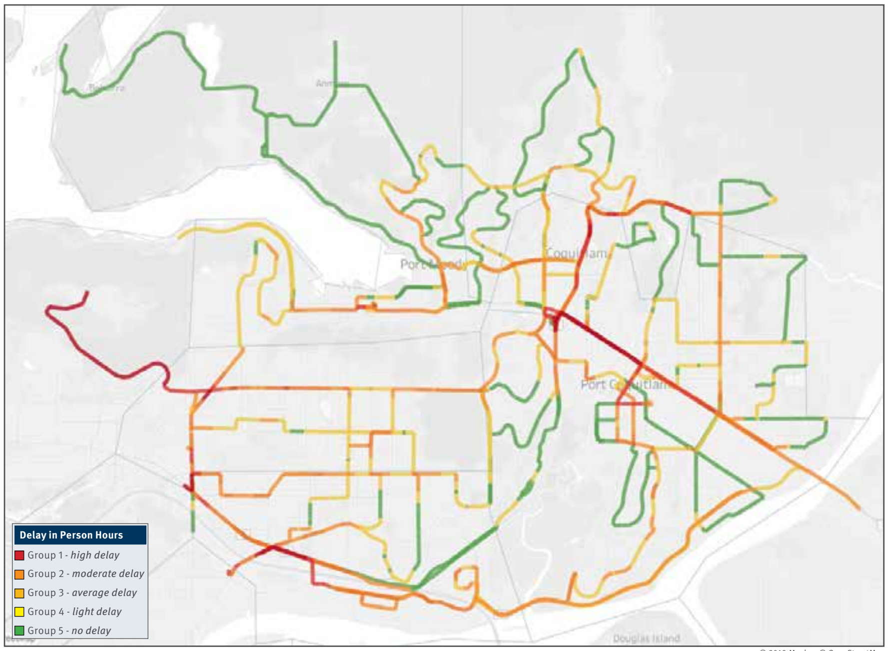
LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
Hastings St	**5**
49th Ave/Imperial	**11**
Willingdon Ave	**16**
Canada Way	
Queensborough Bridge	
Sixth St	
Edmonds St	

MAPLE RIDGE/PITT MEADOWS



LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
Lougheed Hwy	**18**
Dewdney Trunk Rd	
Harris Rd	
Hammond Rd	

NORTHEAST SECTOR



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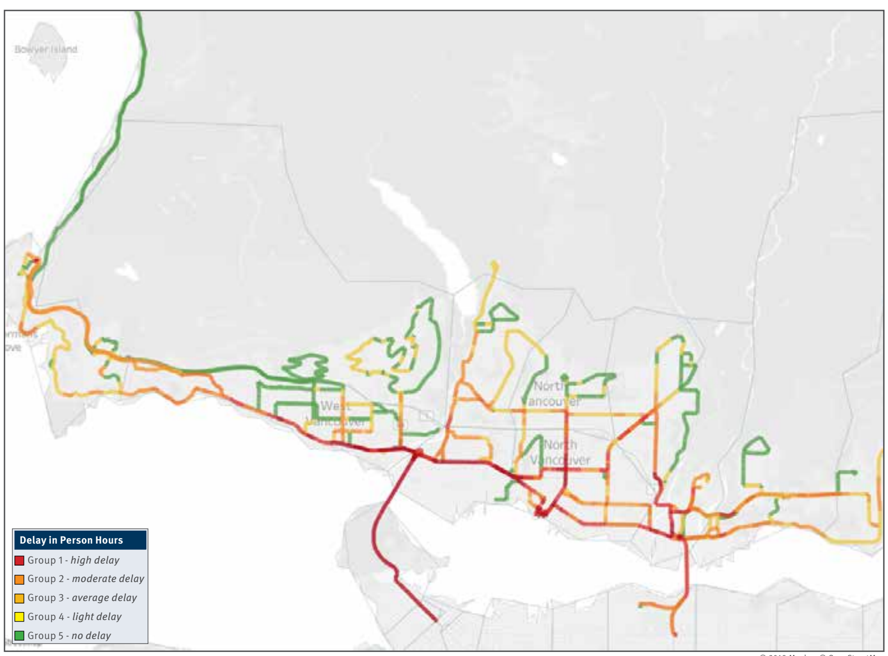
LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
Lougheed Hwy	**18**
Pinetree Way	
North Rd	
Wilson Ave	
David Ave	
St Johns St	

NORTH SHORE



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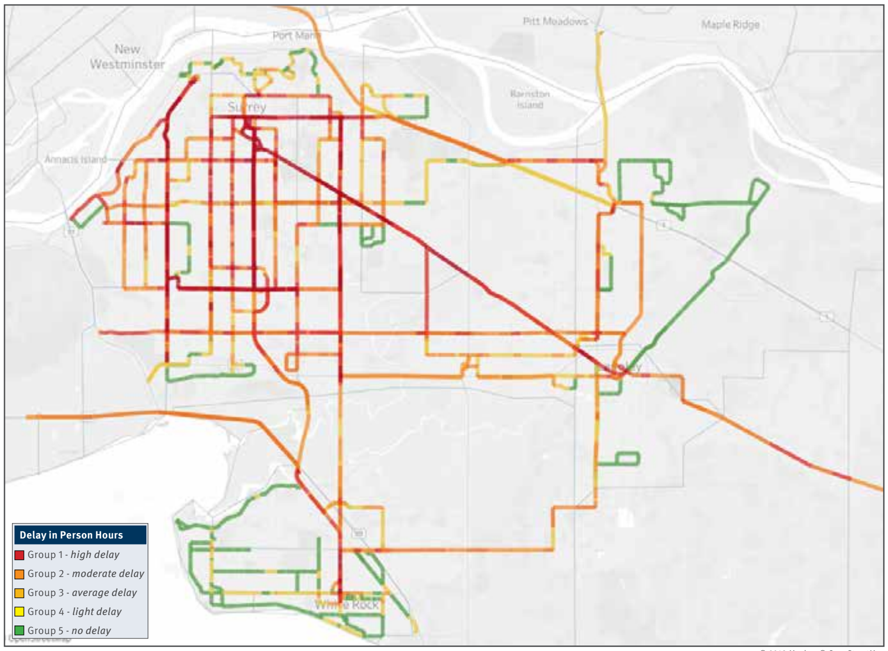
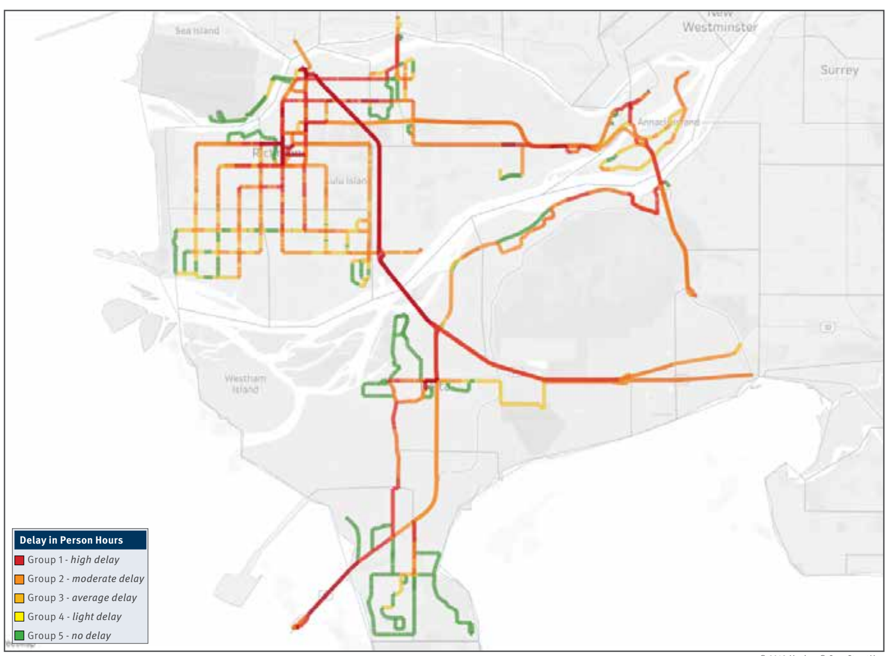
LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
Marine Dr	**7**
Georgia/Lions Gate Bridge	**9**
Lonsdale Ave	**20**
Mountain Hwy	
Lynn Valley Rd	
15th St	
Ironworkers Memorial Bridge	

SOUTHEAST



LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
King George Blvd/104 Ave	**1**
Scott Rd/72 Ave	**6**
Fraser Hwy	**8**
152 St	**13**
108 Ave	
84th Ave	
128 St	

SOUTHWEST



LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
Hwy 99	**2**
No. 3 Rd	**17**
Westminster Hwy	
Cambie Rd	
Ladner Exchange / Hwy 17A	
Granville Ave	
Stevenson Hwy	

VANCOUVER/UBC

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LOCATION OR CORRIDOR	RANKING FOR PASSENGER DELAY
41st Ave	3
Broadway	4
Hastings St	5
Georgia St	9
Granville St	10
49th Ave	11
Pender/Powell/ Cordova/Dundas/ McGill	12
W 4th Ave	14
Main St	15
Burrard St	19

Transit Priority Toolkit

translink.ca

Table of Contents

About this Toolkit

The Transit Priority Toolkit provides TransLink and municipal partners with specific strategies to improve travel time and reliability of transit service for over 900,000 customers who ride the bus each day. The toolkit focuses on 14 transit priority strategies from 5 different groups ranging from interagency coordination to minor capital enhancements to significant infrastructure improvements.

These strategies include:

A. Bus Stop and Curb Management

A1. Bus Stop Placement
A2. Curb Management

B. Traffic Regulations

B1. Movement Restrictions

C. Street Design

C1. Bus Stop Infrastructure
C2. Turn Pockets
C3. Vertical Control Devices
C4. Queue Jump
C5. Transit Approach Lanes
C6. Peak-Hour Bus Lanes
C7. Dedicated Bus Lane

D. Signal Priority

D1. Passive Signal Priority
D2. Transit Signal Priority (Active)

E. TransLink Practices and Policy

E1. All-Door Boarding
E-2. Schedule/Operator Recovery

Each strategy addresses one or more specific challenges that fall into four broad categories:

- Congestion
- Delay
- Operations
- Safey

The summary table (Figure 1) illustrates which specific challenges are addressed by each strategy, as well as relative costs, benefits, and level of coordination required between TransLink and other stakeholders.

Figure 1: Transit Priority Strategy Summary Table

	SPECIFIC CHALLENGES													
	CONGESTION		DELAY			OPERATIONS				SAFETY			COST/COORDINATION	
STRATEGY	INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
A. Bus Stop and Curb Management														
A1. Bus Stop Placement	★		★			★★★	★★	★	★	★★	★★		$–$$	Medium/ High
A2. Curb Management		★				★★	★	★		★	★	★	$–$$	Medium
B. Traffic Regulations														
B1. Movement Restrictions	★★★		★	★★★	★★★		★★		★★	★	★	★★	$–$$$$	Medium/ High
C. Street Design														
C1. Bus Stop Infrastucture						★★	★★	★★★		★★★	★★★		$–$$$	Low
C2. Turn Pockets	★		★★	★	★							★★	$–$$	Medium
C3. Vertical Control Devices		★★★				★★	★		★★	★★★	★★★	★	$	Medium
C4. Queue Jumps	★★★		★★★						★★				$–$$	Medium
C5. Transit Approach Lane	★★★		★★★						★★				$	Medium
C6. Peak-Hour Bus Lane	★★	★★		★★	★★	★★	★★	★★	★★★		★	★★	$$–$$$$	High
C7. Dedicated Bus Lane	★★★	★★★		★★★	★★★	★★★	★★★	★★★	★★★		★	★★	$$–$$$$	High
D. Signal Priority														
D1. Passive Signal Priority	★★	★	★★						★★	★	★	★★	$–$$	Medium
D2. Transit Signal Priority (Active)	★★★		★★★	★★★	★★★				★★★				$$–$$$$	High
E. TransLink Practices and Policy														
E1. All-Door Boarding								★★★	★★	★				Low
E2. Schedule/Operator Recovery									★★★					Low

$ UNDER $50,000
$$ $50,000 - $100,000
$$$ $100,000 - $250,000
$$$$ OVER $250,000

Benefits: ★ LOW ★★ MEDIUM ★★★ HIGH

REPORT STRUCTURE

Each transit priority strategy is detailed in a profile with a brief definition, description of required stakeholder coordination, and a summary of benefits and costs. Each profile concludes with examples of successful implementation in North American cities. The following paragraphs give an overview of the individual sections covered within each profile.

STRATEGY OVERVIEW

Each profile begins with a definition of the transit priority strategy. This includes a summary of technical specifications and a brief explanation of how the strategy improves transit performance. This section also contains information about variations or major considerations.

COORDINATION

Implementation of transit priority strategies requires coordination between agencies and stakeholders. Each profile includes a brief description of required coordination efforts between stakeholders. The list of stakeholders always includes TransLink and the local road authority. It sometimes includes other stakeholders like the business community, residents, or law enforcement.

BENEFITS AND COST

The benefits and costs section describes the typical benefits of each treatment in terms of travel time, transit reliability, customer experience, and safety. The associated typical range of costs of each strategy are provided after the benefits, using costs compiled from similar examples of planned and implemented strategies. These estimates are indicative only. Individual project benefits and costs may vary widely based.

+ This symbol indicates a benefit. – This symbol indicates a cost.

TRAVEL TIME

Travel time is the ability of transit to operate service at an ideal speed.

Treatments can benefit travel time through increased travel speeds or reduced delays, which contribute to more consistent and faster travel through a corridor.

RELIABILITY

Reliability is the ability of transit to operate on schedule.

Consistent and predictable operations reduce travel time variability and dwell times, which can be a major source of delay to transit.

CUSTOMER EXPERIENCE

Customer experience can be improved through transit prioritization.

Though travel time and reliability are major components of customer experience, other factors such as stop amenities or pedestrian infrastructure can reduce confusion and improve customer experience.

SAFETY

Safety is a vital concern for transit operations.

Strategies must promote transit efficiency without compromising the safety of customers, pedestrians, cyclists, or other drivers. Safety concerns include interactions with pedestrians, cyclists, and motor vehicles.

CHALLENGES

Each strategy describes the typical challenges, complementary and alternative treatments for each strategy, and specific agency examples. Challenges describe logistical, temporal, or stakeholder limitations pertaining to the implementation and effectiveness of the treatments.

This table illustrates which specific challenges are addressed by each strategy, as well as relative costs, benefits, and level of coordination required between TransLink and other stakeholders.

COMPLEMENTARY AND ALTERNATIVE TREATMENTS

Complementary treatments highlight other strategies within the Transit Priority Toolkit that can be used to enhance the benefits to transit. Alternative treatments identify treatments that may be either redundant or counterproductive to the specific strategy.

AGENCY EXAMPLES

The final section provides examples of cities in the United States and Canada that have implemented the treatments. It consists of an overview of the project, a description of how the treatment was implemented, and the outcome of implementation including any measured or perceived benefits of the project.

A. Bus Stop and Curb Management

A1. Bus Stop Placement

Bus stop placement directly impacts the convenience and accessibility of the transit system.

Strategy Overview

Determining the proper location of bus stops involves choosing between near-side, far-side and mid-block stops. Each of these stop locations have benefits and drawbacks, and the choice between these stop locations is affected by the existing conditions along a route such as roadway type and width, transit service characteristics, and land use.

Far-side bus stops are located after an intersection, allowing the bus to travel through the intersection before stopping to load and unload customers. Far-side bus stops support the use of a broad array of active transit signal priority treatments, and take up the least amount of curbside space. Near-side bus stops are located before an intersection, allowing customers to load and unload while the vehicle is stopped at a red light or stop sign. Mid-block bus stops are located between intersections.

The minimum stop requirements for curb-side stops are shown in the designs below. However, the design of individual stops may be modified due to complimentary treatments such a curb-side dedicated lane or a boarding island/bulge out.

Stop spacing refers to the distance between bus stops along a route. Stop spacing affects overall travel time and, therefore, demand for transit. The tradeoff is between close stops, which result in short walking distances but longer trip times, and spaced stops, which result in longer walking distances but higher speeds, more reliable bus service, and shorter trip times. Routes and corridors with higher demand and frequency should have stops spaced further apart, while feeder and shuttle services require stops closer together.

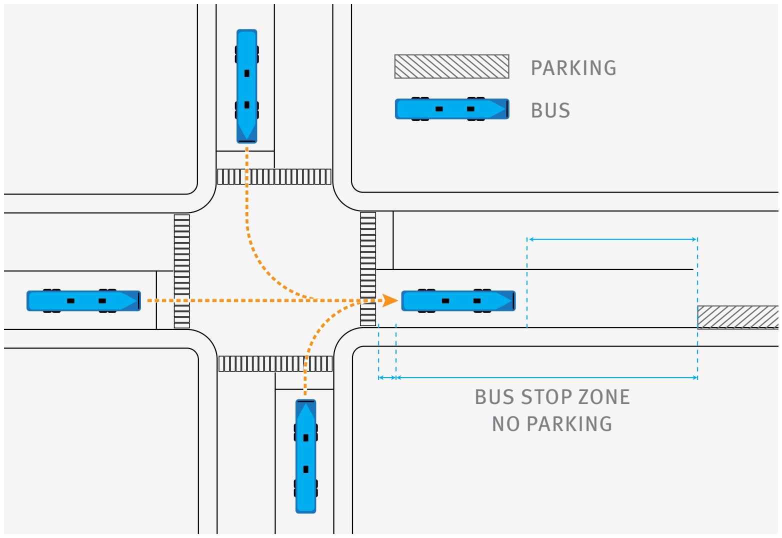
COORDINATION

Bus Stop Placement generally only requires coordination with the local municipality that owns the right-of-way. If bus stops will be located on private property, TransLink will also need to coordinate with the private land owners. Even if bus stops are located on public property, locating or consolidating bus stops can be difficult due to opposition from adjacent businesses or residents.

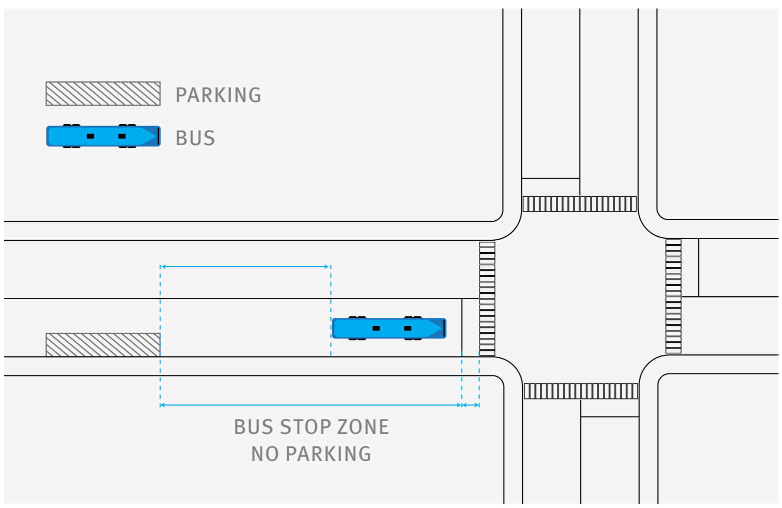
STAKEHOLDER	INVOLVEMENT
TransLink	• Planning of preferred and alternative bus stop locations and determining appropriate spacing of stops along bus routes.
Municipality / Private Land Owner	• Impact on street right-of-way from the installation of passenger landing pads and any additional bus stop infrastructure such as bus stop signs, shelters, etc. Stop locations can be delineated with pavement markings onstreet, on the curb, and/or on the sidewalk.

Figure A1.1: Bus Stop Designs (not to scale)

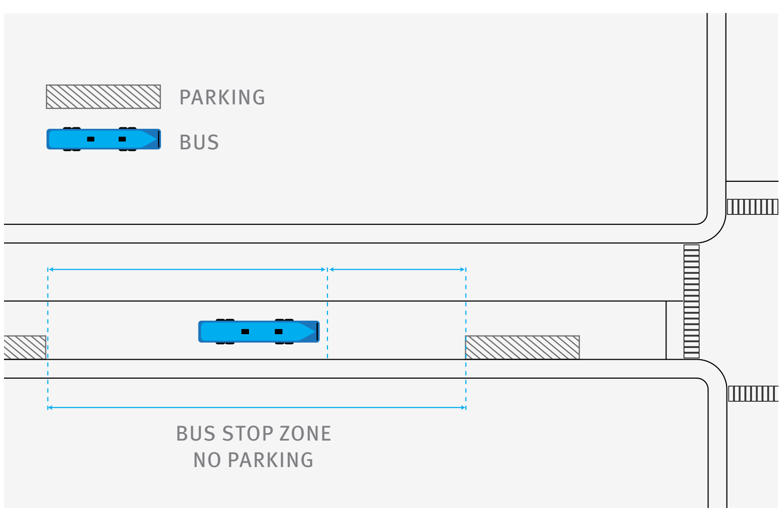
Far-side



Near-side



Mid-block



BENEFITS AND COSTS

FAR SIDE

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Enhances benefits of signal priority	+ Allows buses to travel through an intersection before stopping + Signals provide time for buses to reenter traffic − Queueing buses may block intersections	+ Under correct timing customers pass through intersections before stopping − Can result in stopping twice, one at light and one at bus stop	+ Customers cross behind bus + Creates gaps to reenter traffic + Clears right turn lanes for traffic and other transit vehicles − Drivers may not expect buses to stop immediately after intersections

NEAR SIDE

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Can be used as queue jump lanes + Customers can board when vehicle is stopped at light	*NA*	+ Customers can load/ unload when vehicle is stopped at light or stop sign	+ Allows driver to look for oncoming traffic including other buses for transfers − Customers cross in front of bus − Conflicts with right-turning vehicles

MID-BLOCK

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Useful where buses must make left turns at an intersection − Buses may have to merge to reenter traffic	*NA*	+ Less customer congestion − Increases walking distance	+ Useful where traffic conditions would create safety issues at intersections + Reduces sight distance problems − Encourages jaywalking − Requires a mid-block pedestrian crossing

BENEFITS AND COSTS

STOP CONSOLIDATION

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Overall travel time reduced by up to 6% + Dwell times are a significant portion of overall travel times	+ Reduces maintenance cost due to fewer bus stops + Reduces running time variability	+ Fewer stops with improved facilities – Greater walking distance between stops	*NA*

ESTIMATED TYPICAL COSTS	PER STOP
Basic stops, including stop landing pad, sidewalk, and curb work	$10,000 - $14,000
Sheltered stops, including a shelter and bus bay/curb extension	$14,000 - $40,000

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★		★			★★★	★★	★	★	★★	★★		$–$$	Medium/High

CHALLENGES

- Requires full bus stop inventory, analysis, and engineering in order to identify and change location of bus stops.
- Adjacent developments, such as businesses or residents, may resist bus stops at specific locations due to additional right-of-way space used by bus stops and parking removed (if applicable).
- Depending on local municipalities, private owners, and need for public outreach to customers, the timeline can be a few months to a few years to change bus stop locations.
- Regardless of stop location, areas must be designed to accommodate bus queuing at stops served by multiple routes.
- Customers may oppose stop relocation.
- There must be sufficient space for amenities.

COMPLEMENTARY TREATMENTS

Optimizing the location of bus stops can reduce dwell times and improve transit reliability, but often requires other treatments to enhance those benefits.

Bus Stop Infrastructure

In-lane stops that are in optimized locations improve boarding and further decrease dwell times.

Curb Management

Curbside management can eliminate conflicts with delivery vehicles and passenger drop-offs in front of bus stops.

Movement Restrictions

Restricting turning can reduce conflicts with turning vehicles at near-side stops and allow buses to more easily access near-side stops.

Queue Jumps

At near-side stops, buses can access the queue jump lane after boarding, and far-side stops can also be paired with signal priority.

Transit Approach Lane

An exclusive transit lane leading up to an intersection can easily enable buses to reach far side stops.

Peak-Hour & Dedicated Bus Lane

Bus lanes can improve travel times between stops, with stop consolidation and optimized stop location improving travel times.

Passive Signal Priority & Transit-Signal Priority

Signal priority can enable buses to clear intersections before reaching far side stops or after near side stops.

All-Door Boarding

Stop locations with all-door boarding allow for a higher volume of passenger activity, reduce dwell times, and facilitate stop consolidation.

ALTERNATIVE TREATMENTS

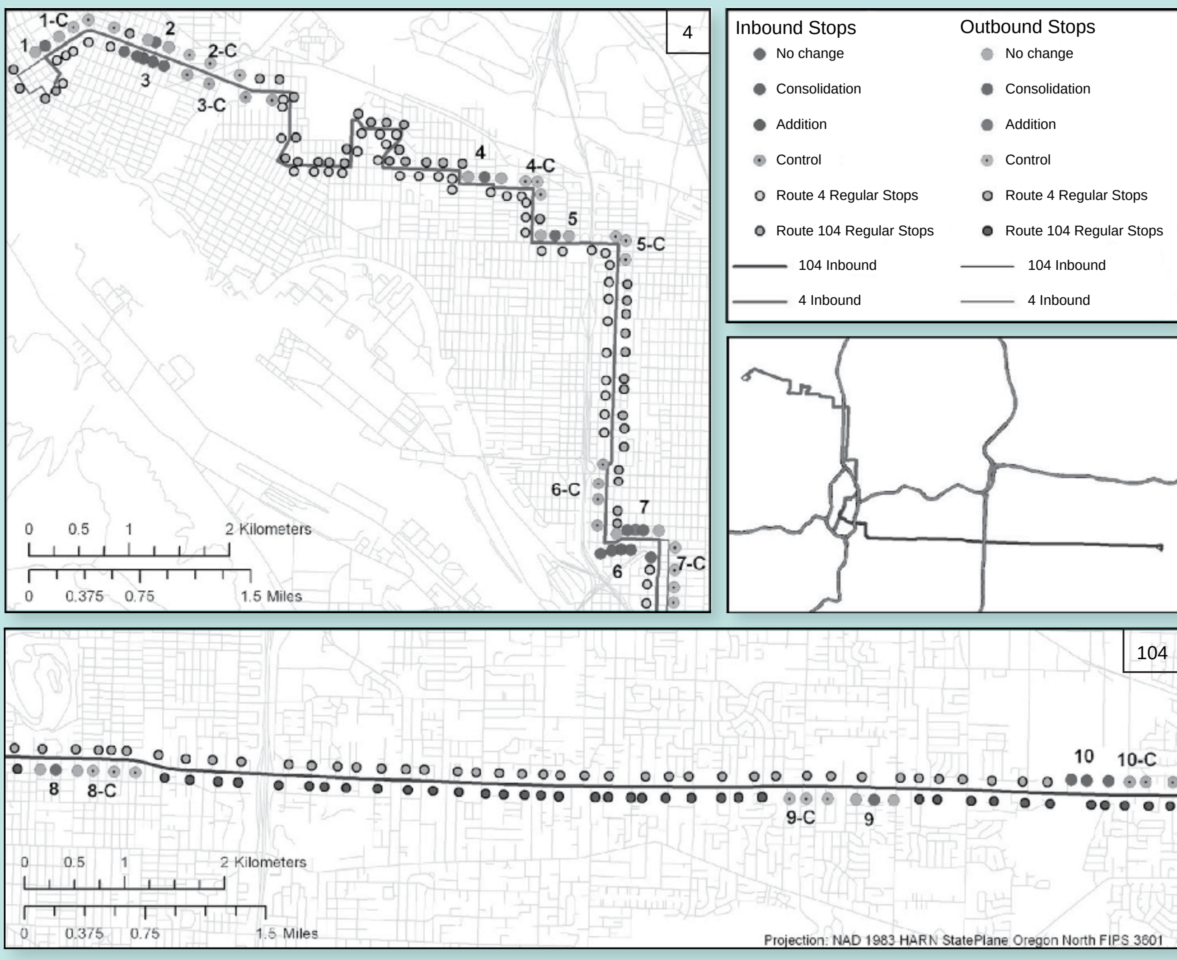
Not applicable

BUS STOP PLACEMENT EXAMPLES

Multiple transit agencies have done partial or full implementation of moving bus stop locations and consolidating bus stops. Results vary based on the level of intervention and use of complementary treatments.

- In 2005, a study analyzing the implementation of bus stopconsolidation for TriMet in Portland, Oregon found that passenger activity was unchanged after bus stop consolidation. Additionally, **bus running times decreasedby 6%**, and may have been greater, due to lack of schedule adjustments.[1]
- In 2013, a study of potential bus stop consolidation in Fairfax, Virginia proposed removing about 40% of bus stops, as the walking distance threshold was increased to 800m. 83% of existing service area was still covered, while **travel time could be reduced by up to 23%**.[2]

Figure A1.2: TriMet Stop Consolidation Example[1]

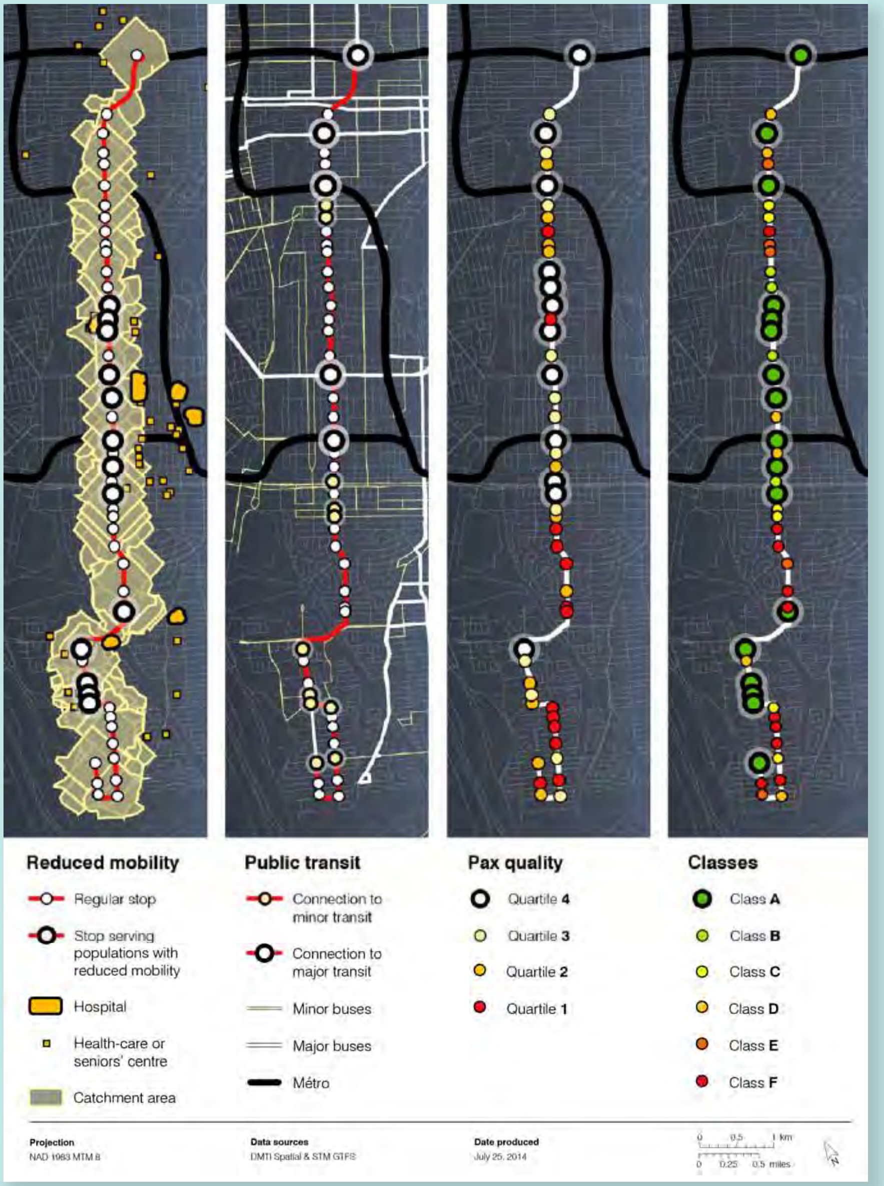


1 El-Geneidy et al., "Effects of Bus Stop Consolidation on Passenger Activity and Transit Operations," 2005. http://tram.mcgill.ca/Research/Publications/Bus_Stop_consoildation.pdf

2 Shrestha & Zolnik, "Eliminating Bus Stops: Evaluating Changes in Operations, Emissions, and Coverage," 2013. http://www.nctr.usf.edu/wp-content/uploads/2013/07/16.2_zolnik.pdf

- In 2015, a study from McGill University analyzed potential bus stop consolidation on the Société de transport deMontreal (STM) using a simpler methodology. The study assumed a removal of 23% of bus stops while only reducing service area by 1%. 75 bus routes would be able to **operate with one fewer bus and reduce running times by 2% system wide.**[3]
- From 2009 to 2014, the MBTA implemented the Key BusRoute Improvement Program, which increased overall quality of service on the 15 busiest routes in MBTA system. As part of the improvements, the MBTA aimed to remove 25% of bus stops and improve the remaining stops with better passenger amenities. The program was able to reduce 20% of all stops along the corridors and add additional transit priority strategies along select corridors, such as queue jump lanes, transit signal priority and bus stop curb extensions.[4]

Figure A1.3: Montreal Stop Consolidation Example



3 Stewart & El-Geneidy, "Don't Stop Just Yet!: A simple, effective, and socially responsible approach to bus-stop consolidation," 2015. http://tram.mcgill.ca/Research/Publications/Bus_stop_consolidation_Montreal.pdf

4 MBTA, "Key Bus Route Improvement Program", 2015. http://old.mbta.com/about_the_mbta/t_projects/default.asp?id=190479

A2. Curb Management

Curb management is the act of organizing the various demands for curb space through clear, legible rules about when, where, and under what conditions specific uses are permitted.

Strategy Overview

Effective curb management reduces conflict between transit and other vehicles in travel lanes and at bus stops to improve schedule reliability and customer access.

Cities can manage curb space by thoughtfully regulating the total supply and specific location of curb dedicated to each use. Supplying clearly designated loading zones, taxi stands, parking spaces, and bus stops maximizes the efficient use of curb space and flow of vehicles in adjacent travel lanes. Signage and enforcement are common tools for curb management. Enforcement can help maintain compliance.

Cities can also manage curb space by guiding the demand for each use. On-street parking pricing strategies and time limits are common tools for redistributing parking activity to times or locations where parking is more readily available.

Some curb management practices may include converting parking lanes into bus lanes during peak hours or on high-frequency transit corridors. Parking revenues can also help fund other community amenities through a parking benefits district.

Managing the space along a curb helps improve reliability and efficiency for all travelers—including people in buses.

COORDINATION

Changes to street curbs requires close coordination with local municipalities.

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of bus stops or blocks with poor customer access due to in adequate bus stop spacing or heavy delay due to bus stops and travel lanes being used for passenger and commercial loading. • In some cases, consideration of consolidating or deactivating closely-spaced bus stops to provide space for other uses like passenger or commercial loading.
Municipality/ Private Land Owner	• Management of street curbs falls solely onto the local municipality. • The city also has the ability to manage parking costs on-street and off-street in public lots to reduce on-street demand and allow for additional curb uses.

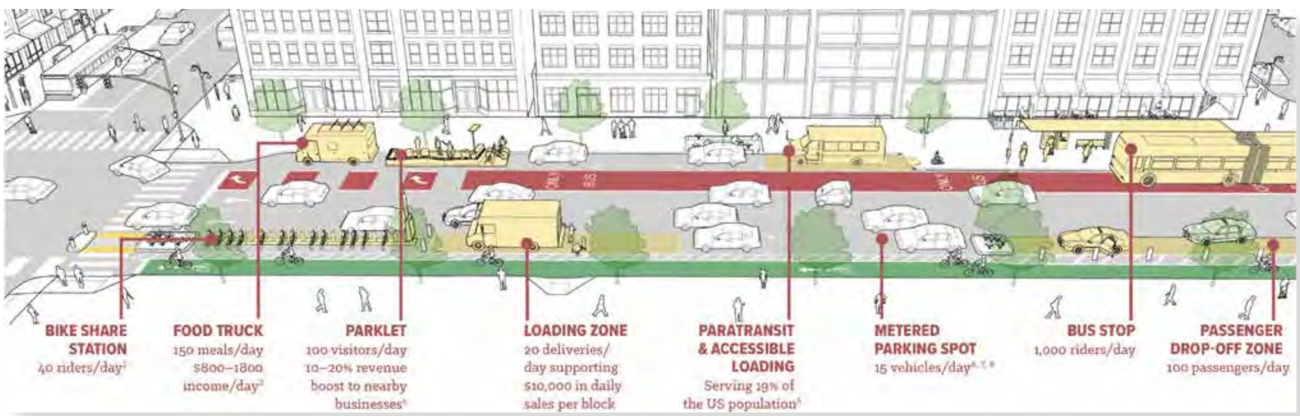
Figure A2.1: Sidewalk Parking Zones

Source: Google Maps

Figure A2.2: Designated Rideshare Location

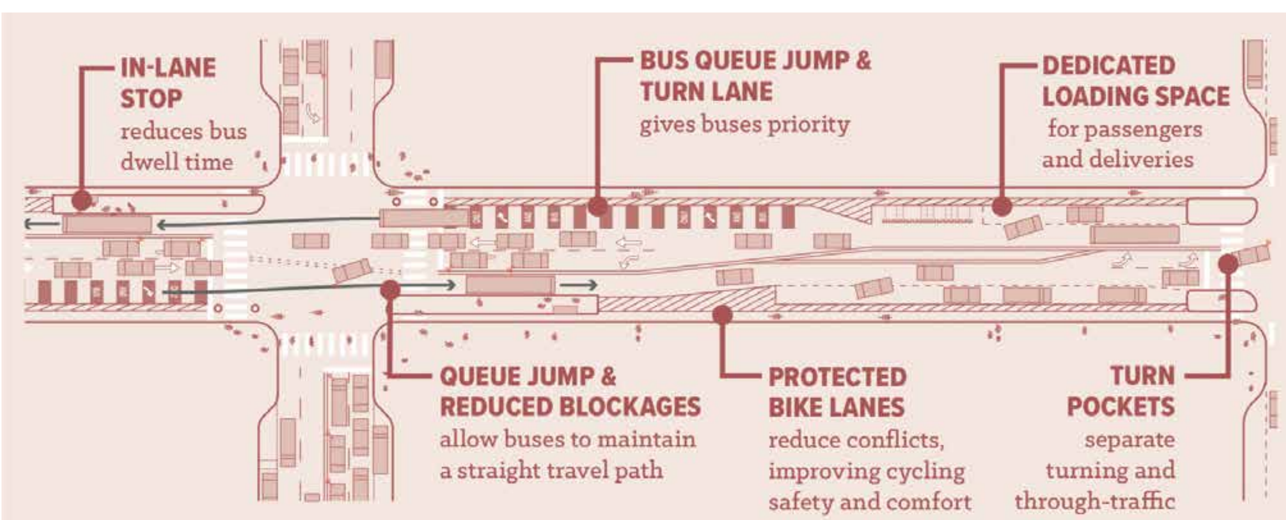
Source: Cincinnati Enquire

Figure A2.3: Different Curbside Uses



Source: NACTO

Figure A2.4: Curb Management Allows for More Efficient Traffic Flow



Source: NACTO

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Travel time decreased by up to 22% + Transit is less vulnerable to double-parking	+ 2% increase in transit speeds + Double parking reduced by 22% – Requires enforcement to ensure uses adhere to designated spaces	+ Dedicated bus stop space is less confusing and safer for boarding – Drivers may object to removing spaces or raising rates	+ Fewer conflicts with passenger drop-offs + Improves visibility

ESTIMATED TYPICAL COSTS	PER 30M
Signage and striping per 30m	$500-$3,000

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
	★				★★	★	★		★	★	★	$–$$	Medium

CHALLENGES

- Requires full bus stop inventory, analysis, and engineering in order to identify and change location of bus stops.
- Adjacent developments, such as businesses or residents, may resist bus stops at specific locations due to additional right-of-way space used by bus stops and parking removed (if applicable).
- Customers may oppose stop relocation.
- Depending on local municipalities, private owners, and need for public outreach to customers, the timeline can be a few months to a few years to change bus stop locations.
- Regardless of stop location, areas must be designed to accommodate bus queuing at stops served by multiple routes.
- There must be sufficient space for amenities.

COMPLEMENTARY TREATMENTS

Curb management can improve transit operations and efficiency, but incorporating other treatments can reinforce and enhance the benefits of managing the space along the curb.

Bus Stop Placement

Optimally locating bus stops in designated zones further reduces conflicts and delays caused by other curbside uses.

Bus Stop Infrastructure

Bus bulges and boarding islands prevent buses from having to make curbside stops, which reduces the potential for conflict and interference with other curbside uses, thereby decreasing travel time, increasing reliability, and increasing safety.

Transit Approach Lane

A bus-only lane on the approach to an intersection allows for transit prioritization through an intersection while allowing curb space in the rest of the block for other curbside uses.

Dedicated & Peak-Hour Bus Lane

Curb-side bus lanes clearly reinforce space for transit and discourage other vehicles from using bus lanes. Clear lane striping (e.g. red lanes) or strong enforcement during introduction is advisable to ensure lanes are not misused by other vehicles.

ALTERNATIVE TREATMENTS

Not applicable

CURB MANAGEMENT EXAMPLES

Multiple cities have implemented various curb management techniques to reduce the impacts of other curbside uses.

- In 2011, San Francisco implemented SF park, a parking management pilot focused on improving parking availability through demand-responsive pricing, improved meters, and real-time information. As a result, blocks were full 16% less often, with a 43% decrease in the amount of time spent searching for parking. This reduced peak period congestion, contributed to an **8% decrease in traffic volumes**, and **reduced double parking by 22%**, which enabled a **2.3% increase in transit speeds** and improved reliability for Muni.[1]

1 SFMTA, "SFpark: Pilot Project Evaluation", 2014. http://sfpark.org/wp-content/uploads/2014/06/SFpark_Pilot_Project_Evaluation.pdf

Figure A2.5: SFpark Transit Travel Time Savings[1]

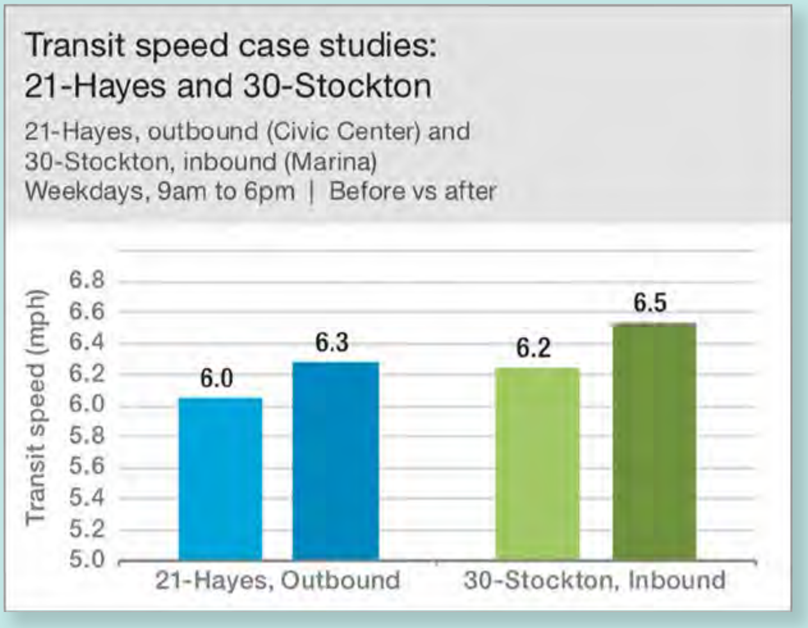
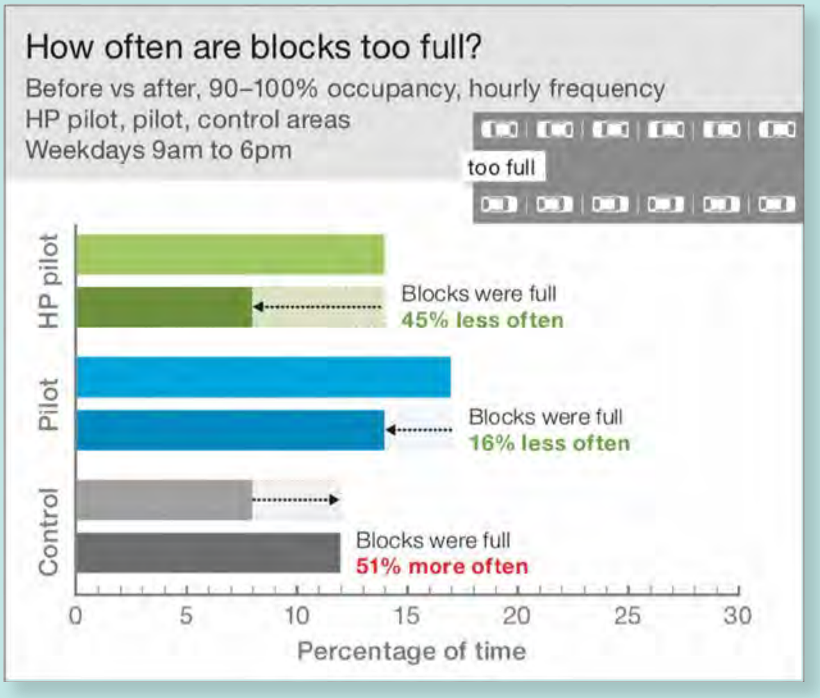


Figure A2.6: SFpark Parking Availability Improvements[1]



- In 2013, NYC DOT implemented curbside improvements in conjunction with Select Bus Service upgrades on the B44 route in Brooklyn. NYC DOT provided loading zones with delivery windows according to merchant surveys that allowed trucks to access the curb, reducing double-parking which had largely been caused by loading vehicles. **Travel times along Nostrand Avenue decreased by 19-22%** due to curbside regulations that expanded "No Standing" zones and added commercial loading zones. They were able to justify prioritization of transit to merchants based on a survey of customers that found that 84% of shoppers on Nostrand Avenue had walked or arrived by transit.[2]

- Toronto's Curbside Management Strategy, as part of their Congestion Management Plan, aims to prioritize curbside uses without impacting traffic. Strategies include designated zones for delivery vehicles, turn and stopping restrictions, taxi drop-off areas, encouraging off-peak deliveries, and increased enforcement.[3] Though they are still in the process, initial measures taken have been successful in minimizing the impact of curbside uses on traffic operations.[4]

- Seattle has utilized pricing strategies to reduce the number of people who drive alone. The most effective strategy has been the shift from monthly parking fees to daily payments for garages or lots. Whereas monthly parking fees encourage driving to work because parking has already been paid for, daily parking fees provide the flexibility for commuters to decide their commute mode on a daily basis.[5]

2 NYC DOT, "B44 SBS on Nostrand Avenue Progress Report", 2016. http://www.nyc.gov/html/brt/downloads/pdf/brt-nostrand-progress-report-june2016.pdf

3 City of Toronto, "Congestion Management Plan", 2016. https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-109153.pdf

4 Toronto Transportation Services, "Curbside Management Strategy: Improving How Curbside Space Is Used", 2017. https://www.toronto.ca/legdocs/mmis/2017/pw/bgrd/backgroundfile-109153.pdf

5 Gutman, David, "The not-so-secret trick to cutting solo car commutes: Charge for parking by the day", 2017. https://www.seattletimes.com/seattle-news/transportation/the-not-so-secret-trick-to-cutting-solo-car-commutes-charge-for-parking-by-the-day/

B. Traffic Regulations

B1. Movement Restrictions

Movement restrictions are limitations on general vehicular movements to either use travel lanes more efficiently or limit access to corridors in order to reduce delay for transit vehicles.

Strategy Overview

The use of movement restrictions improves bus travel speeds and reliability by reducing delays caused by motor vehicle traffic at key intersections. These improvements reduce travel time and operating cost of service.

Left-turns can cause delay to buses traveling straight or turning left. For buses traveling straight, a single motorist queuing in a general purpose lane to turn left can severely limit the flow of traffic through an intersection. Because left-turn signal phases are often very short, any queue of left-turning motorists reduces a bus's likelihood of getting through an intersection in a single signal cycle.

Because buses often travel in the curbside lane, restricting right turns reduces delay at intersections and unnecessary weaving in and out of traffic to avoid queuing vehicles. Right-turn restrictions have the added benefit of reducing conflict between right-turning motorists and pedestrians crossing the intersection.

Restricting through traffic reduces the amount of congestion along a stretch of roadway. While some movement restrictions try to interrupt vehicular traffic at an intersection, using transit only signage can create a transit exclusive area, such as a transit mall or bypass road.

COORDINATION

The implementation of movement restrictions requires close coordination with local municipalities.

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations for effective implementation of turn or movement restrictions to maximize potential benefits.
Municipality	• Impact on city street right-of-way from the addition of lane striping and signage placement. • Additional traffic enforcement requirements.

Figure B1.1: Example of Transit Only/General Vehicular Restriction Signage

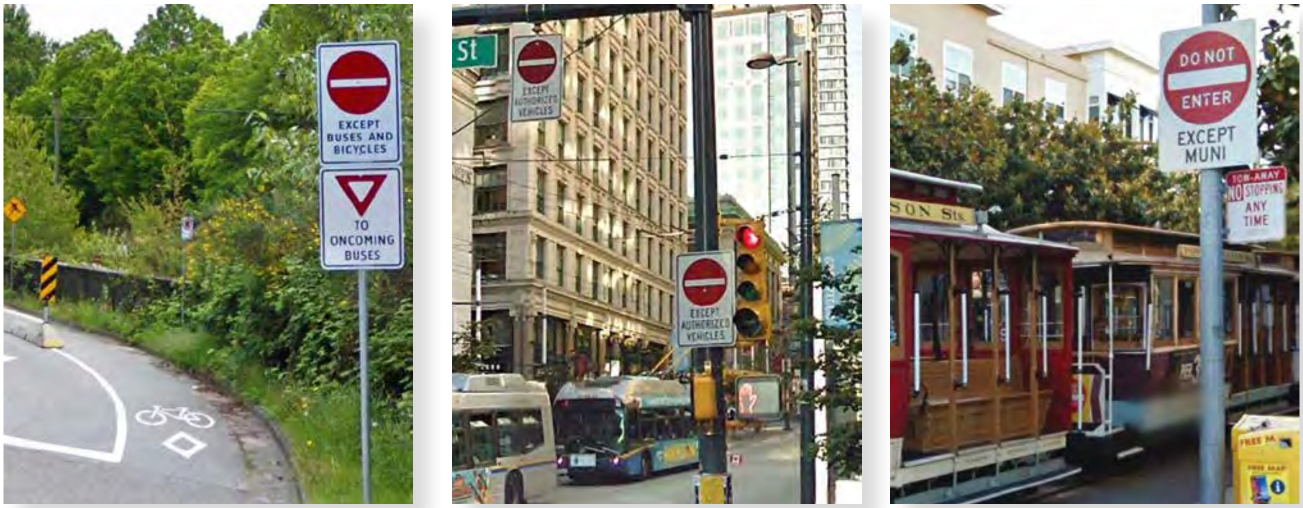


Figure B1.2: Toronto King Street Movement Restrictions

Source: City of Toronto and the Toronto Transit Commission

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Corridor travel time reduced up to 25%	+ 33% reduction in travel time variability	+ Increases travel speed and reliability	+ Reduces interaction with motor vehicle traffic, bicyclists, and pedestrians

ESTIMATED COSTS	
Cost of Design and Implementation (includes cost of new turn lanes and signal adjustments)	$255,000 per km $20,000 per intersection

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★★		★	★★★	★★★		★★		★★	★	★	★★	$–$$$$	Medium/High

CHALLENGES

- Each movement restriction will place higher traffic volumes elsewhere. For example, left-turn restrictions may increase capacity in general traffic lanes, but can also increase right-turn traffic.
- Thorough network analysis must be completed for all modes of transportation to identify conflicts or holes in implementation.
- While movement restrictions can be applied on their own, maximum benefits for turn-restrictions are often combined with other complementary treatments.
- Requires traffic enforcement.

COMPLEMENTARY TREATMENTS

Implementing movement restrictions alone can reduce delays and improve travel times, but other treatments can be included alongside restrictions to enhance these benefits.

Bus Stop Placement

Locating bus stops where turns are restricted can mitigate safety concerns and allow for additional space for passenger amenities.

Curb Management

Curb management ensures that curbside uses do not interfere with transit or traffic operations.

Bus Stop Infrastructure

In-lane stops allow buses to remain in the through lane while other vehicles must turn, minimizing interference with transit operations.

Peak-Hour & Dedicated Bus Lane

Bus-only lanes combined with turn restrictions can minimize delays and conflicts with other vehicles, enabling faster and more reliable service.

Passive Signal Priority & Transit-Signal Priority

Signal priority for buses allows transit to consistently move through a corridor with movement restrictions with minimal delays or variability at intersections.

Vertical Control Devices

Vertical control devices can be used in conjunction with movement restrictions as a physical restriction on the roadway.

ALTERNATIVE TREATMENTS

Turn Pockets

Separate lanes for turning vehicles at intersections are unnecessary when turns are not permitted.

MOVEMENT RESTRICTION EXAMPLES

Multiple transit agencies have implemented turn restrictions on high demand corridors.

- Starting in 2011 as a way to address pedestrian and bicycle safety, SFMTA began implementing movement and turn restrictions along the Market Street corridor in downtown San Francisco from 10th Street to the Embarcadero. First to be implemented was the forced right turn off of Market Street at all applicable intersections for general travel. In 2015, turn restrictions were put into place for almost all general vehicular traffic turning onto Market Street,[1] which resulted in a 22% reduction in traffic and a 72% decrease in speeding.[2] In 2017, SFMTA announced a new plan to remove all general vehicular traffic and only allow transit, emergency vehicles, bikes, and pedestrians. Specific transit savings on travel time or reliability are difficult to calculate due to the additional improvements also implemented such as center-running dedicated transit lanes, transit stop islands, and all-door boarding.

Figure B1.4: Market Street Turn Restrictions starting Aug 2015 [1]

1 SFMTA, "Safer Marker St: Vision Zero in Action", 2014.
https://www.sfmta.com/sites/default/files/projects/2014/SMS_web_final.compressed.pdf

2 Zendrive, "Turning Towards Safety: San Francisco's Market Street", 2016.

MOVEMENT RESTRICTION EXAMPLES

Multiple transit agencies have implemented turn restrictions on high demand corridors.

- Starting in November 2017, the City of Toronto and the TTC implemented a pilot of movement restrictions on King Street in downtown Toronto. General vehicular traffic must make right turns at most major intersections that have two-way traffic. No left turns or continuation on King Street is allowed. The total project cost was $1.5 million CAD and included other transit priority strategies, including stop placement and infrastructure and reconfiguring the curb space along King Street. While the pilot has just a few months of data, the results are already very positive. Ridership on the King Street streetcar has increased by 25%, without decreasing on parallel routes. Streetcar reliability has improved by 33%, as the range of travel time variability went from 10 minutes to 6.7 minutes. Additionally, overall travel time on the route has increased by 6%, which is about a 20-25% increase in travel time on the section of the corridor with the pilot.[3]

Figure B1.5: Toronto King St Pilot Design Before (Top) and After (Bottom) [3]

3 City of Toronto, "King Street Transit Pilot", 2017.
https://www.toronto.ca/city-government/planning-development/planning-studies-initiatives/king-street-pilot/

C. Street Design

C1. Bus Stop Infrastructure

Bus stop infrastructure can take many forms, as different bus stop configurations may prioritize transit, motorists, bicyclists, or pedestrians.

Strategy Overview

Bus stops may be designed to pick up and drop off customers in the travel lane ("in-lane") or in the parking lane ("curbside"). In-lane stops reduce delay associated with accessing, serving, and exiting bus stops by eliminating the need for buses to merge in and out of traffic.

Bus bulges (also known as bus bulbs or curb extensions) and boarding islands commonly permit buses to stop in-lane while providing an area for transit customers to comfortably wait without blocking the sidewalk.

Bus bulges extend the curb into the parking lane so that buses can pick up or drop off customers without exiting the travel lane. Bus bulges can be implemented for near-side, far-side, or mid-block stops, and work particularly well with offset transit lanes. Bus bulges can also be designed to function as a raised bike lane, reducing weaving movements between buses and bicyclists on shared corridors. Bicyclists can use the bike lane when there is no boarding occurring, but must yield when a bus stops.

Boarding islands can be separated from the curb by a travel lane or a bike lane. When paired with a bike lane, boarding islands allow buses to make stops while eliminating the conflict between buses and bicyclists. In-street boarding islands, separated from the sidewalk by a travel lane, enable in-lane stops for center-running transit, as transit vehicles can pick up and drop off customers at a boarding island or median in the street. At intersections with a high volume of right turns or heavy transit activity, in-street boarding islands also separate right turns from through movements.

Boarding islands and bus bulges improve transit travel times and speeds by separating some of the other traffic movements on the street, such as turning lanes, other travel lanes, or bike lanes. In-lane stops also reduce delay accessing, serving, and exiting bus stops, further improving transit service and efficiency.

COORDINATION

The development of bus stop infrastructure requires coordination between TransLink and the local municipality that owns the right-of-way at each stop.

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of routes and stop locations that will most benefit from improved stop infrastructure. • Identification of additional structural (trolley wire) or operational (rapid/local tandem, turning movements) analyses or changes required.
Municipality	• Impact on street right-of-way from the installation of bus bulges or boarding islands and any additional bus stop infrastructure such as bus stop signs, shelters, real-time info, etc. • Permitting and possibly construction of bus stop infrastructure.

Figure C1.1: Near & Far-Side Boarding Island Stops

Source: NACTO

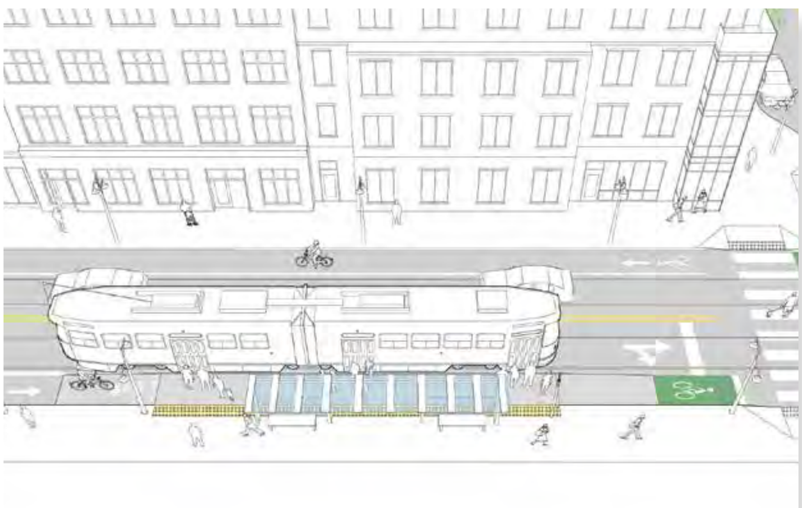
Figure C1.2: In-Street Boarding Island Stop

Source: NACTO & SFMTA

Figure C1.3: Bus & Streetcar Bulge

Source: NACTO

Figure C1.4: Shared Cycle Track Stop



Source: NACTO & Toronto TTC

BENEFITS AND COSTS

TRAVEL TIME

+ Travel times reduced due to up to 3 km/h increase in vehicle speeds
+ 7% increase in vehicle speed at stops with bus bulges
- Bus bulges preclude peak-hour bus lanes from operating in the parking lane

RELIABILITY

+ Reduces variability from traffic delays due to merging
+ Reduces dwell times by 15-30 seconds per stop with the elimination of delays due to merging

CUSTOMER EXPERIENCE

+ Increased footprint allows for more stop amenities, such as shelters, benches, etc.
+ Facilitates bus alignment with customer waiting area to improve accessibility
- Bus bulges or boarding islands paired with bike lanes or travel lanes increase the interaction between customers walking to/from the bus and other modes

SAFETY

+ Reduces vehicle conflicts with bicycles and pedestrians
+ Additional space for passengers to wait
+ Reduces crosswalk distance
- Increase in conflicts with vehicles when bus stays in travel lane
- Increases interaction between customers walking to/from the bus and other modes
- High volume stops may not be suitable for cycle tracks

ESTIMATED COSTS	PER STOP
Bus Bulge/Curb Extension	\$20,000-\$90,000
Single Bus Boarding Island	\$35,000-\$200,000

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
					★★	★★	★★★		★★★	★★★		\$-\$\$\$	Low

CHALLENGES

- Boarding islands require consideration of how transit customers will cross bike lanes or street traffic to access the bus stop.
- High volume stops may not accommodate cycle tracks due to safety concerns.
- In-lane stops without a dedicated bus lane can cause large delays to traffic depending on dwell times.
- All bus stop infrastructure should be able to accommodate customers who use wheelchairs, walkers, canes, strollers, and other mobility devices.

COMPLEMENTARY TREATMENTS

Implementing enhanced bus stop infrastructure alone will yield some speed and reliability improvements. However, combining bus stop infrastructure with additional treatments will enhance the overall benefits.

Bus Stop Placement

Bus stop locations are supported by proper curb management which allows the optimum placement of bus stops to improve safety, reduce dwell time, and improve travel speed.

Curb Management

Curb management ensures that stops are serviceable, reducing dwell time and increasing safety.

Dedicated Bus Lane

Bus-only lanes improve safety and ensure that traffic does not back up when stops are placed in-lane.

Passive Signal Priority & Transit-Signal Priority

Signal prioritization supports the use of in-lane stops by allowing the bus to board customers at intersections and immediately continue, improving travel speed.

All-Door Boarding

All-door boarding can reduce dwell time at bus stops, making efficient use of larger bus stop footprint and minimizing impacts to general traffic.

ALTERNATIVE TREATMENTS

Peak-Hour Bus Lane

Bus bulges cannot be used with peak-hour bus lanes that are parking lanes during non-peak hours, as bus bulges require dedicated space in parking lanes.

BUS STOP INFRASTUCTURE EXAMPLES

While the majority of transit agencies have utilized bus bulges/curb extensions on some routes, only a few have installed side boarding or in street bus stop islands.

- Starting with designs in the late 1980's, San Francisco's Muni developed median transit lanes with transit islands to serve bus routes on Market Street and the F Line streetcar. Since then, Muni has implemented bus bulges and bus islands along many surface streets with rapid transit (light rail and frequent bus). A report on the effects of bus bulges on transit found that buses experienced a 7% increase in vehicle speed and delays were significantly reduced at near-side stops.[1] Additionally, the amount of space for pedestrians also increased by 134%, allowing for a more comfortable and safe transit experience.[1]

- Seattle Department of Transportation has implemented bus boarding islands on multiple corridors in order to provide safer streets for bicyclists and pedestrians. Bus boarding islands have been installed on Dexter Avenue, Broadway, and Roosevelt Way. Over the 2.5 km of Dexter Avenue to be reconfigured, travel time remained the same as traffic volumes increased by 19%. Ridership on the corridor also increased by 40%.[3]

Figure 5: SFMTA Boarding Island on Market Street[2]

Figure 6: Seattle DOT Bus Island on Dexter Avenue[4]

1 Fitzpatrick et al., "TCRP Report 65: Evaluation of Bus Bulbs," 2001. https://nacto.org/wp-content/uploads/2015/04/tcrprpt65_fitzpatrick.pdf

2 Google Maps, 2017. https://www.google.com/maps/@37.7804934,-122.4125139,3a,75y,41.02h,90.38t/data=!3m6!1e1!3m4!1sZcg5GZpvKJRWlXBqqkyKVQ!2e0!7i16384!8i8192

3 Chang, Dongho, "Expanding Networks to Seattle's Job Centers," 2015. http://www.lgc.org/wordpress/wp-content/uploads/2015/07/Dongho-Chang.pdf

4 NACTO, "Transit Boarding Islands, Dexter Avenue, Seattle," 2018. https://nacto.org/case-study/dexter-avenue-bus-island-seattle/

- In Toronto, multiple corridors along streetcar and bus lines have had a shared cycle track stop installed. These stops are generally used when right-of-way space is limited. Example corridors include Sherbourne Street and Roncesvalles Avenue. Additionally, as part of the King Street Transit Pilot, most of the stops within the pilot area along King Street have been marked out with partial and temporary bus bulges. These temporary bus bulges can be seen in Figure 8.[6]

- In 2005, a study for the New Jersey Department of Transportation found that after bus bulges were implemented, buses saved 15-30 seconds per stop at along high traffic corridors. Bus speeds along corridors increased by 3 km per hour.[7]

- Many agencies, such as AC Transit in Okaland and New York MTA, have also implemented temporary or piloted bus infrastructure by using temporary materials. These include implementing "stoplets" (a play on the parklet concept), painting the street and using wood ramps, or using rubber pads bolted to the street until a permanent bus bulge or boarding island can be installed.[8]

Figure 7: Toronto TTC Shared Cycle Track Stop on Roncesvalles Avenue[5]

Figure 8: TTC King Street Temporary Transit Bulge[6]

5 NACTO, "Shared Cycle Track Stop," 2018. https://nacto.org/publication/transit-street-design-guide/stations-stops/stop-configurations/shared-cycle-track-stop/

6 Neil, Lauren, "Toronto Can't Seem to Agree on Future of King St," 2018. https://www.blogto.com/city/2017/12/toronto-future-king-street-pilot-project/

7 Daniel and Konon, "Effectiveness of Bus Bulbs for Bus Stops," 2005. HTTPS://NTLREPOSITORY.BLOB.CORE.WINDOWS.NET/LIB/24000/24700/24789/BUSNUBS.PDF

8 Transit Center, "Why Tactical Transit is the Next Big Thing," 2016. http://transitcenter.org/2016/12/19/why-tactical-transit-is-the-next-big-thing/

C2. Turn Pockets

Turn pockets are separate lanes for vehicles turning left or right at an intersection or driveway. Turn pockets provide space for vehicles to wait for a dedicated turn signal, a break in opposing traffic, or pedestrians to cross an intersection.

Strategy Overview

This specialized storage space minimizes delay to other users of the roadway, including transit vehicles, as transit and other vehicles would otherwise have to weave around turning vehicles.

Turn pockets are commonly employed at intersections with a high volume of turns. Turn pockets can also be effective tools to reduce delay and conflicts at intersections with relatively low—but consistent—turning volumes and high volumes of concurrent pedestrian movements and/or a high volume of transit vehicles. Right-turn pockets are often placed in the parking lane, while left-turn pockets may be placed in an existing median. However, turn pockets may require widening a roadway where those options are not available. On wide roads, turn pockets may be paired with boarding islands or transit approach lanes to further reduce conflict between buses and motorists.

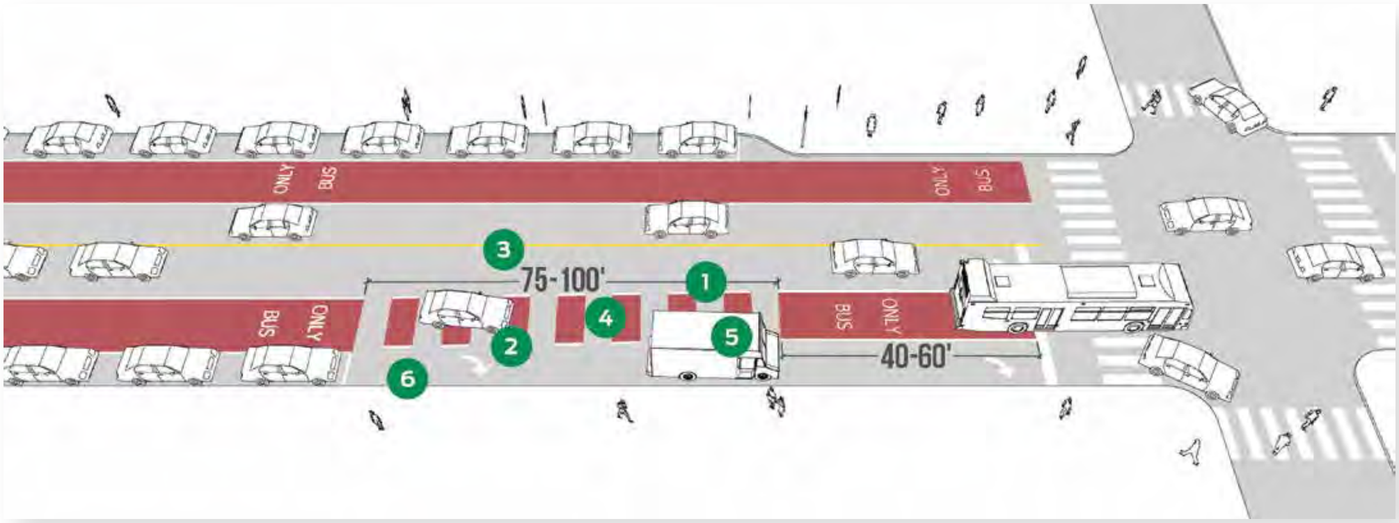
Motor vehicle turns made from a general purpose lane can cause delay to transit by limiting the flow of buses through an intersection. Turn pockets reduce delay to buses caused by turning vehicles, thereby reducing the likelihood of encountering a red light.

COORDINATION

The implementation of turn restrictions requires close coordination with local municipalities.

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations where turning movements cause delay to transit operations.
Municipality	• Impact on city street right-of-way from the addition of lane striping and signage placement. • Additional traffic enforcement, if necessary.

Figure C2.1: Right-Turn Pocket



Source: NACTO

Figure C2.2: Las Vegas Right-Turn Pocket

Source: Google Maps

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Allows transit to remain in lane improving travel times by 2 minutes over a 4 km corridor + Fewer delays for through-moving transit	+ Reduces delays at intersections with high right-turn, pedestrian, and/or transit volume − Large turning queues or lack of enforcement can block transit lane	+ Reduces travel time through corridor + Improves reliability of scheduled service	+ Reduces weaving of motorists around turning vehicles + Can reduce accidents by up to 85% − Additional interactions between transit and turning vehicle traffic − May increase pedestrian crossing distance

ESTIMATED COSTS	COST
Single Bus Boarding Island	$35,000-$200,000
Left turn pocket signage and striping	$500-$3,000
Signal upgrades	$500-$14,000

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★		★★	★	★							★★	$–$$	Medium

CHALLENGES

- May require the removal of a median, parking spaces, or other curbside uses.
- Turning vehicles must still cross the transit lane, which can cause delays if there is a high volume of turning vehicles.
- The location of bicycle lanes or cycle tracks must also be considered so that turning vehicles are not in conflict with cyclists.
- May lengthen pedestrian crossing distance.

COMPLEMENTARY TREATMENTS

Turn pockets are most effective when paired with the following complimentary treatments:

Bus Stop Placement

Curb-side bus stops should be located downstream from turn pockets, ideally on the far side of the intersection.

Curb Management

On-street parking may be adjusted to provide turn pockets.

Bus Stop Infrastructure

Transit boarding islands allow for physical separation of turning vehicular traffic, increasing safety. Access to pocket lane must be provided before boarding island, which may require additional curb space.

Dedicated Bus Lane

Turning traffic crosses dedicated right of way for buses to reach turn pocket.

ALTERNATIVE TREATMENTS

Movement Restrictions

Restricting vehicle traffic to making only left or right turns would negate the need for pocket lanes, instead requiring full travel lanes separated from dedicated lanes. Additionally, restricting turns would negate the need for turn pockets.

Transit Approach Lane

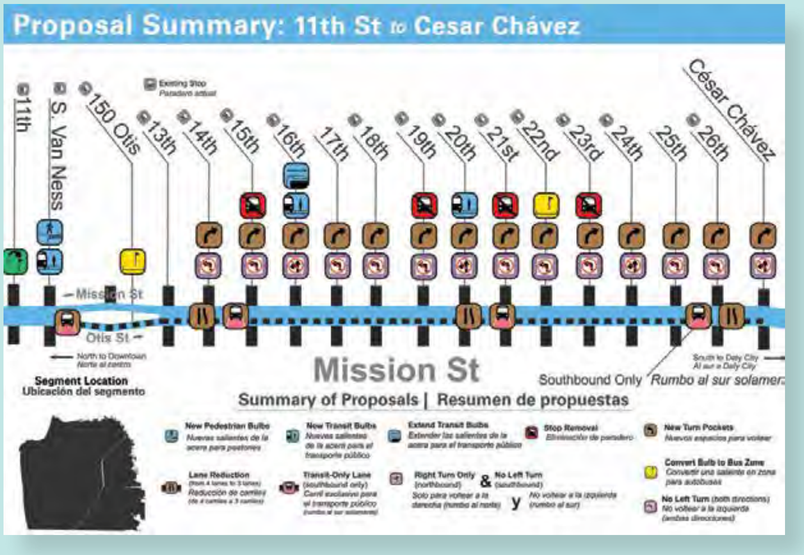
Turning traffic may be split off from dedicated transit before intersection through the use of a transit approach lane.

TURN POCKET EXAMPLES

Multiple road authorities and transit agencies have implemented turn pockets at intersections with a high volume of right turns.

- Turn pockets are frequently used by SFMTA to reduce delays at intersections caused by right-turning vehicles. Implementation includes both full-time and peak-hour turn pockets, where on-street parking is prohibited during peak hours to allow for a right turns across transit lanes. In 2017, SFMTA completed the 14 Mission Rapid Project, which consisted of a number of transit treatments along Mission Street, including the implementation of turn pockets at 20 intersections. Though specific benefits of turn pockets were not calculated, the project reduced Muni collisions by 85%, reduced corridor travel times by two minutes, and improved reliability by reducing time spent waiting at signals.[1]

Figure C2.3: Mission Street Treatments, Including Turn Pockets[1]



- The United States Federal Highway Administration has found that by adding right turn lanes at major intersections, collisions between right turning traffic and through traffic can be reduced by 5%. By using part of a transit lane to lengthen the deceleration area for right turning traffic, all collisions can be reduced by an additional 10%.[2]

- Many other cities, such as Los Angeles, use turn pockets to prioritize through-moving transit. Left-turn pockets are used to accommodate left turns across center-running transit, while right-turn pockets are useful for curbside or offset transit.[3]

Figure C2.4: Transit Lane Turn Pockets on 3rd Street in San Francisco[4]

1 SFMTA, “14 Mission Rapid Project”, 2017. https://www.sfmta.com/projects/14-mission-rapid-project

2 https://www.fhwa.dot.gov/publications/research/safety/04091/12.cfm#c123

3 Los Angeles Department of City Planning, “Complete Streets Manual”, 2014. http://planning.lacity.org/Cwd/GnlPln/MobiltyElement/Text/CompStManual.pdf

4 Google Maps

C3. Vertical Control Devices

Vertical control devices are protrusions or depressions in the roadway that limit the speed or movement of vehicles through a corridor or intersection.

Strategy Overview

These devices can be modified to mitigate impacts to transit speed and customer comfort or even promote exclusive access to transit vehicles.

Speed humps and speed tables are most commonly used in low-volume corridors, narrow intersections in commercial corridors with heavy pedestrian volume, or residential neighborhoods to promote slow, consistent speed and discourage through-traffic. As an alternative, speed cushions are protrusions in the roadway that include wheel cut-outs to allow larger transit vehicles, emergency response vehicles, and bicyclists to pass through unimpeded, while slowing down general purpose traffic.

Some vertical control devices are designed to limit access of a roadway for the exclusive use of transit vehicles. Hydraulic bollards can allow transit vehicles into limited access areas by lowering the bollards with automatic readers or remote control when a bus approaches. Sump busters are raised concrete barriers designed to permit access to buses and emergency response vehicles, but not smaller motor vehicles. Similarly, bus traps are depressions in the roadway designed to accommodate the wheelbase of buses and emergency vehicles, but not smaller motor vehicles. Hydraulic bollards, sump busters, and bus traps may be placed at the entrance of a dedicated busway as an extra precaution to deter any unauthorized vehicle access.

COORDINATION

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations for possible transit cut through or need to limit potential vehicular traffic from transit lane.
Municipality	• Minor impact on city street right-of-way from the installation of vertical speed controls to major impacts with street closures to general vehicular traffic.

Figure C3.1: Vertical Control Devices – Speed Hump (Left), Speed Table (Middle), and Speed Cushion (Right)

Source: NACTO

Figure C3.2: Sump Buster (Left) and Bus Trap (Right)

Source: https://bracknellblogger.wordpress.com/2014/09/03/what-is-a-sump-trap/ & https://twitter.com/pbakhmut/status/850370440350416896

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Restricting access to only transit improves travel time by creating transit-only streets – Some vertical control devices reduce vehicle speeds	+ Speed humps, tables, and cushions may reduce vehicle volumes – Larger vehicles may be able to avoid devices	+ Transit-only streets eliminate congestion – May face public opposition in restricting access to motor vehicle traffic	+ Transit-only restrictions eliminate interactions with other vehicles + Up to 14 km/h speed reduction and up to 30% injury collision reduction – Sump busters can be tampered with and damage buses

ESTIMATED COSTS	COST
Speed table	$3,000-$30,000
Hydraulic bollards	$15,000-$100,000

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
	★★★				★★	★		★★	★★★	★★★	★	$	Medium

CHALLENGES

- Devices should be paired with visible signage or clear street markings to indicate that speed must be reduced or access is not permitted.
- Devices should be located on streets that do not interfere with emergency vehicles' access routes.
- Neighborhoods and communities should be consulted before implementing vehicle control devices, particularly those that restrict motor vehicle access.
- Devices should be part of a comprehensive traffic plan, as they may contribute to congestion on other streets or interfere with emergency services.
- Sump busters and bus traps are not as effective for larger motor vehicles, and tend to face public backlash.

COMPLEMENTARY TREATMENTS

Bus Stop Placement
Locating bus stops in areas that are restricted to all traffic except for transit significantly improves boarding times, transit reliability, and safety.

Movement Restrictions
Restricting turns with the use of diverters or bollards to prevent congestion can reduce conflicting traffic patterns to benefit transit.

Dedicated Bus Lanes
With separated dedicated transit lanes, vertical control devices can help provide passive enforcement of transit only lanes.

Transit-Signal Priority
When entering a transit-only area after a signal, activation of the transit signal priority can also automatically activate the use of a hydraulic bollard by a transit vehicle.

ALTERNATIVE TREATMENTS

Peak-Hour Bus Lanes
Permanent vertical control devices cannot be used with a peak-hour travel lane, as the lane must be used by general vehicular traffic during off-peak times.

VEHICLE CONTROL DEVICES EXAMPLES

Vertical control devices are often used for safety and speed reduction benefits, rather than as a means of promoting transit. While some devices may reduce vehicle speeds, they can also reduce vehicle volumes, which may improve transit reliability as fewer vehicles contributes to less congestion and delays for transit.

- Many cities in North America use raised intersections and crosswalks to reduce traffic speeds and increase safety.
- Speed humps are the most commonly used traffic calming device in Quebec, and have contributed to reduced speeds and fewer collisions.[1] For example, speed humps were installed in Saint-Aimé-des-Lacs, Quebec in 2008, which resulted in speed decreased of 5-14 km/hr, which correlates to a 10-30% reduction in injury collisions.[3]
- Sump busters are used on the O-Bahn Busway, a 12km long guided busway connecting Adelaide, South Australia to its suburbs. Though the sump busters are not directly responsible for the benefits of the O-Bahn, they reinforce the exclusive right-of-way for buses that has reduced travel times between Adelaide and the suburbs from 40 minutes to 25 minutes.[4]
- In 1992, the City of Cambridge, UK implemented hydraulic bollards to restrict traffic into and out of the city center at key entry points, permitting only local buses, taxis, and bicycles.[5] The bollards were successful in aiding transit, and resulted in a 21% decrease in traffic through the city center and an 88%increase in bicycling along with additional infrastructure. The bollards were removed in 2016 due to complications with emergency vehicles and replaced by more cost-effective cameras that automatically capture and ticket vehicles that use the restricted streets.[6]

Figure C3.3: Raised Crosswalk in Cambridge[2]

Figure C3.4: Sump Buster on the O-Bahn Busway[7]

Figure C3.5: Rising Bollards on Bridge Street in Cambridge, UK[5]

1 Ministère des Transports du Québec, “Traffic Calming in Québec: Speed Humps and Speed Cushions”, 2013. https://nacto.org/wp-content/uploads/2015/04/traffic_calming_in_quebec_berthod.pdf

2 Google Maps

3 “Motorized Traffic and Health: Interventions to Mitigate its Impacts”, 2012. http://www.ncchpp.ca/docs/CPHA2012_4Highways_en.pdf

4 “Adelaide, Australia: O-Bahn Guided Busway, 2003. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp90v1_cs/Adelaide.pdf

5 Walls, Tom, “Traffic Management in City Centres”, 2015. http://www.atgaccess.com/wp-content/uploads/2015/09/white-paper-traffic-management.pdf

6 Brown, Raymond, “Nearly 100 drivers a day are fined for using city ‘rat runs’ where rising bollards used to be”, 2017. https://www.cambridge-news.co.uk/news/cambridge-news/cambridge-rat-run-anpr-roads-13014779

7 https://railgallery.wongm.com/adelaide-obahn/E112_7604.jpg.html

C4. Queue Jumps

Queue jump lanes are either short dedicated transit lanes or shared turn pockets paired with transit signal priority that allow transit vehicles to bypass traffic at an intersection.

Strategy Overview

Queue jumps can be implemented at both near-side and far-side bus stops, though different treatments are appropriate depending on the stop placement. In either case, queue jumps must be implemented with transit signal priority (TSP). When paired with TSP, buses approach an intersection in a dedicated lane or shared turn pocket and receive an early green signal or transit-only signal that allows them to proceed through an intersection before other traffic.

Allowing transit vehicles to bypass the queue can significantly decrease delay at traffic signals and reentry from the bus stop to travel lane. By reducing delays at intersections, queue jumps can further improve the reliability of the route, especially if paired with transit signal priority.

COORDINATION

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations for effective implementation of queue jump lanes. • Working with municipality to locate stops to maximize potential benefits.
Municipality	• Signal installation, programming, and coordination for transit signals, if necessary. • Impact on city street right-of-way from the addition of lane striping and signage placement. • Assistance relocating bus stops to maximize benefits.

Figure C4.1: Queue Jump Diagram

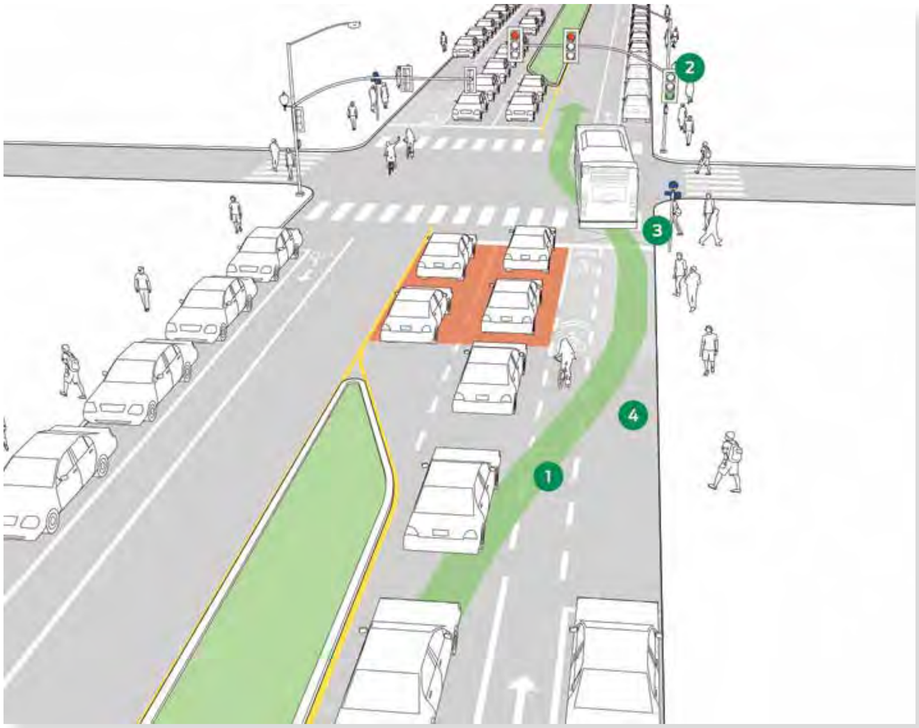


Figure C4.2: New York MTA Select Bus Service Queue Jump Lane

Source: NACTO; NYC DOT

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Reduces travel times by up to 30%	+ Reduces delays at intersections by 7% + Improves schedule adherence by 45% – Right-turns can congest queue jump lanes	+ Reduces wait times at traffic signals	+ Fewer conflicts at intersections + Visibility improvements – In non-TSP lanes merging can be hazardous

ESTIMATED COSTS
$5,000-$20,000, based on the type of detection deployed, including $500-$3,000 for signage and striping

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★★		★★★						★★				$–$$	Medium

CHALLENGES

- Requires either the construction of additional lanes or the conversion of existing general purpose or parking lanes.
- Requires transit signal priority.
- High volume of right turns and/or high volumes of concurrent pedestrian crossings limit the effectiveness of queue jumps in the right-turn pocket.
- The queue jump lane must be long enough to allow for turns and time savings, but not so long as to significantly impede traffic.
- Queue jumps can be implemented at both near-side and far-side bus stops, though different treatments are appropriate depending on the stop placement.
- Bus stop location must be considered.

COMPLEMENTARY TREATMENTS

Queue jump lanes can be effective when implemented alone, but are most effective when paired with the following complementary treatments:

Bus Stop Placement

Bus stops should be located mid-block or near-side the queue jump to avoid stopping both before and after the intersection to reduce dwell time.

Turn Pocket

Turn pockets allow conflicting turning traffic to be separated from the queue jump lane to ensure the bus can utilize the queue jump and improve travel speed.

Transit-Signal Priority

Designated bus signals with inserted green phase can improve the safety at queue jumps and reduce dwell time at nearside stop boarding locations.

ALTERNATIVE TREATMENTS

Movement Restrictions

Restrictions that prohibit through movements for non-transit vehicles would negate the need for queue jump lanes by only permitting access through an intersection for transit.

Transit Approach Lane

Transit approach lanes serve a similar purpose as queue jumps by allowing transit to bypass congestion at an intersection.

Dedicated & Peak-Hour Bus Lane

Dedicated right-of-way separates transit from general vehicular traffic at intersections, negating the need for queue jump lanes.

QUEUE JUMP EXAMPLES

Multiple transit agencies have implemented queue jumps at intersections, often in conjunction with other transit priority treatments.

- In 2015, the MTA launched Select Bus Service for the M86 route, which included three queue jump lanes. As a result of the queue jumps, time stopped in traffic was reduced by 7% in the westbound direction and 30% in the eastbound direction. Travel times were also decreased by 2 minutes, with an increase of 14% in the amount of time buses spent traveling above 15 mph.[1]
- Calgary Transit implemented queue jump lanes along a high volume corridor, resulting in travel time savings of 25-30% in the corridor and 1.5 to 2 minutes off of trip times. The queue jump lanes also improved schedule reliability by 45%, though merging back into travel lanes did contribute to some delay.[2]
- In 2003, TransLink implemented a number of bus treatments on the 98 B-Line route between Vancouver and Richmond, including queue jump lanes. The transit priority improvements resulted in travel time savings of 20%, and precluded need for five additional vehicles.[3]

Figure C4.3: Queue Jumps Reduced Average Dwell Times[1]

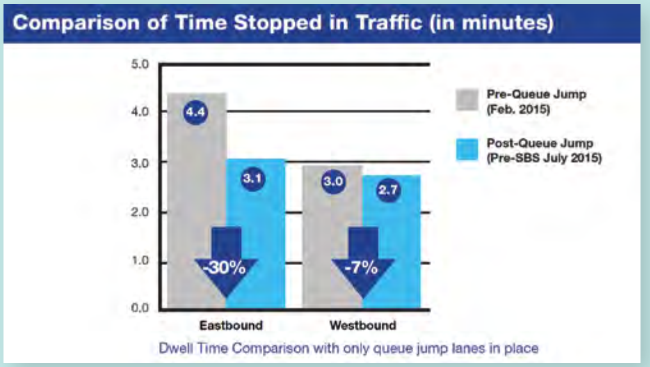


Figure C4.4: Queue Jump Lanes in Calgary, AB[2]

1 New York City DOT, "M86 Select Bus Service Progress Report", 2017. http://www.nyc.gov/html/brt/downloads/pdf/brt-m86sbs-progress-report-april2017.pdf

2 City of Calgary, "Bus Queue Jump (Lane) Utilization: A case study in Calgary, AB Canada", 2017. http://itsworldcongress2017.org/wp-content/uploads/2017/11/Asim.pdf

3 Transport Canada, "Bus Rapid Transit (BRT), Queue Jump Lanes, Transit Signal Priority", 2003. http://data.tc.gc.ca/archive/eng/programs/environment-utsp-tdm-prj18e-832.htm

C5. Transit Approach Lane

Transit approach lanes are short dedicated lanes that separate buses from traffic queues at intersections.

Strategy Overview

Transit approach lanes typically divide a general purpose lane and turn pocket at the approach of a controlled intersection. This treatment is often implemented with red paint, “bus only” decals, striping, and signage.

Transit approach lanes are beneficial at intersections with long queues of motorists, high frequency of right turns, and/or high volume of concurrent pedestrian movements that delay right-turning motorists. Unlike some queue jumps, transit approach lanes offer an exclusive right-of-way for transit. They also align with a receiving lane on the far side of the intersection, allowing transit approach lanes to function independent from any signal infrastructure.

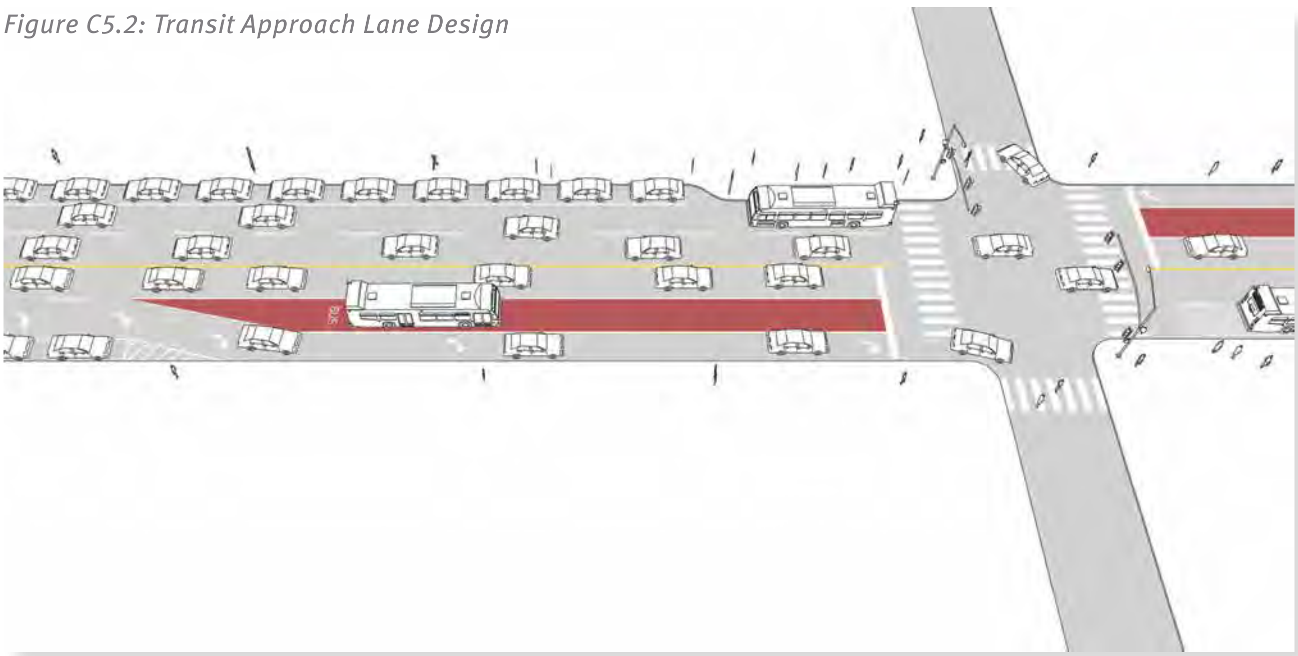
COORDINATION

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations with heavy congestion and turning traffic for effective implementation of transit approach lanes to maximize potential benefits.
Municipality	• Impact on city street right-of-way from the addition of lane striping and signage placement. Requires additional traffic enforcement.

Figure C5.1: San Francisco Muni Transit Approach Lane – Stockton St

Source: Google Maps

Figure C5.2: Transit Approach Lane Design



Source: NACTO

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Allows transit to remain in lane, reducing travel time	+ Reduces delays at congested intersections or with longer cycle times − Lack of enforcement can block transit lane	+ Reduces wait times in traffic at signals by 30%	+ Visibility improvements − Potential conflicts with right turn vehicle traffic

ESTIMATED COSTS	COST
Signage and striping at intersection	$500-$3,000

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★★		★★★						★★				$	Medium

CHALLENGES

- Requires either the construction of additional lanes or the reallocation of space on the roadway reducing the space available for general purpose lanes or on-street parking.
- Length of transit approach lane depends on length of right-turn queues and availability of curb to create right-turn pocket.
- Other vehicle queues may get longer if a lane is converted to a transit only lane.
- Requires enforcement of vehicle restrictions in transit approach lane, although highly visible markings (e.g. red lanes) improve compliance.

COMPLEMENTARY TREATMENTS

Transit approach lanes are effective when implemented alone, but are most effective when paired with additional complementary treatments:

Bus Stop Placement

Curb-side bus stops should be located mid-block or far-side, as the turn lane would be located at the near side of an intersection.

Curb Management

Reduction of parking along curb required to create turn lane.

Bus Stop Infrastructure

Transit boarding islands allow for physical separation of turning vehicular traffic, increasing safety.

Transit-Signal Priority

An extended green or truncated red signal allows transit to more reliably clear an intersection in a transit approach lane.

ALTERNATIVE TREATMENTS

Movement Restrictions

Restricting vehicle traffic to making only left or right turns would result in transit approach lanes becoming dedicated transit lanes.

Dedicated & Peak-Hour Bus Lane

Transit approach lanes are not needed if dedicated or peak-hour bus lanes are already present.

Queue Jumps

Queue jumps serve a similar purpose as transit approach lanes by allowing transit to bypass congestion at an intersection.

TRANSIT APPROACH LANE EXAMPLES

The use of transit approach lanes is almost always implemented as other strategies, such as queue jumps or the beginning of dedicated or peak-hour bus lanes.

- In 2015, the City of Chicago built the Loop Link to provide faster service in the downtown Chicago area. The main one-way pair of Washington St and Madison St were reconstructed to have dedicated transit lanes and level boarding platforms. Due to the north-south one-way streets in downtown Chicago, stations were placed on blocks where the next intersection had only left turn or straight traffic patterns. At the intersections between these blocks, traffic patterns are either straight or right turning. The right turning traffic is separated from the transit lane by a transit approach lane, as seen in Figure 4. The transit approach lane allows transit vehicles to pass queueing right turn traffic.[1]

- Many transit agencies, such as New York MTA, have implemented transit approach lanes as queue jump lanes with or without transit signal priority. From the M86 conversion to Select Bus Service, MTA tracked individual pieces of bus priority strategies. The transit approach lanes helped reduce time in traffic by 30%, while traffic volumes remained the same, even after removal of a travel lane.

- Transit approach lanes would also provide some of the benefits that queue jump lanes do, such as reducing the number of signal cycles transit must wait through at highly congested intersections.

1 City of Chicago, "Loop Link", 2018. http://www.transitchicago.com/looplink/

2 Google Maps

3 New York City DOT, "M86 Select Bus Service Progress Report", 2017. http://www.nyc.gov/html/brt/downloads/pdf/brt-m86sbs-progress-report-april2017.pdf

Figure C5.3: Beginning of Transit Approach Lane with Allowed Turning Traffic – Washington Street in Chicago[2]

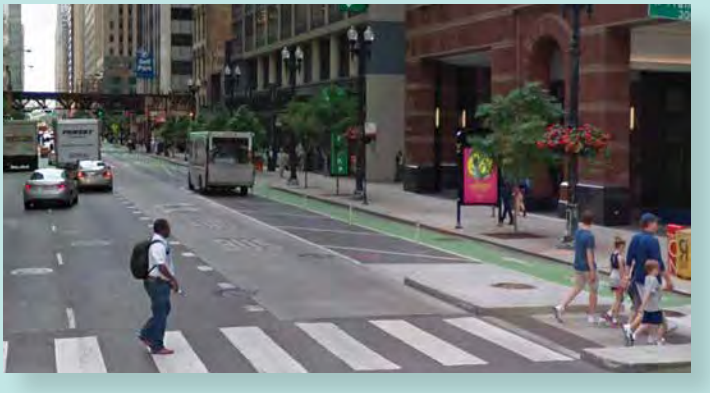


Figure C5.4: End of Transit Approach Lane with Separated Turning Traffic – Washington Street in Chicago[2]

Figure C5.5: MTA Select Bus Service (SBS86) Approach Lane[3]

C6. Peak-Hour Bus Lane

Peak-hour bus lanes are lanes reserved for the exclusive use of buses during designated peak periods and free for general use or parallel parking during off-peak times.

Strategy Overview

These lanes are typically located curbside and facilitate improved transit service during periods of high demand. Designed lanes may be restricted to buses only in the peak commute direction, often inbound in the morning and outbound in the afternoon.

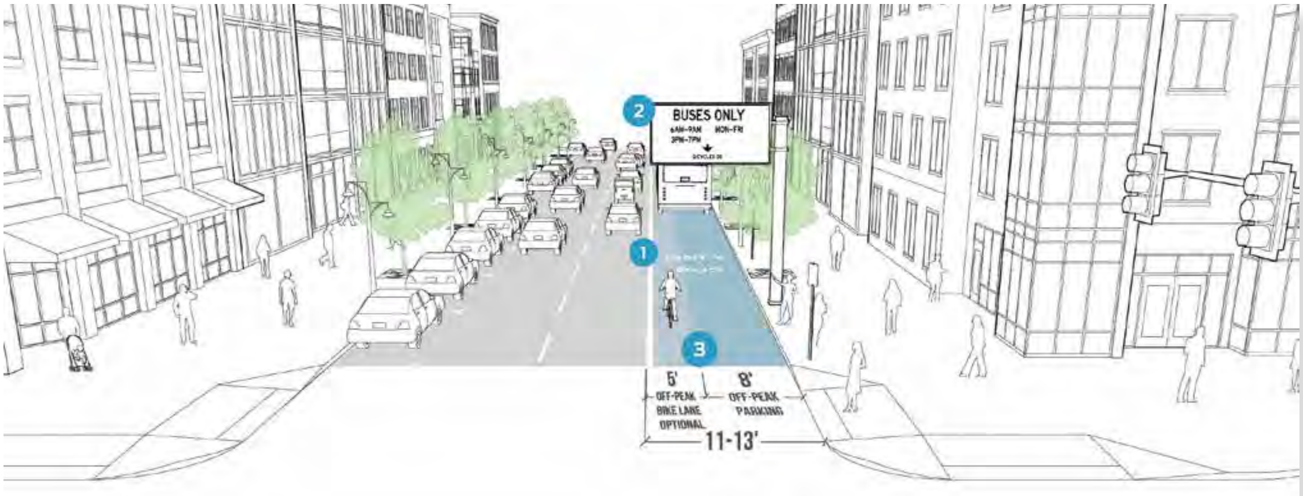
Peak-hour bus lanes improve bus travel speeds and reliability by reducing delays caused by motor vehicle traffic during the most congested times. These improvements reduce travel time and the cost of providing service. In addition to improving operating speed, peak-hour bus lanes improve schedule reliability by reducing variability in travel time.

COORDINATION

Peak-hour bus lanes require close coordination with local municipalities.

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations for effective implementation of peak-hour bus lanes and locating stops in optimum locations (far side) to maximize potential benefits.
Municipality	• Impact on city street right-of-way from the addition of lane striping and signage placement. Additional traffic enforcement requirements during transit only times.

Figure C6.2: Peak-Hour Bus Lane Diagram



Source: NATCO

Figure C6.1: WMATA Peak-Hour Bus Lane on Georgia Avenue (shared with bicycle, left) & LA Metro Peak-Hour Bus Lane on Wilshire Boulevard (right)

Source: NATCO

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Corridor travel time reduced by up to 30%	+ On-time performance increased by 65% – Benefits only apply during peak times	+ Increases travel speed + Reduces time waiting at bus stop, as buses do not need to merge + Improves travel time reliability	+ Reduces interaction with motor vehicle traffic – Potential conflicts with right turn motor vehicle traffic

ESTIMATED COSTS	COST
Separated Lanes in Existing Right-of-Way	$4,000,000-$6,500,000 per lane km[1]
Converting Existing Lanes	$200,000-$450,000 per lane-km[1]
Maintenance Costs	$20,000 per lane-km per year[1]

1 TRB, "TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic", 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★	★★		★★	★★	★★	★★	★★	★★★		★	★★	$$–$$$$	High

CHALLENGES

- While peak-hour travel times will be improved, customers will not experience travel benefits during off-peak hours.
- Lanes should be painted red and visibly marked to minimize violations.
- Benefits are dependent on the enforcement and legibility of lane restrictions.
- Peak-hour only lanes are often limited to curbside lanes, which may restrict additional stop improvements such as curb extensions and conflict with pedestrian traffic and right turning motor vehicle traffic.

COMPLEMENTARY TREATMENTS

Peak-hour bus lanes provide significant benefits to travel times and reliability, but can be combined with other treatments to enhance transit improvements.

Bus Stop Placement

Optimizing bus stop locations reduces dwell times and further increases the reliability and travel time benefits of bus lanes.

Curb Management

Curbside management can reduce the occurrence of parked or loading vehicles in bus lanes.

Movement Restrictions

Turn restrictions can reduce the conflicts with bus lanes at intersections.

Bus Stop Infrastructure

In-lane bus stops prevent buses in peak-hour lanes from having to merge to re-enter traffic.

Turn Pockets

Allow vehicles to make turns at an intersections while minimizing interruption to bus-only travel lanes.

Passive Signal Priority & Transit-Signal Priority

Signal priority for transit allows buses to travel through intersections in the bus lane, eliminating delays from traffic at intersections.

All-Door Boarding

Stop locations that facilitate all-door boarding can reduce dwell time and variability, providing further travel time benefits.

ALTERNATIVE TREATMENTS

Queue Jumps

Allowing transit to bypass traffic at an intersection is unnecessary with a bus-only travel lane.

Transit Approach Lane

An exclusive transit lane just before an intersection is unnecessary with a bus-only travel lane.

Dedicated Bus Lane

Providing a full-time travel lane for transit negates the need for peak-hour lanes.

PEAK-HOUR BUS LANE EXAMPLES

Multiple transit agencies have implemented peak-hour bus lanes.

- Starting in 1990, Montreal's STM has been operating reserved bus lanes as part of their Bus Preferential Measures (BPM). STM now has 221.7 km of reserved bus lanes with 19 peak-hour bus lanes and 17 24-hour bus lanes.[1] On an individual corridor, a reserved bus lane can yield 15-20% shorter travel times, with an increase of 65%in overall on-time performance.[2]
- In 2006, TransLink and the City of Vancouver implemented peak-hour bus lanes along the Broadway corridor on the 99B-Line. However, due to the high number of right turn traffic along the corridor, the bus only lanes provided little to no travel time savings.[3]
- In 2011, Calgary Transit and the City of Calgary announced the implementation of a peak-hour bus lane on 9th Ave in the Inglewood neighborhood. At time of implementation, the peak direction, peak-hour bus lanes carried 25 buses per hour through the corridor.[4]
- In 2016, the City of Everett, Massachusetts deployed a pop-up bus lane in the morning peak. The lane is used by buses from 4 am to 9 am and then reverts to on-street parking and a bicycle lane during all other hours. After a successful pilot for a week, the bus lane was extended permanently, and in 2017 was officially painted. Along the 1.5 km stretch, bus travel times decreased by 20-30%.[5]

1 Société de transport de Montréal, "Bus Preferential Measures," 2018. http://www.stm.info/en/about/major_projects/bus-preferential-measures-bpm

2 Surprenant-Legault, "Introduction of a reserved bus lane: Impact on bus running time and on-time performance," 2010. https://journals.sagepub.com/doi/10.3141/2218-02

3 City of Vancouver, "Bus Lanes on Broadway – Progress Report," 2007. http://council.vancouver.ca/20070612/documents/tt4_broadwayBusLanes.pdf

4 City of Calgary, "9 Avenue SE Bus-only lanes coming soon," 2011. http://www.calgarycitynews.com/2011/11/inglewood-9-avenue-se-bus-only-lanes.html

5 Transit Center, "Everett Bus Lane: The Little Pop-Up That Could," 2018. http://transitcenter.org/2018/01/02/everett-bus-lane-the-little-pop-up-that-could/

Figure C6.3: Peak-Hour Bus Lane Signs in Calgary[4]

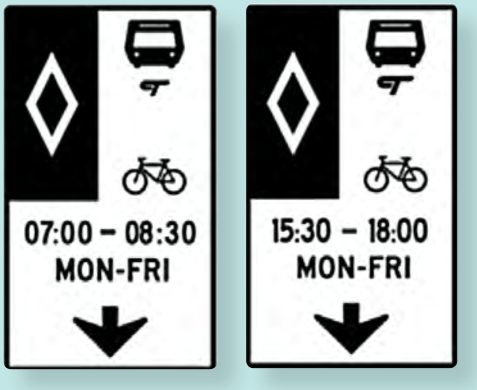


Figure C6.4: Peak-Hour Sign on Traffic Light in Calgary[4]

Figure C6.5: Peak-Hour Bus Lane in Everett, MA[5]

C7. Dedicated Bus Lane

Dedicated bus lanes are lanes reserved for the exclusive use of buses, except as specified. These lanes are typically found on corridors with heavy congestion and frequent bus service.

Strategy Overview

Dedicated bus lanes are often implemented by repurposing an existing travel lane or on-street parking lane. Legibility and compliance can be enhanced by designating bus lanes with red paint, "bus only" decals, signage above or adjacent to the lane, and separation from general travel lanes with a solid white line.

There are many variations of dedicated bus lanes. Dedicated bus lanes can be located curbside, offset from the curb by parking lanes or cycle tracks, or located in the median of a roadway. Bypass lanes allow buses to use existing right-turn lanes or shoulders to pass traffic at an intersection. Contraflow bus lanes allow buses to travel in the opposite direction of traffic on what would otherwise be a one-way street. Reversible bus lanes permit travel only in a single direction, often the peak commute direction.

Dedicated bus lanes can dramatically improve bus travel speeds and reliability by reducing delays caused by motor vehicle traffic. These improvements reduce the cost of providing service. Dedicated bus lanes also reduce conflict between buses and other vehicles, improving safety and comfort for roadway users.

COORDINATION

STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of locations for effective implementation of peak-hour bus lanes and locating stops in optimum locations (far-side) to maximize potential benefits.
Municipality	• Impact on city street right-of-way from the addition of lane striping and signage placement. • Assistance relocating bus stops to maximize benefit, as needed • Traffic enforcement requirement to ensure use only by authorized transit vehicles. • Additional stop amenities or full separation from other travel lanes may require additional right-of-way space.

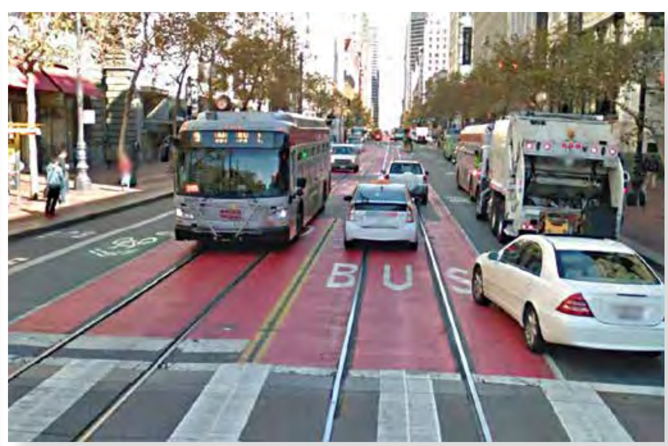
Figure C7.1: Diagram (Left) and Example of Curbside Bus Lane, Chicago CTA (Right)

Source: MTA & NACTO

Figure C7.2: Diagram (Left) and Example of Offset Bus Lane, New York MTA Select Bus Service (Right)

Source: NACTO

Figure C7.3: Dedicated Median Bus Lane – Diagram (Left) & San Francisco Market St (Right)



Source: NACTO & Google Maps

BENEFITS AND COSTS

STOP CONSOLIDATION

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Increases travel speeds + Improves average travel times by up to 8 minutes per km	+ Separates transit from general traffic and congestion + Reduces traffic conflicts, delays – Vulnerable to double-parked vehicles	+ Reduces travel times by up to 23% + Improves schedule adherence by up to 27%	+ Fewer conflicts with other vehicles – Drivers may ignore restrictions without proper enforcement

ESTIMATED COSTS	COST
Separated Lanes in Existing Right-of-Way	\$4,000,000-\$6,500,000 per lane km[1]
Converting Existing Lanes	\$200,000-\$450,000 per lane-km[1]
Maintenance Costs	\$20,000 per lane-km per year[1]

1 TRB, "TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic", 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★★	★★★		★★★	★★★	★★★	★★★	★★★	★★★		★	★★	\$\$–\$\$\$\$	High

CHALLENGES

- Requires either the construction of additional lanes or the conversion of existing lanes, which may reduce the space available for other traffic.
- Requires enforcement and signage to prevent the encroachment of double-parking, deliveries, taxis, or loading vehicles.
- Turning movements must be carefully managed to minimize conflicts with pedestrians, bicyclists, and other vehicle traffic.
- The conversion of travel lanes to bus lanes may face public opposition.

COMPLEMENTARY TREATMENTS

Dedicated bus lanes provide significant benefits to travel times and reliability, but are most effective when paired with the following complementary treatments:

Bus Stop Infrastructure

In-lane bus stops reduce lateral weaving of buses pulling into and out of bus stops, reducing acceleration and deceleration time and providing a more comfortable ride for customers.

Curb Management

Curbside management can reduce the occurrence of parking or loading activity taking place in the bus lane.

Movement Restrictions

Movement and turn restrictions can reduce the conflicts with bus lanes at intersections.

Turn Pockets

Turn pockets separate turning movements from transit lanes, reducing the potential for conflicts with turning vehicles queuing in dedicated bus lanes at intersections with a high volume of turns.

Passive Signal Priority & Transit-Signal Priority

Signal priority reduces delay caused by signals (red lights) and traffic (queues of cars).

All-Door Boarding

Curbside dedicated lanes or offset lanes with bus bulbs can reduce dwell times and variability by using all-door boarding.

ALTERNATIVE TREATMENTS

Dedicated bus lanes include a transit-only lane leading up to an intersection, which negates the need for any other treatments that allow buses to bypass vehicles to travel through intersections.

Queue Jumps

Allowing transit to bypass traffic at an intersection is unnecessary with a bus-only travel lane.

Transit Approach Lane

An exclusive transit lane just before an intersection is unnecessary with a bus-only travel lane.

Peak-Hour Bus Lane

Providing a peak-hour travel lane for transit negates the need for dedicated lanes.

DEDICATED BUS LANE EXAMPLES

Multiple transit agencies have implemented dedicated bus lanes. Dedicated lanes are often accompanied by a number of other bus prioritization treatments, such as transit-signal priority, turn-movement restrictions, and bus bulbs.

- In 2013, SFMTA implemented the Church Street Transit Lanes Pilot, which provided red-painted median bus lanes along three blocks on Church Street that were exclusive to transit and taxis. The dedicated lanes reduced travel time by 12-13% and travel time variability by 27%, providing faster and more reliable service along the corridor. Though left-turn restrictions and parking changes were also included, SFMTA found that delays for other vehicle traffic did not significantly increase and parking supply was not impacted, and the changes were made permanent.[1]
- Beginning in 2008, NYC DOT has implemented a number of Select Bus Service (SBS) routes, which benefit from several different prioritization treatments. In conjunction with off-board payments and the provision of real-time information, SBS routes included 61 km of dedicated bus lanes in the first five years. Bus lanes along the first six SBS routes have contributed to improved transit reliability and travel time savings of 13-23%, and helped increase ridership by 5-10%.[2]
- Many other cities have benefited from bus lanes, including:[3]
  - Los Angeles, CA – reduced travel times by 50-75 seconds per km for PM peak buses, improved reliability by 12-27%.
  - Dallas, TX – reduced travel times by 1.5-2.5 minutes per km.

Figure C7.4: Church Street Transit Lanes in San Francisco [1]

Figure C7.5: SBS Projects Implemented June 2008-November 2013[2]

1 SFMTA, "Church Street Transit Lanes", 2015. https://www.sfmta.com/sites/default/files/agendaitems/2015/6-2-15%20Item%2012%20%20Church%20St.%20Rapid%20Pilot%20-%20Final%20Report_1.pdf

2 NYC DOT, "Select Bus Service", 2013. http://www.nyc.gov/html/brt/downloads/pdf/brt-routes-fullreport.pdf

3 Transportation Research Board, "TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic", 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

D. Signal Priority

D1. Passive Signal Priority

Passive signal priority refers to adjusting signal timing on a corridor to promote the uninterrupted flow of transit between bus stops.

Strategy Overview

Transit signal progressions are pre-timed to provide a series of green lights, or a “green wave,” that matches historic or desired transit speeds. The timing of the signal cycles can differ depending on the time of day or day of the week. This is most effective on high-volume streets with closely-spaced signals and short signal cycles.

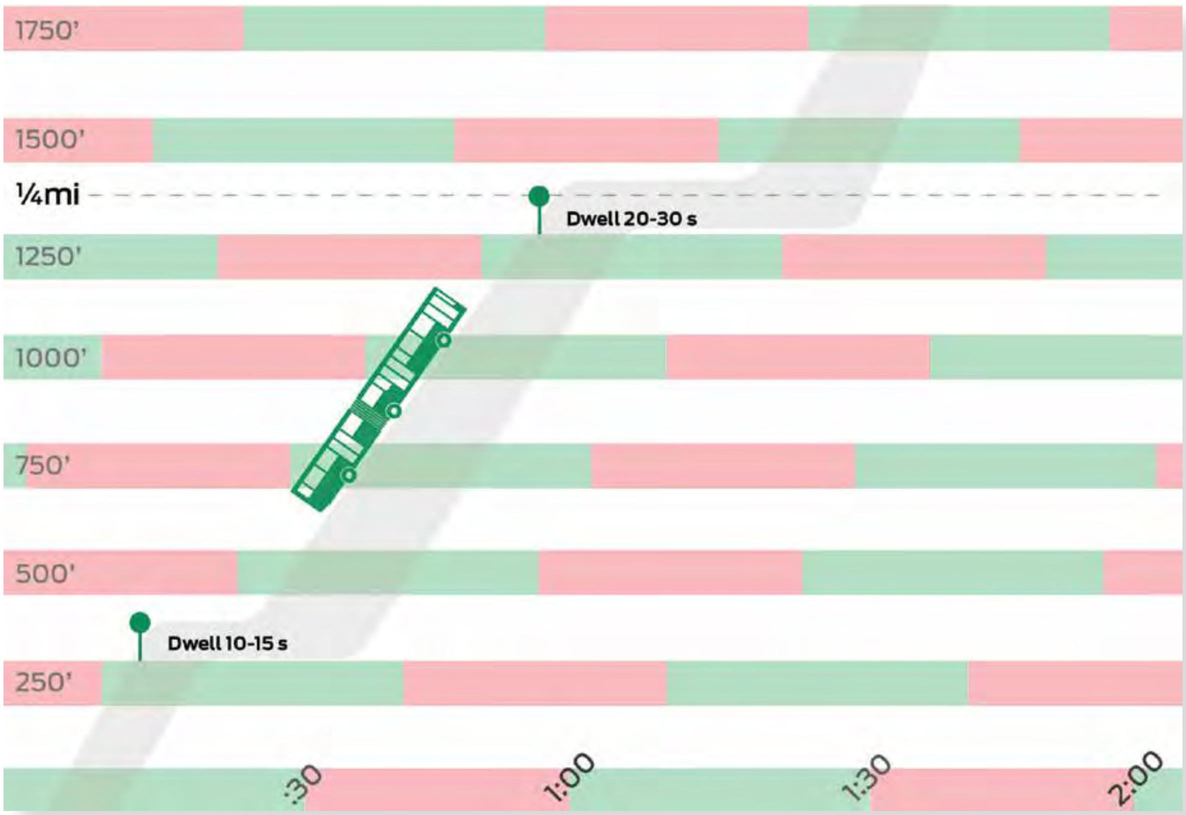
Passive signal priority can reduce travel times, minimize delays at signals, and increase travel time predictability, as transit can more reliably progress through intersections. Signal timing should account for dwell time at bus stops and traffic between signals. Passive signal priority strategies can be reinforced with complementary transit priority measures to reduce delay that might otherwise cause buses to fall behind the signal progression. Timing traffic signals for transit speeds also has safety benefits for bicyclists and pedestrians.

COORDINATION

Passive Signal Priority requires coordination with the local municipality that owns and operates the individual intersection signal. Corridors that cross highways or multi-jurisdictional streets may require the involvement of additional government agencies.

STAKEHOLDER	INVOLVEMENT
TransLink	• Determining preferred corridors to improve service and working with local transportation planners to determine corridors with high delay impacts due to signal timing.
Municipality	• Modeling of traffic impacts of corridor signal timing and the implementation of retiming at required signals.

Figure 1: Traffic Signal Progressions Provide Green Lights for Transit



Source: NACTO

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Corridor travel time reduced by up to 12% – Signals cannot be timed to meet the needs of more the one service such as limited stop and local service	+ Provides standard travel times through corridors + Schedule variation reduced by up to 20% – Any change to scheduled running time eliminates all operating benefits – Signals should be retimed every 3-5 years	+ Reduces stopping + Reduces travel time through corridor	+ Lowers speeds of all vehicles

ESTIMATED COSTS	COST
Signal Retiming	$3,500 - $7,500 per intersection, including data collection and analysis

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★	★	★★						★★	★	★	★★	$–$$	Medium

CHALLENGES

- Targeted speeds must incorporate a variety of factors, including block length, traffic volume, and cross-street signals, to ensure that transit vehicles do not fall behind the signal progression.
- May require prioritizing some transit services over others (e.g. local service vs. limited-stop service).
- Signal timing must account for stop-related delays, such as dwell times and acceleration at stops, and should not simply be set at or near speed limits.
- Pre-timed signals cannot properly account for fluctuations in traffic or for isolated intersections.

COMPLEMENTARY TREATMENTS

Passive signal timing can benefit travel times, but other treatment measures may be necessary to ensure that buses can keep up with the "green wave", or make up time to catch it when running behind schedule. Complementary treatments reduce dwell times and variability so buses can more reliably reach and travel through intersections at a consistent speed.

Bus Stop Placement and Consolidation

Stop consolidation can reduce dwell time variability and far-side stops ensure buses do not waste green signals.

Bus Stop Infrastructure

Allows buses to remain in the through lane at stops, reducing dwell times and variability so buses can keep up with the signal progression.

Queue Jumps

Mitigate the impact of congestion at intersections, allowing transit to travel through intersections.

Transit Approach Lane

Allows buses to reach and clear an intersection more reliably to benefit from signal priority.

Peak-Hour & Dedicated Bus Lane

Reduces traffic delays and variability, allowing for signal timing to be more reliable.

All-Door Boarding

Reduces dwell times and variability so buses can keep up with the signal progression.

ALTERNATIVE TREATMENTS

Active Transit-Signal Priority

Active signal timing would negate the need for passive TSP.

PASSIVE SIGNAL PRIORITY EXAMPLES

Many transit agencies have implemented passive TSP as part of a greater set of improvements for transit service along a corridor.

- In 2013, LADOT finalized the connection of all signalized intersections into the signal synchronization system. The system started in 1984 and works to adjust traffic patterns either on a passive or active basis. As of 2016, LADOT prioritizes rapid transit when possible. For passive transit priority, LADOT traffic engineers use pre-timed signals on major corridors to allow transit to move at a consistent pace. Along major corridors, signal synchronization increased travel speeds by 16% and reduced travel time by 12%.[1]

- In 2014, SFMTA implemented a pilot project on a 1.5 km section of Geary Street to improve travel times and reliability on Route 38L Geary Limited. The pilot sought to define the average speed of bus service along the corridor, while taking in consideration the additional dwell time. The dedicated bus lane allowed for more predictable traffic patterns, but varying dwell times reduced overall effectiveness. Over the 1.5 km corridor, buses generally had a 4% travel time saving and a 6% reduction in schedule variance on the limited route and a 20% reduction on the local route.[2]

- In 2016, King County Metro and the Seattle DOT partnered to develop multiple strategies to improve reliability on bus Route 8. In addition to stop enhancements, on-street parking restrictions, turn restrictions, and queue jump lanes, the Seattle DOT will adjust multiple adjacent signals to add additional green light time to allow for faster bus travel. These improvements are currently being implemented in multiple phases.[3]

Figure 2: Coordinated Signal Timing, Longview, WA[4]

- Many other major transit agencies, such as New York MTA and TTC have implemented signal timing adjustments as part of a larger strategy of active transit signal priority. Therefore, it is difficult to determine what benefits were from passive or active transit signal priority.

1 LADOT, "Los Angeles Signal Synchronization," 2016. http://ladot.lacity.org/sites/g/files/wph266/f/LADOT%20ATSAC%20%26%20Signals%20_%20Fact%20Sheet%202-14-2016.pdf

2 Pangilinan and Carnarius, "Traffic Signal Timing for Optimal Transit Progression in Downtown San Francisco," 2011. https://nacto.org/wp-content/uploads/2016/04/1-2_Pangilinan-Carnarius_Traffic-Signal-Timing-for-Optimal-Transit-Progression-in-Downtown-San-Francisco_2011.pdf

3 King County Metro, "Metro and Seattle DOT team up to ease Route 8 traffic choke points," 2016. https://kingcountymetro.blog/2016/12/12/metro-and-seattle-dot-team-up-to-ease-route-8-traffic-choke-points/

4 Knopf, Alfred. "A Speed Nudge?" 2008. http://howwedrive.com/2009/06/22/a-speed-nudge/

D2. Transit-Signal Priority (Active)

Transit-Signal Priority (TSP) is a set of tools and traffic management systems that detect transit vehicles and modify traffic signals to prioritize transit movements.

Strategy Overview

Signal prioritization can be given to all buses or exclusively to buses that are running behind schedule. TSP can be implemented throughout an entire corridor or at specific intersections.

Different TSP treatments include phase reservicing, phase extension, phase truncation, and phase insertion.

- Phase reservicing enables the same phase – such as a left-turn signal – twice in the same cycle, providing an additional opportunity for transit to clear an intersection.
- Phase extension prolongs a green light to allow transit more time to clear an intersection.
- Phase truncation ends a red light for cross traffic and provides an earlier green signal.
- Phase insertion prioritizes buses by providing bus-only phases that may make use of queue jumps to allow buses to bypass traffic.

The proper treatment depends on the conditions at an intersection or corridor, such as traffic volume and direction, cycle length, and distance between signals. TSP is most effective at intersections or corridors where signal cycles are long, causing large delays and frequent, lengthy queues, because longer cycles allow for greater flexibility in prioritizing transit. TSP strategies can be reinforced with complementary transit priority measures like far-side stops and an appropriate degree of dedicated lanes.

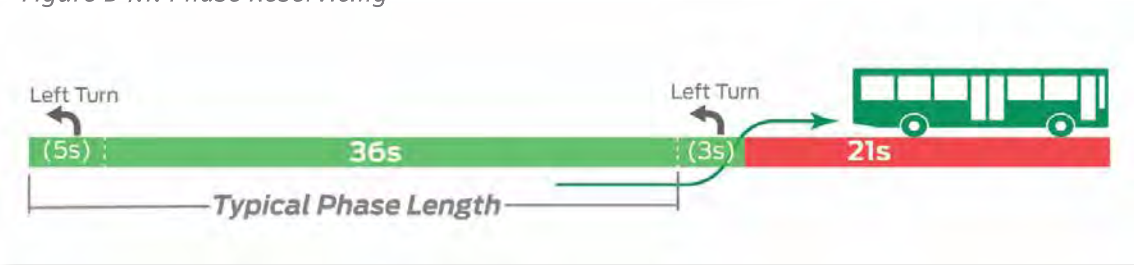
Signal delays can be a significant impediment to transit reliability and service. By prioritizing transit at intersections, TSP can reduce signal delays, improving travel time and reliability.

COORDINATION

The development of TSP requires a high level of coordination between TransLink and the local or regional agency that owns the right-of-way and signal at each intersection. Coordination must be on-going to maintain hardware, manage systems, review performance, and implement changes, as needed.

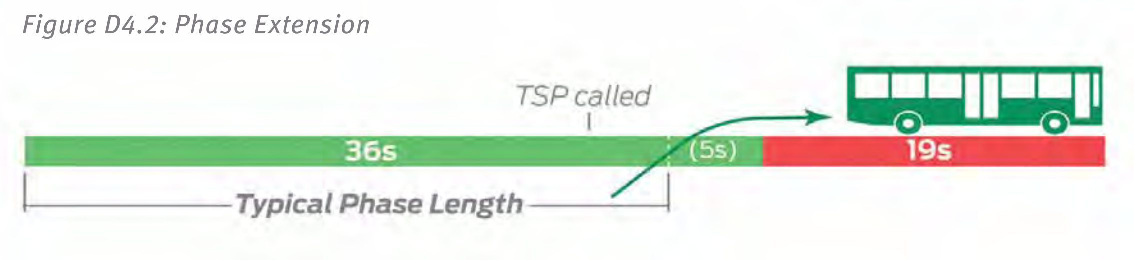
STAKEHOLDER	INVOLVEMENT
TransLink	• Identification of routes and intersections that will most benefit from implementation of TSP. • Acquisition, installation, and maintenance of vehicle devices to ensure proper use of TSP on approved routes. • Adjustment of schedules accordingly to have highest probably use of TSP.
Municipality/Ministry of Transportation	• Acquisition, installation, and maintenance of TSP devices at intersections to ensure proper use of TSP on approved routes. • Hardware maintenance, systems management, performance review, and implementation of changes, as needed.

Figure D4.1: Phase Reservicing



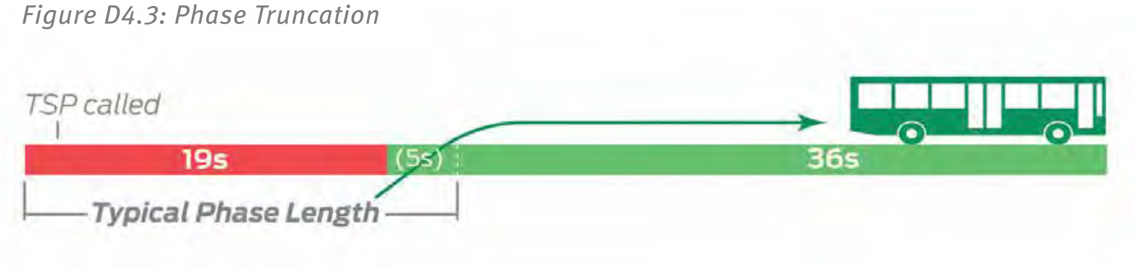
Source: NACTO

Figure D4.2: Phase Extension



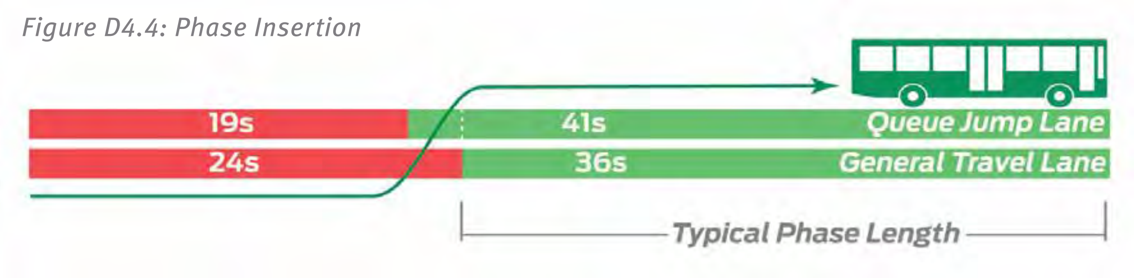
Source: NACTO

Figure D4.3: Phase Truncation



Source: NACTO

Figure D4.4: Phase Insertion



Source: NACTO

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Travel time reduction of up to 18%	+ Decreases delay at single intersections by up to 80% + Travel time variability reduced by up to 40% – General traffic delay may increase slightly by up to 2.5%	+ Increases travel speeds of up to 40% + Fewer delays at intersections	+ Fewer conflicts at intersections – New signals may be confusing to drivers or pedestrians

ESTIMATED COSTS	COST
Existing equipment can be used	$4,000-$7,000 per intersection
Existing equipment must be replaced	$25,000-$40,000 per intersection

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
★★★		★★★	★★★	★★★				★★★				$$–$$$$	High

CHALLENGES

- Can increase delays on cross streets.
- Passive signal timing may be better for high-volume intersections or corridors with short distances between signals.
- Requires a high level of coordination between traffic and transit agencies.
- Heavy traffic congestion can impede the efficiency of TSP by preventing transit from reaching and activating the signal.
- Disaggregating the effects of TSP from other transit priority measures installed at the same time can be difficult.

COMPLEMENTARY TREATMENTS

Some aspects of TSP, such as phase insertion, are only useful with other treatments like queue jump lanes or transit approach lanes. The following are some complimentary treatments:

Bus Stop Placement

Bus stop location should be optimized to reduce delays caused by unnecessary or excessive stopping.

Movement Restrictions

Restricting vehicle movements, particularly unprotected turning movements, can minimize delay and ensure that transit vehicles are in ideal positions to utilize TSP, increasing travel speeds.

Bus Stop Infrastructure

Bus bulbs and islands can keep the bus in the traffic lane to reduce delay accessing, serving, and exiting a bus stop, ensuring that the bus benefits from modified signal timing.

Queue Jumps

Eliminating traffic delay at intersections ensures that the bus benefits from modified signal timing.

Transit Approach Lane

Eliminating traffic delay at intersections ensures that the bus benefits from modified signal timing.

ALTERNATIVE TREATMENTS

Passive Signal Priority

Where transit travel speeds are reliable, signal cycles are short, or service frequency is very high, signal timing on a corridor may be adjusted to match observed or desired transit travel speeds.

Dedicated & Peak-Hour Bus Lane

Eliminating traffic delay along corridors results in more reliable transit travel times, making it easier to program signal timing for transit speeds and ensuring that the bus benefits from modified signal timing.

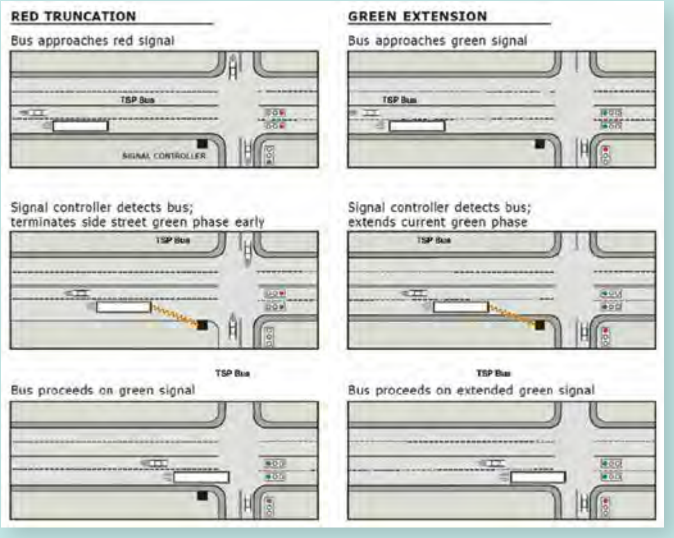
TRANSIT-SIGNAL PRIORITY EXAMPLES

Multiple transit agencies have implemented TSP on one or several corridors.

- Starting in 1998, the City of Ottawa implemented TSP at over 30 locations as part of their 2003 Transportation Master Plan. Ottawa TSP utilizes multiple TSP treatments including green phase extension, red truncation, and phase insertion for queue jump lanes. One corridor saw a 35-40% decrease in travel time due to TSP in conjunction with other transit priority treatments. Costs for TSP installation ranged from $3,000 to $35,000 per intersection.[1]
- In Portland, Oregon, TriMet has implemented TSP at over 250 intersections, with a 10% reduction in travel times and a 19% reduction in travel time variability. Travel time savings as a result of TSP enabled them to avoid having to add an additional bus.[2]
- Between 2012 and 2017, the MTA implemented TSP at 260 intersections on 5 corridors in New York City. MTA primarily used green extension and red truncation treatments. Routes that run along these corridors have travel times reduced by 18%. They plan to increase the number of intersections with TSP to nearly 1,000 by 2020.[3]
- Los Angeles County first implemented TSP in 1999, at 211 intersections with green extension and red truncation. Bus delays were reduced by 33-35% at intersections and the system realized an overall travel time savings of 8-10%. They have since expanded to provide TSO for multiple other routes.[4]
    - Many other cities have implemented TSP with positive results, including:[2]
    - Chicago, IL – Decreased travel times by 15-18%
    - Seattle, WA – Reduced travel times by 8%, with a 35% reduction in travel time variability
    - Vancouver, BC – Reduced travel time variability by 40%

Figure D4.5 : Current and Future TSP Locations in New York City[3]

Figure D4.6 : Red Truncation and Green Extension Diagrams[5]



1 Transport Canada, "Transit Priority Program: Putting Buses First" http://publications.gc.ca/collections/collection_2012/tc/T41-1-01-eng.pdf

2 Transportation Research Board, "TCRP Report 118: Bus Rapid Transit Practitioner's Guide", 2007. https://nacto.org/docs/usdg/tcrp118brt_practitioners_kittleson.pdf

3 New York City DOT, "Green Means Go: Transit Signal Priority in NYC", 2017. http://www.nyc.gov/html/brt/downloads/pdf/brt-transit-signal-priority-july2017.pdf

4 Transportation Research Board, "TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic", 2010. https://nacto.org/docs/usdg/tcrp_synthesis_83_danaher.pdf

5 Smith, et al. "Transit Signal Priority: A Planning and Implementation Handbook", 2005. https://nacto.org/docs/usdg/transit_signal_priority_handbook_smith.pdf

E. TransLink Practices and Policy

E1. All-Door Boarding

All-door boarding is an operational policy that allows customers to board a transit vehicle at any open door.

Strategy Overview

This practice is commonly used in transit systems with limited-access stations or designated fare-paid zones like rail and some bus rapid transit systems. Fares are enforced through validation at ticket vending machines (TVMs), on or off-board validators, fare gates, mobile ticketing applications, or by fare inspector personnel.

Buses spend up to one-third of operating hours at bus stops loading and unloading customers. This time, referred to as "dwell time," often increases with ridership. By reducing the length and variability of dwell time at each bus stop, all-door boarding improves total travel time and schedule reliability for customers and reduces operating costs for transit agencies.

COORDINATION

All-door boarding generally requires less coordination than other treatments. The level of coordination between stakeholders will vary depending on the fare validation method chosen.

STAKEHOLDER	INVOLVEMENT
TransLink	• Addition of fare validators and technology, hiring of fare inspection personnel, and requiring the necessary fare media to comply with the validation.
Municipality	• Impact on city street right-of-way from the installation and operation (powering) of off-board fare collection or validation. Could also include pavement or sidewalk markings to indicate boarding available at all doors.

Figure E1.1: New York MTA Select Bus Service with All-Door Boarding

Figure E1.2: LA Metro Platform Validation & SFMTA Fare Inspector

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
+ Overall travel time reduced by 3%	+ Dwell times reduced up to 40% + Travel speed increased by 2% + 10% improvement in on-time performance – Additional maintenance cost for ticket validators	+ Reduces boarding time + Reduces time waiting at bus stop + Increases access to fare (new TVMs or mobile options)	+ Reduces door crowding – Rear door trip hazard

ESTIMATED COSTS
\$3,000 per unit for mobile validators/ \$80,000 per unit for TVMs

RELATIVE BENEFITS AND COSTS

INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
							★★★	★★	★				Low

CHALLENGES

- Requires the use of either off-board payment systems or all door proof-of-payment systems (such as cash & card front door payment and rear-door card readers). All TransLink buses are already equipped with all door proof of payment systems.
- Potentially requires implementation of fare inspections by dedicated staff, but reduces fare validation done by bus drivers.
- Timeline can be a few months, to use existing infrastructure and develop mobile app, or a few years, with new equipment and fare media.
- All-door boarding is most effective when implemented across an entire system, which requires greater upfront capital than a phased approach, and reduces confusion for transit customers about which routes in a system have all-door boarding and which do not.

COMPLEMENTARY TREATMENTS

Implementing all-door boarding alone will yield limited benefits in terms of speed and reliability. Combining all-door boarding with additional transit priority measures can enhance the benefits to transit operations.

Bus Stop Placement

Bus stops should be located at optimal locations to maximize the benefits of all-door boarding throughout a bus route.

Bus Stop Infrastructure

In-lane stops along with all-door boarding enable faster and more reliable boarding, further reducing dwell times.

Peak-Hour & Dedicated Bus Lane

Bus-only lanes facilitate faster and more reliable boarding, further reducing dwell times and variability.

ALTERNATIVE TREATMENTS

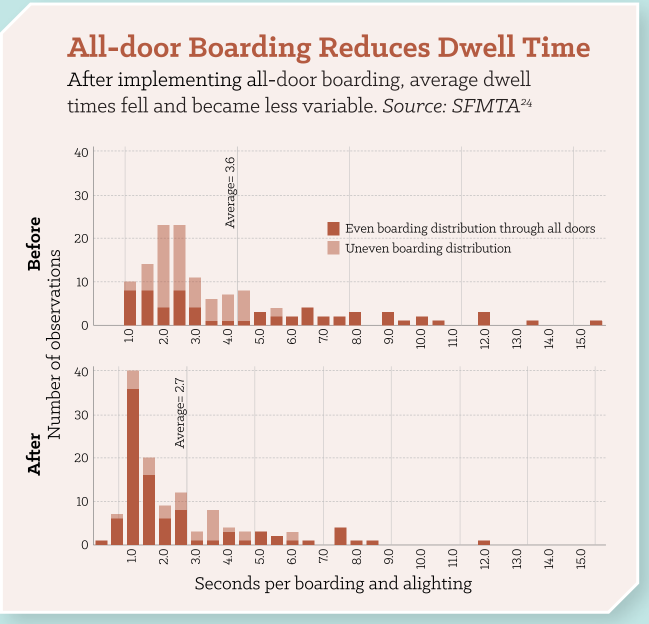
Not applicable

ALL-DOOR BOARDING EXAMPLES

Multiple transit agencies have done partial or full implementation of all-door boarding on buses.

- In 2012, SFMTA implemented full system all-door boarding. Dwell times decreased 38% per customer on average and bus speeds increased by 2% as ridership increased 2%.[1]

Figure E1.3: SFMTA All-Door Boarding Observations[3]



- In 2009, New York MTA implemented all-door boarding on their Select Bus Service using off-board fare collection and inspection based fare validation. Dwell times decreased by an average of 36% as ridership grew an average of 18%.[1]
- Austin Cap Metro implemented all-door boarding on their MetroRapid buses with on-board validation and implementation of a mobile payment system. 92% of customer used either a prepaid fare (80%) or the mobile app (12%) after implementation.[1]
- Since 2007, TransLink has used all-door boarding on Route 99 B-Line with card readers at all doors, while still allowing cash at the front door. Even though ridership increased, trip times fell by 3% and dwell times decreased by 17% per customer on average.[1]
- For two weeks in 2017, the MBTA Silver Line routes 4 and 5 operated with all-door boarding through a pilot funded by the Barr Foundation. During the pilot, dwell times decreased by 30% and fewer buses started trips late.[2]
- LA Metro implemented all-door boarding on the Metro Silver Line. The project increased on-time performance by 10%and lead to expanded trials on Wilshire Boulevard and Vermont Avenue.[3]

1 NACTO, "Better Boarding, Better Buses: Streamlining Boarding & Fares," 2017. https://nacto.org/wp-content/uploads/2017/02/NACTO_Better-Buses_Boarding.pdf

2 Barr Foundation, "All-Door Boarding a Boost for the MBTA's Silver Line Bus," 2017. https://www.barrfoundation.org/blog/all-door-boarding-boosts-mbta-silver-line-bus

3 Metro, "L.A. Metro expands all-door boarding for key Metro Rapid Lines" http://www.metro-magazine.com/bus/news/726161/l-a-metro-expands-all-door-boarding-for-key-metro-rapid-lines

E2. Schedule-Operator Recovery

Requiring time in the schedule between the start and end of the trip (layover time), helps ensure operators are able to take a break and helps ensure the next trip starts on time.

Strategy Overview

If a route falls behind schedule during a trip, the recovery time provides an opportunity to get the route back on schedule, thereby improving the reliability of the route.

While a layover time of 10% of the running time is often used as an industry standard, enough layover time should be scheduled to ensure that 90-95% of trips start at their scheduled time.[1] Automatic Vehicle Location (AVL) devices can track the speed between stops for every trip. With this more precise data, individual trip layovers can maximize the cost effectiveness of a route, while maintaining high reliability.

COORDINATION

The location of layover locations may require some coordination with local municipalities.

STAKEHOLDER	INVOLVEMENT
TransLink	• Identifying locations at end of routes for vehicles to wait during layover time.
Municipality	• Providing sufficient curb space or right-of-way to allow laying over of transit vehicles.

1 Strathman et al., "Bus Transit Operations Control: Review and an Experiment Involving Tri-Met's Automated Bus Dispatching System," 2001. http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1742&context=jpt.

BENEFITS AND COSTS

TRAVEL TIME	RELIABILITY	CUSTOMER EXPERIENCE	SAFETY
NA	+ Clockface schedules for easier understanding of route schedule	+ Appropriate amount of recovery time can increase trip reliability	+ Layover allows for necessary breaks for transit operators for safer driving

RELATIVE BENEFITS AND COSTS

CONGESTION		DELAY			OPERATIONS				SAFETY			COST	COORDINATION
INTERSECTION	ROADWAY	SIGNAL	RIGHT TURN	LEFT TURN	ACCESS TO BUS STOP	LEAVING BUS STOP	DWELL TIME	INSUFFICIENT RUNNING TIME	PEDESTRIANS	CYCLISTS	MOTORISTS		
								★★★					Low

CHALLENGES

- Layovers require space for the bus to wait, which can be difficult to find in dense urban areas. Multiple buses requires more space that may take curb space from on street parking.
- In addition to recovery time, layover may need to be longer due to agency or union contracts.
- Layover time may result in inefficient cycle times, reducing productivity of routes.

COMPLEMENTARY TREATMENTS

Implementing appropriate layover times can improve reliability, but other treatments can enhance these benefits.

Bus Stop Placement

Locating terminal bus stops where buses layover reduces additional time moving the bus to and from the start/end of the route.

Curb Management

Curb management ensures that curbside uses do not interfere with layover space.

Passive Signal Priority & Transit-Signal Priority

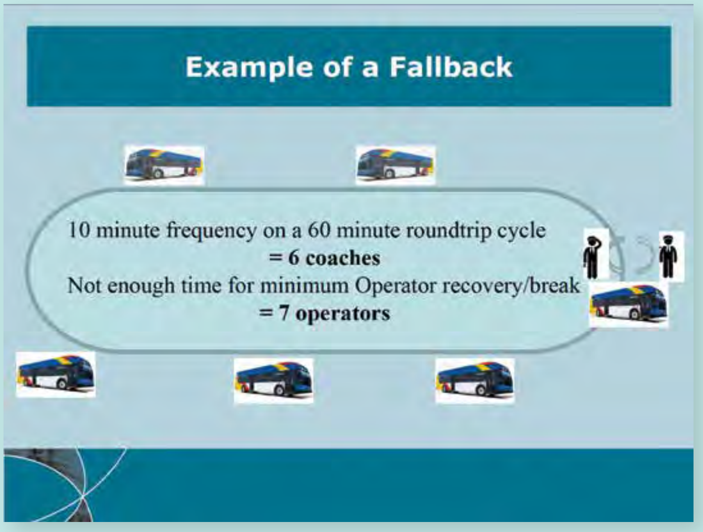
Signal priority for buses can allow transit to consistently move through a corridor, reducing variability in layover, and therefore cycle times, between trips.

SCHEDULE-OPERATOR RECOVERY EXAMPLES

Most agencies have minimum layover standards. However, in order to be more efficient with vehicles or operators, some transit agencies have adopted less common strategies.

- In King County METRO, layover space can be difficult to find, especially in more dense areas like downtown. In order to accommodate breaks for operators and maintain a higher frequency of service, King County has used fallback operators on some of their routes. A fallback operator is when there is an additional operator than vehicles on a route. At the end of a trip, the operator is switched with the one at the terminal, and continues with the next trip. The operator who just completed a trip takes a break and then waits for the following bus to arrive. While this allows for operators breaks, there is less time for recovery, so this type of operating scheme is only effective when there is little variability to trip times.[2]

Figure E2.1: King County METRO Actively Managed Fallbacks[2]



2 Bez, Jon. "King County Metro Transit: Actively Managed Fallbacks," 2017. https://www.apta.com/wp-content/uploads/Resources/mc/sustainability/previous/2017sustainability/presentations/Presentations/Actively%20Managed%20Fallbacks%20-%20Jon%20Bez.pdf