TRANSIT SPEED & RELIABILITY

GUIDELINES & STRATEGIES

King County METRO

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CONTENTS

ACKNOWLEDGMENTS

KING COUNTY METRO

IRIN LIMARGO
Speed and Reliability Group, Supervisor

AUTHORS:

OWEN KEHOE, PE, PTOE
Speed and Reliability Group, Spot Improvement Program Manager

MASHA PODOLSKY
Speed and Reliability Group, Corridor Planner

GABI KAPPES, AICP
Speed and Reliability Group, Corridor Planner

The consultant team authored and illustrated the Speed and Reliability Guidelines in 2017. Some of those efforts have been modified in this updated version.

2017 VERSION CONSULTANT TEAM

PARAMETRIX

FEHR & PEERS

PRINCIPAL, STEPHERSON & ASSOCIATES COMMUNICATIONS

The King County Metro Speed and Reliability Group would like to acknowledge and thank several of our agency partners for their contributions and input in developing the Transit Speed and Reliability Guidelines and Strategies:

CITY OF BELLEVUE

FRANZ LOEWENHERZ
Principal Transportation Planner

CHRIS LONG
Assistant Director,
Traffic Management

CITY OF KIRKLAND

KIMBERLY SCRIVNER
Transportation Planner

CITY OF SEATAC

DAVID TOMPOROWSKI
Senior Transportation Planner

CITY OF SEATTLE

JONATHAN DONG
Senior Transit Planner

MARIA KOENGETER
Streetcar and Transit Corridors Manager

WSDOT

CELESTE GILMAN
Deputy Director, WSDOT Regional Transit Coordination Division

DAN HOYT
Planning Manager

GLOSSARY

This glossary contains terms used in the Speed and Reliability Guidelines.

THE AMERICANS WITH DISABILITIES ACT (ADA)	The Americans with Disabilities Act (ADA) became law in 1990. The ADA is a civil rights law that prohibits discrimination against individuals with disabilities in all areas of public life, including jobs, schools, transportation, and all public and private places that are open to the general public.
ACCESSIBLE PEDESTRIAN SIGNALS (APS)	Accessible pedestrian signals and detectors provide information in non-visual formats (such as audible tones, speech messages, and/or vibrating surfaces).
BUSINESS ACCESS AND TRANSIT (BAT) LANE	Curbside lane designated for only buses with the exception of general traffic to access driveways and make right-turns.
CORRIDOR	A major pathway or series of streets on which multiple bus routes operate that connect key activity centers.
FREQUENT SERVICE ROUTE	Fixed bus service that operates 16 hours per day with headway frequencies of every 10-15 min or less during the day.
HEADWAY	The interval of time between the arrival of two subsequent buses at the same stop.
HUB	Center of activity where multiple routes converge, such as a transportation center, a rail station, or a major destination.
INTERSECTION LEVEL OF SERVICE (LOS)	LOS is a quantitative measure used to relate the quality of motor vehicle traffic service by assigning a letter grade (A-F) to roadway segments, with LOS A representing the best operating conditions from the traveler's perspective, and LOS F the worst, based on performance measures like vehicle speed, density, congestion, etc.
LEADING PEDESTRIAN INTERVAL (LPI)	A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter an intersection 3-7 seconds before vehicles are given a green indication. With this head start, pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn left.
METRO CONNECTS	Metro Connects is King County Metro's long-range transportation vision that was adopted by the King County Council in 2017 and outlines a plan to bring more transit service, more choices, and one easy-to-use system over the next 25 years.
RAPIDRIDE	King County Metro's arterial-based bus rapid transit service that includes a unique fleet of vehicles, high all-day frequency, and corridor-wide capital investments, such as transit signal priority and improved passenger facilities.
RELIABILITY	The ability for transit vehicles to arrive at stops at predictable times.
RIGHT-OF-WAY (ROW)	City, State or County owned land for uses including roadways, sidewalks, bridge structures, bike lanes, public utilities, etc.
SPEED	The measurement of distance traveled normalized by the time it takes a bus to travel from one point to another.
SPEED AND RELIABILITY IMPROVEMENTS	Street and intersection design; bus stop and station spacing; traffic regulation and signal projects; are all examples of Speed and Reliability Improvements that allow buses to operate more efficiently on city streets.
SPOT IMPROVEMENT	A transit improvement at a specific location that can be made without significant capital expense and implemented relatively quickly.

1. INTRODUCTION

The Speed and Reliability Guidelines and Strategies (the "Guidelines") is a living document that describes how King County Metro (Metro), local jurisdictions, WSDOT and other stakeholders work together to improve transit speed and reliability. Enhancing transit speed and reliability can be a "win-win" for Metro, local jurisdictions, and community members. Customers value and rely on transit trips that arrive and travel predictably (King County Metro Transit 2019 Rider and Non-Rider Survey). Speed and reliability methods help deliver that predictability, which attracts riders, makes service more cost-effective, and assists jurisdictions in implementing road and signal improvements.

What is "Speed and Reliability ?"

Dependable, efficient, and swift bus service. Street and intersection design; bus stop and station; traffic regulation and signal projects; are all examples of Speed and Reliability Improvements.

Who is the intended audience for this document?

This document is for transportation professionals representing jurisdictions in King County, Washington. Also, it can be used as a resource by metropolitan areas nationwide.

These updated Speed and Reliability Guidelines support the overall Metro policy updates:

- Metro Connects is Metro's long-range document that outlines a vision and strategy for capital and service improvements to the transit system, including speed and reliability improvements.
- The Mobility Framework was community-led and co-created with the King County Metro Mobility Equity Cabinet, a group of 23 community leaders representing riders and a variety of organizations and communities county-wide, focused on low- and no-income people, black, indigenous, and people of color, immigrants and refugees, people with disabilities, and limited-English speaking communities. The Mobility Framework informs how Metro allocates its transit service, resources, and updates to existing policies to ensure that Metro is investing in areas where needs are the greatest.
- Metro's Service Guidelines provide direction for planning and outreach around developing and changing service.

The Guidelines were first published in 2017 to facilitate discussions between Metro and local jurisdictions, understand what opportunities are available to partner with Metro, and describe types of improvement projects. They also aim to strengthen and broaden transit partnerships with local jurisdictions in developing new tools to implement speed and reliability improvements.

Columbia Steet Two-way Project
Source: Metro, 2020

These Guidelines will:

Establish a framework for how Metro, local jurisdictions, WSDOT and other stakeholders can work together to create and realize opportunities to plan and implement speed and reliability improvements. In general, local jurisdictions or WSDOT own and maintain the public right-of-way (ROW), including streets and traffic signals. Metro operates transit service and builds and maintains its trolley Overhead Catenary System, bus stops and layover facilities in the ROW. To effectively reach our shared transportation, development and climate goals, Metro must partner with local jurisdictions in the planning, design and implementation of projects that improve the speed and reliability of transit service along corridors and at specific locations. The success of speed and reliability projects depends on Metro, local jurisdictions, WSDOT and other stakeholders understanding each other's policies, standards, shared goals, and decision processes.

Define speed and reliability improvements and their benefits. Transit speed and reliability improvements are essential to the functionality of Metro's transit system and meeting customers' needs. Because Metro works with local jurisdictions and other agencies that own and manage the public streets in which transit operates, it is important that stakeholders understand the scope and benefits of speed and reliability improvements, and how these improvements can advance our shared goals for a sustainable and quality multi-modal system that attracts people to use transit instead of a single-occupant vehicle.

Provide details on the benefits, trade-offs, and implementation of specific speed and reliability strategies. This document integrates national best practices about speed and reliability improvements within the context of Metro's transit system and jurisdictions in King County, Washington. Additionally, this document includes lessons learned from Metro's Speed and Reliability team's extensive experience leading speed and reliability projects, including consideration for new and innovative strategies that Metro has not yet put into practice. For each of these strategies, we outline considerations, benefits, and tradeoffs.

How to use this document:

- Understand transit speed and reliability – see *"2. OVERVIEW OF SPEED AND RELIABILITY" on page 3*.
- Understand how to form speed and reliability project partnership with Metro – see *"3. FRAMEWORK FOR PARTNERSHIP" on page 21*.
- Learn about a variety of speed and reliability tools – see *"4. TRANSIT SPEED AND RELIABILITY TOOLS" on page 33*.
- Review case studies and understand speed and reliability benefits, and trade-offs – see *"5. CASE STUDIES" on page 99*.

2. OVERVIEW OF SPEED AND RELIABILITY

The Overview of Speed and Reliability section defines the issues of transit speed and reliability – what they are, the challenges, and the benefits.

NE Pacific Street & Montlake Boulevard NE, Seattle
Source: Metro, 2021

2.1 WHAT ARE SPEED AND RELIABILITY?

Speed is the measurement of distance traveled normalized by the time it takes a bus to travel from one point to another.

Reliability is the ability for transit vehicles to arrive at stops at consistent and predictable times.

Speed and reliability are closely related because bus schedules are designed to accurately reflect the transit system so that customers can predict and plan their trips. Slowing of buses affects the maintenance of bus schedules and inconsistent arrival times results in in unreliable and slow trips for passengers.

Transit speed and reliability can be measured by metrics like:

- Adherence to a route's schedule and determined headways at least 80 percent of the time.
- Comparing peak to off peak travel times, or 20-80 percentile (consistency) for corridor, spot, or route. The 80th percentile value means 80% of trips are equal to or faster than that value. Schedules are often based on the 80th or 90th percentile to be conservative so passengers aren't late.
- Variability of end to end transit travel time throughout the day.
- Other quantitative measures such as examining transit travel times or delay on a route segment or intersection.
- Average delay approaching intersections.
- Average travel time between bus stops.
- Comparing peak to off peak as potential for time savings.

These metrics help to define measures of effectiveness that are used to evaluate the performance of routes, and to identify routes that could benefit from speed and reliability improvements. To learn more about reliability measures of effectiveness please refer to *"TCRP Research Report 215 - Minutes matter: A Bus Transit Service Reliability Guidebook"*.

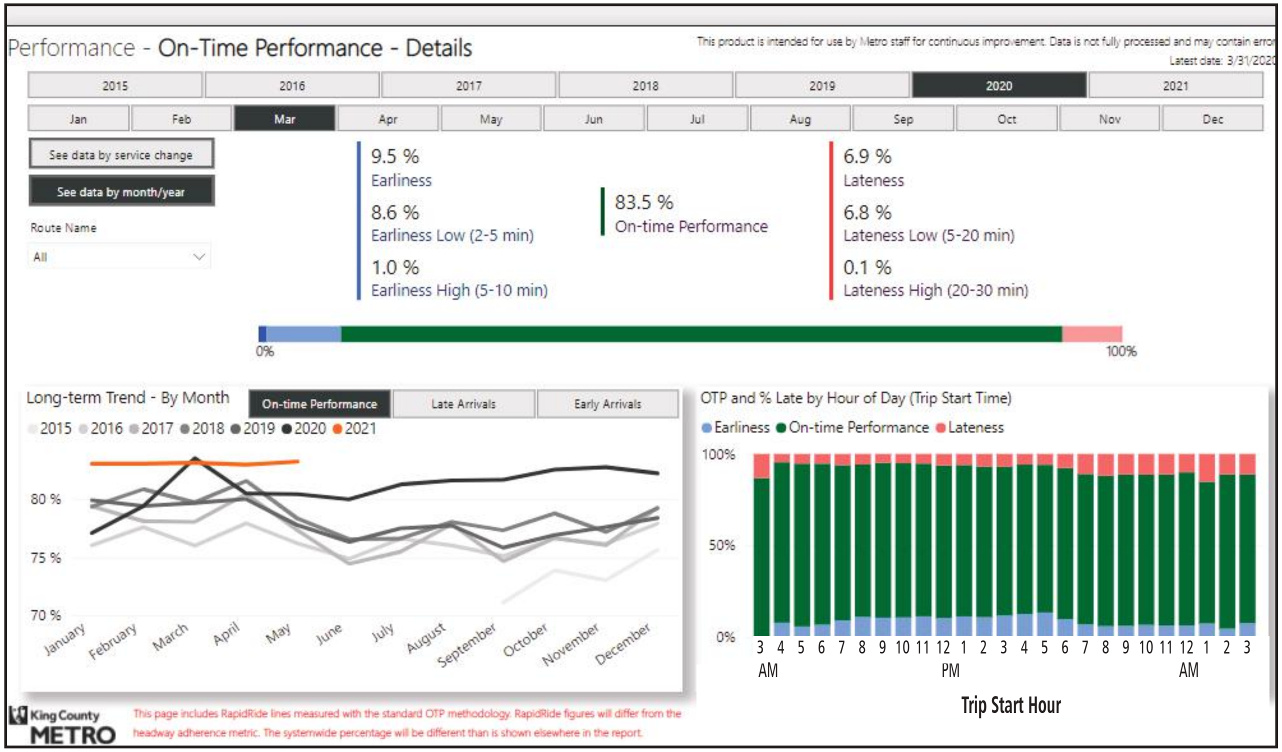
For Metro's frequent transit service, speed and reliability means maintaining consistent, predictable, and reliable transit travel times that riders can depend on throughout the region in which Metro operates, regardless of where a rider is using transit to reach their destination and the number of transfers required. Transit service should adhere to published bus schedules, within reasonable variance based on time of day, and travel conditions.

Westlake Avenue N Bus Lane, Seattle
Source: Metro, 2021

52nd Avenue S and Interurban Avenue S, Tukwila
Source: Metro, 2020

Metro defines "on-time" performance as an arrival at designated points along a route that is no more than five and a half minutes late or departing less than one minute early relative to the scheduled time. For Metro bus rapid transit RapidRide Lines, service performance is measured using headway adherence - the actual headways at designated points should be no more than 2 minutes earlier or later from the scheduled headway for scheduled headways of up to 8 minutes; for scheduled headways between 8 and 15 minutes – no more than 3 minutes earlier or later.

Metro is look at ways strengthen and expand headway-based operations (and supporting strategies) as well as new operational procedures to help keep bus service on-time and reliable.



Metro Transit Performance Metrics
Source: Metro

Maintaining transit speed and reliability through capital investments requires coordination among Metro, local jurisdictions, WSDOT, and other agencies. These Guidelines focus on ways that Metro and local jurisdictions work together to improve speed and reliability on Metro's bus routes. When prioritizing speed and reliability projects for investment, Metro will work in coordination with local jurisdictions to evaluate projects using metrics including but not limited to:

- **PERSON THROUGHPUT:** the number of people that can be moved through a roadway segment
- **PERSON DELAY:** the amount of delay per person at an intersection based on vehicle occupancy
- **INTERSECTION LEVEL OF SERVICE (LOS):** the amount of delay vehicles experience at an intersection (on a scale of A-F)
- **VEHICLE QUEUES:** the space used by vehicles waiting at an intersection, which can exceed the design capacity of the intersection
- **PROJECT COST:** the cost to design and construct the project
- **EASE OF CONSTRUCTION:** the complexity to construct the project
- **CONSISTENCY WITH LOCAL AND REGIONAL POLICY:** how well the project fits within local and regional policy
- **TRAVEL TIME REDUCTION:** changes in transit travel time in corridor
- **REDUCTION IN POTENTIAL COLLISIONS AND CONFLICTS WITH OTHER MODES OF TRANSPORTATION:** how the improvement may reduce potential conflicts
- **COMMUNITY SUPPORT:** the level of community support for the improvement
- **CONSISTENCY WITH LOCAL TRANSIT PLANS:** how well improvements align with local jurisdiction transit plans, if applicable
- **SERVICE RELIABILITY:** how often buses arrive on-time or within the desired headway
- **TRAVEL TIME RELIABILITY:** consistency of travel time during different times of day and traffic conditions

4th Avenue S and S Jackson St, Seattle
Source: Metro, 2021

Transit is one among many competing modes that cities and Metro are striving to balance within the public ROW. Other modes include pedestrians, bicyclists, freight, general purpose traffic, parking, and public space. Within this context, the following are some key factors that influence transit speed and reliability which these Guidelines seek to address:

- **LOCAL CONGESTION**: A congested street or intersection where traffic is delaying all modes, including general purpose traffic and transit.
- **REGIONAL GROWTH**: Increasing traffic caused by rapid development across the region affects a street's performance; increased traffic congestion reduces transit speed and reliability.
- **CHALLENGING MOVEMENTS**: Navigating narrow city streets can be challenging for transit vehicles, which must contend with crossing oncoming traffic, signal phasing, crossing pedestrians, stopped vehicles, through-moving bicyclists, and small curb radii. Parked vehicles that encroach upon the intersection can also complicate turning movements for transit vehicles.
- **BUS ZONE ISSUES**: Speed and reliability can be compromised when a bus has difficulty moving in and out of a bus stop ("bus zone"), when it takes too long to load and unload passengers, or when bus stops are too closely spaced along a route.
- **MULTI-MODAL ROADWAYS**: The needs of other motor vehicles, pedestrians, bicycles, and other modes should be balanced with buses. Walking and biking directly support transit ridership and access. In recent years many cities throughout the region have dedicated more ROW to making walking and biking safer and more accessible.

Section *"4. TRANSIT SPEED AND RELIABILITY TOOLS" on page 33* describes a wide range of speed and reliability tools to address and propose ways to improve transit speed and reliability while still complementing the other users of the street.

Zicla Bus Platform Bus Stop on 108th Avenue Northeast in Bellevue, WA.
Benefits of the new bus platform include:

- *Smoother, safer operations for buses, which no longer need to pull alongside the curb;*
- *A reduction in travel time of five to 20 seconds for each of the roughly 65 buses per weekday that stop at the platform; and*
- *Dedicated space for bicyclists to safely pass buses, which will no longer block the bike lane when stopping for passengers.*

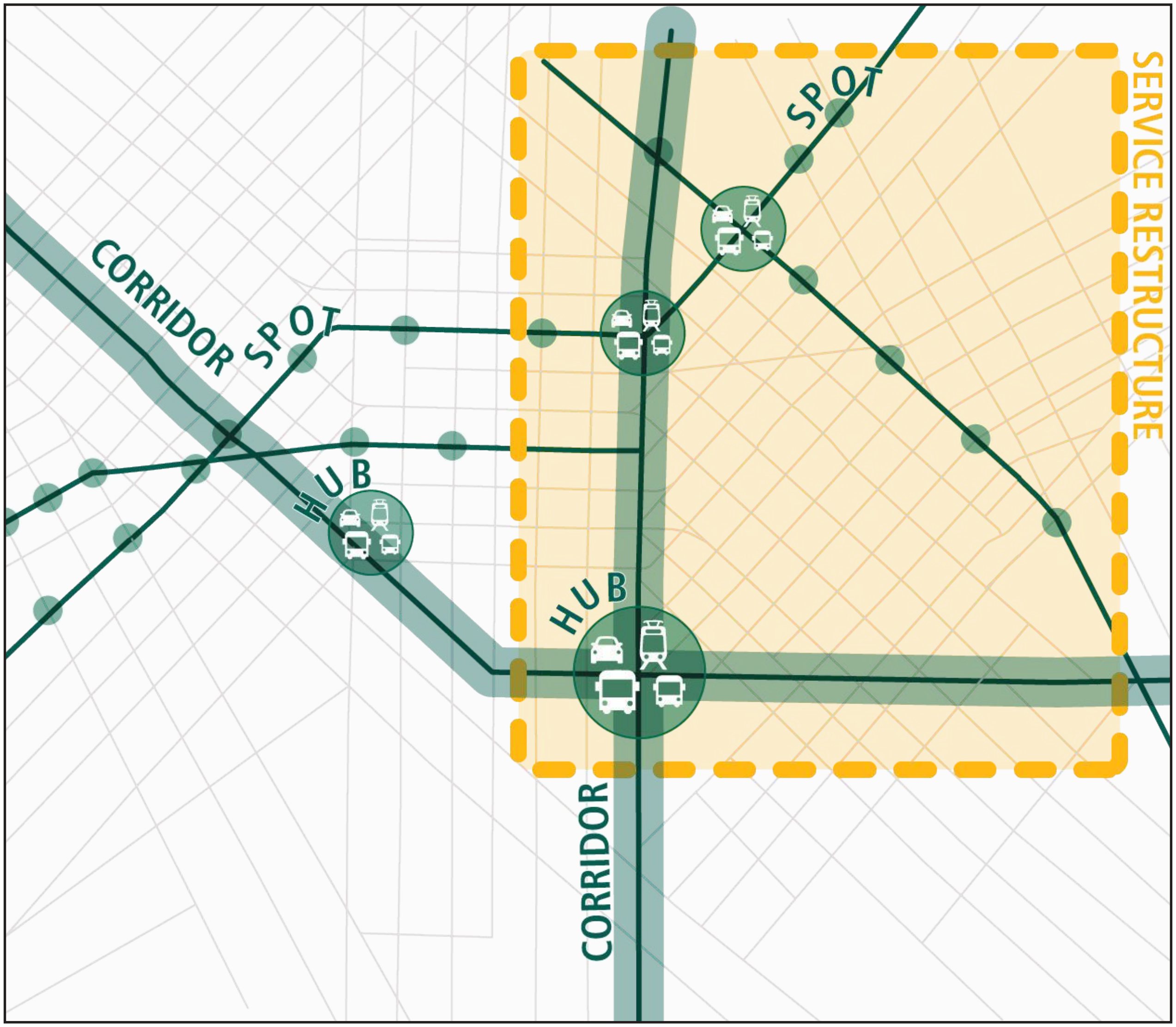
Source: Bellevue, 2018
https://bellevuewa.gov/city-news/safer-bikes-faster-buses-new-bus-platform

2.2 TYPES OF PROJECTS

Metro builds speed and reliability projects of different types and scales that meet operational and local jurisdiction needs. These include:

- Corridors,
- Spot Improvements,
- Hubs, and
- Speed and Reliability Improvements for Service Restructures.

Metro welcomes and encourages partner jurisdictions to have an active role in studying speed and reliability improvements. Both the analytic tools and partner jurisdictions understanding about corridor needs will inform the project scope of work for planning to be carried out into design and implementation. Early involvement with partner jurisdictions during the planning phase is critical in developing financial strategies to cover the cost of the project, including pursuing grant funding opportunities together.



CORRIDORS

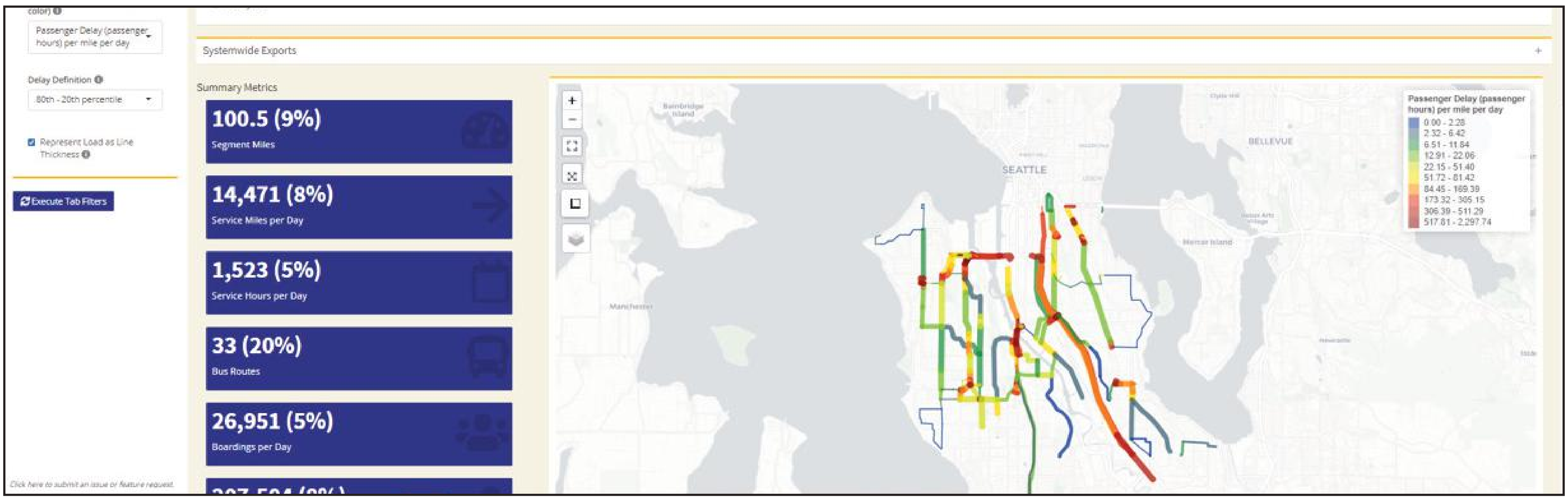
A corridor is a physical pathway with one or more transit routes. Corridors provide an opportunity to bundle a series of spot improvements or corridor-long improvements along a pathway that is often used by multiple routes.

Focusing speed and reliability improvements on corridors is an effective strategy to improve transit performance. Corridor projects:

- Provide an economy of scale for the process needed to build the improvements.
- Can be competitive projects for grant funding opportunities.
- Are a way for multiple jurisdictions to contribute and benefit from a coordinated set of improvements.
- Often benefit multiple routes, especially routes in the frequent service network.

In accordance with Metro Connects policy, Metro prioritizes corridors with frequent service, defined as a peak frequency of 15 minutes or better all-day or at least 16 hours a day, for speed and reliability improvements. Metro uses an analytic dashboard (Pictured below) to display selected speed and reliability metrics and to help evaluate the benefits and costs of future speed and reliability improvements for short and mid-term planning. The analysis includes a priority list of speed and reliability improvements and corresponding corridor investments. This approach will result in a prioritized list of future projects for the next four to six years or longer depending on the funding availability.

Consistent with Metro Connects, speed and reliability projects could be prioritized to focus capital improvements where they are most important, such as areas where improvements uphold social equity, frequent service routes, and where roadways are most congested. These projects would keep buses moving through traffic and on schedule, allowing Metro to deliver even more service.



Corridor Planning and Prioritization Dashboard
Source: Speed and Reliability Team (Metro), Nelson/Nygaard

SE Eastgate Way & 148th Ave SE, Bellevue
Source: Metro, 2020

Bothell Way NE and NE 153rd Street, Bothell
Source: Metro, 2021

SPOT IMPROVEMENTS

Spot improvements are projects that target specific points or short segments along a route or corridor. They are typically less complex improvements that generate quick fixes to transit speed and reliability issues that have emerged. The identification and addressing of spot improvements is generally a less formal process than the corridor process.

Metro generates spot improvement projects through feedback from bus operators, local stakeholders, riders, or others. Metro works with the local jurisdiction or agency to analyze the transit and traffic conditions and decide whether the issue can be improved, or whether a similar type of issue was addressed before.

Some cities have spot improvement programs of their own. For example, Metro has worked closely with the City of Seattle on over 21 spot improvements in 2020. Metro and Seattle define the problem together, jointly develop a solution, and identify funding resources. In the past five years, Metro, local jurisdictions and WSDOT have completed about 100 spot improvements countywide.

HUBS

Hubs, where multiple routes converge, present an exciting opportunity for speed and reliability improvements. These centers of activity, such as transportation centers, rail stations, and major destinations, provide a way to bundle improvements in a small area (1-mile radius from the hub) to enable the movement of many people to and from a popular location. Hubs provide an opportunity to improve bus flow where there are high passenger loads and many converging routes, allowing benefits to extend to multiple jurisdictions.

Consequently, hubs can be a focal point of investment for a partnership of agencies and jurisdictions. Transit speed and reliability upgrades at hubs can complement other improvements such as pedestrian connectivity, urban design elements, sightlines, security, and passenger amenity projects to improve passenger experience.

SERVICE RESTRUCTURE SUPPORT

Speed and reliability improvements for service restructures are projects that provide capital investments to support a service change and, in some cases, are necessary for routing changes and/or service improvements. In accordance with the Metro Connects policy, "Metro will seek to coordinate service investments and service changes with capital investments and improvements."

Metro periodically plans and implements service restructures.

The Capital Planner for speed and reliability improvements will work closely with Service Planning staff and local jurisdictions in developing new and/or modified service routings and in finding opportunities to add speed and reliability improvements to new or existing transit routes.

Service planners generally begin developing service routing changes two years prior to when the service changes will go into effect. During this planning process, proposed transit routing plans could change due to feedback from community, feedback from elected officials, or roadway infrastructure/ operational deficiencies.

The short planning timeframe and possibility of last-minute changes can add challenges to the implementation of speed and reliability improvements because capital investments typically take 12 to 36 months to plan, design, and implement. Projects can be prioritized so that critical speed and reliability improvements are implemented on or prior to the service change date, and the remaining projects can be constructed after the service change.

RKAAMP , Renton Transit Center
Source: King County Metro Photo Gallery, 2020

2.3 BENEFITS OF SPEED AND RELIABILITY IMPROVEMENTS

Speed and reliability improvements have a large range of benefits for King County residents, Metro, local jurisdictions, and other transit agencies. Providing predictable and reliable bus service is important for customers, for overall regional goals, and for Metro's effectiveness at delivering service. More efficient transit will help meet objectives for equity, sustainability, and multi-modal travel by enabling people to reach their destinations reliably by transit, without depending on personal vehicles.

Capital investments related to speed and reliability will improve general traffic flow on local streets and can have a demonstrable impact on bicycle and pedestrian conditions and safety. Metro depends on local jurisdiction knowledge to identify areas where these types of benefits will have the greatest impact.

2.3.1 MEASURED BENEFITS

Benefits described in this section include bus operations, bicycle and pedestrian safety, bus operational safety, ridership, avoided operating costs, and bus travel time. Section *"4. TRANSIT SPEED AND RELIABILITY TOOLS"* of this document lists the tools that are effective ways to address the challenges outlined previously in *"2.2 TYPES OF PROJECTS"*.

Spot improvements are typically low-cost targeted investments that improve congested intersections or segments. Annual Spot Improvements Reports, prepared by Metro's Speed and Reliability Group at the end of each year, describe projects that were implemented through partnerships with local jurisdictions.

The benefits from completed spot improvements in years 2018-2020 can be found in *"Table 1. Spot Improvements Benefits"*.

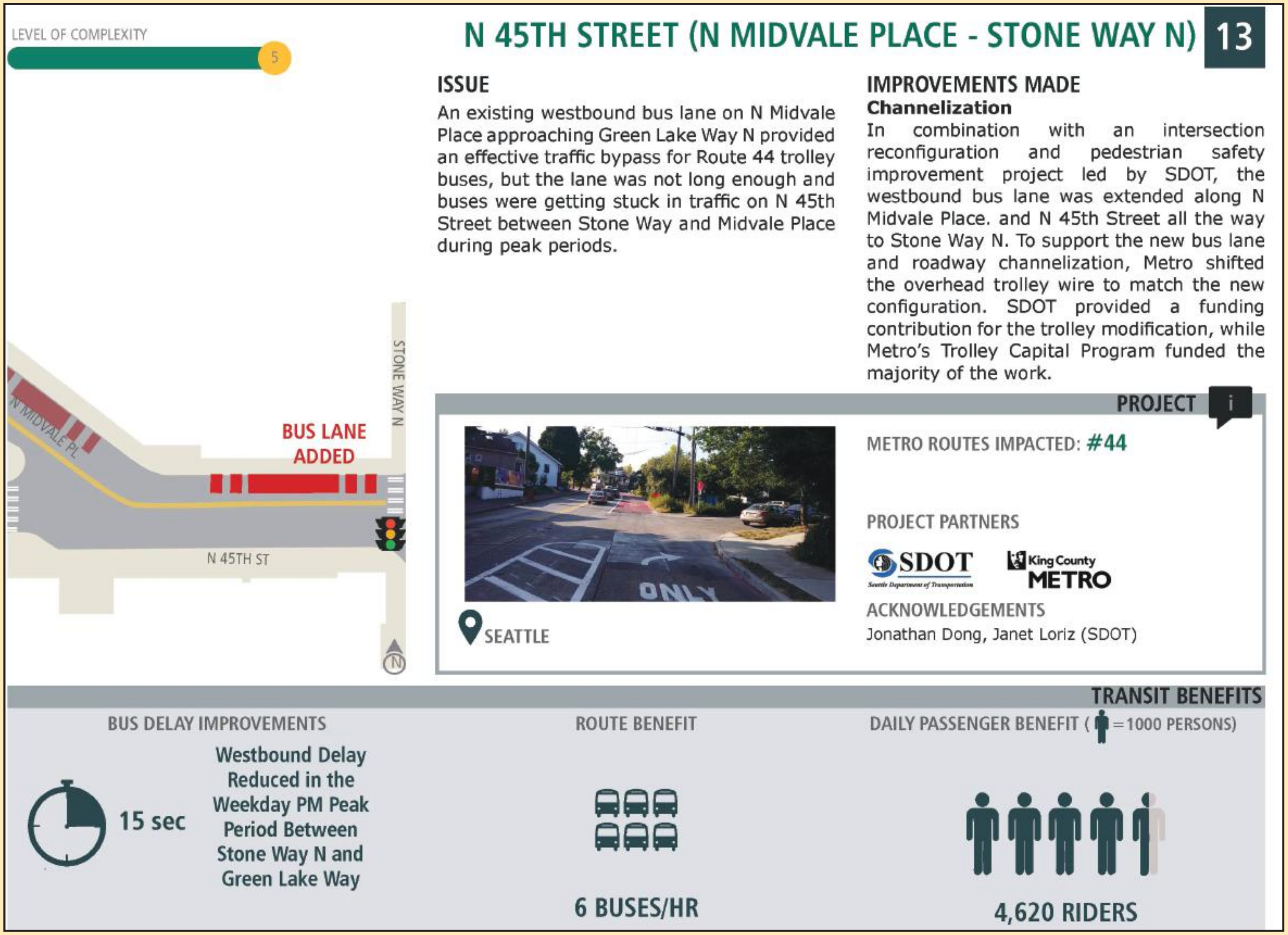
The Annual Spot Improvements Report includes specific project details like issues addressed and speed and reliability tools used. It also describes the benefits of each spot improvement, including safety related improvements, bus delay decrease and riders and routes impacted.

	COMPLETED SPOT IMPROVEMENTS	WEEKDAY RIDERS BENEFITTED	PERSON HOURS DELAY AVOIDED* (DAILY)	# BUS ROUTES BENEFITTED	AVOIDED OPERATING COST
2018	14	263,000	575	72	$1,489,000
2019	16	162,700	280	103**	$607,000
2020	23	224,000	880	125**	$357,000
TOTAL	**53**	**649,700**	**1,735**	**300**	**$2,453,000**

TABLE 1. *Spot Improvements Benefits*
** Only calculated using available time savings before/after reports (some improvements may not be taken into account)*
*** Includes Metro, Sound Transit, Community Transit, Pierce Transit*

RKAAMP, Tukwila Transit Center
Source: King County Metro Photo Gallery, 2020

ANNUAL SPOT IMPROVEMENT REPORT



LEVEL OF COMPLEXITY 5

N 45TH STREET (N MIDVALE PLACE - STONE WAY N) 13

ISSUE

An existing westbound bus lane on N Midvale Place approaching Green Lake Way N provided an effective traffic bypass for Route 44 trolley buses, but the lane was not long enough and buses were getting stuck in traffic on N 45th Street between Stone Way and Midvale Place during peak periods.

IMPROVEMENTS MADE

Channelization

In combination with an intersection reconfiguration and pedestrian safety improvement project led by SDOT, the westbound bus lane was extended along N Midvale Place. and N 45th Street all the way to Stone Way N. To support the new bus lane and roadway channelization, Metro shifted the overhead trolley wire to match the new configuration. SDOT provided a funding contribution for the trolley modification, while Metro's Trolley Capital Program funded the majority of the work.

PROJECT

SEATTLE

METRO ROUTES IMPACTED: #44

PROJECT PARTNERS

SDOT Seattle Department of Transportation | King County METRO

ACKNOWLEDGEMENTS

Jonathan Dong, Janet Loriz (SDOT)

TRANSIT BENEFITS

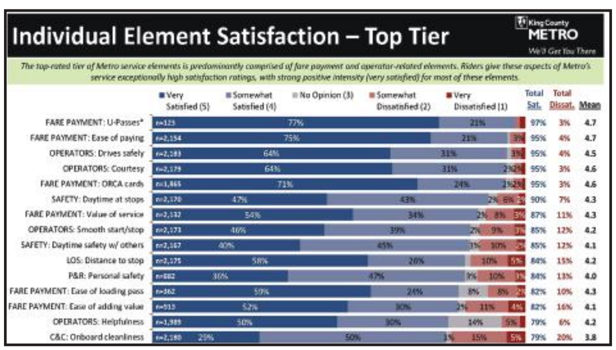
BUS DELAY IMPROVEMENTS	ROUTE BENEFIT	DAILY PASSENGER BENEFIT (= 1000 PERSONS)
15 sec Westbound Delay Reduced in the Weekday PM Peak Period Between Stone Way N and Green Lake Way	6 BUSES/HR	4,620 RIDERS

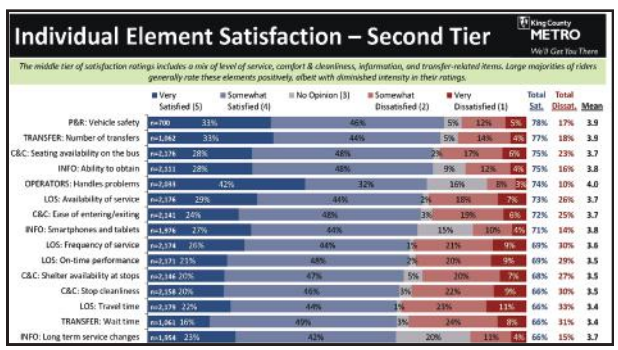
Speed and Reliability Spot Improvements Annual Report, Page Example
Source: King County Metro, Speed and Reliability Group, 2020

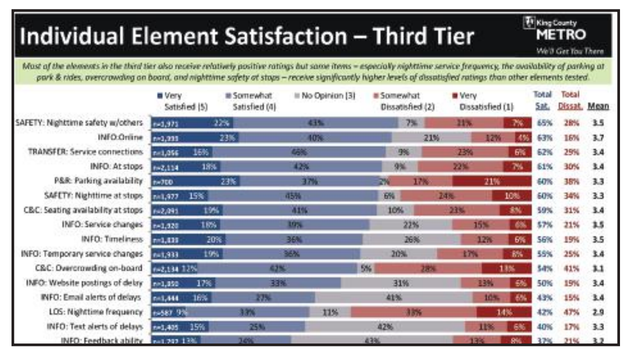
2.3.2 ACHIEVE REGIONAL AND LOCAL GOALS

Fast and reliable transit reinforces and helps to achieve many regional and local goals, such as:

- **EFFICIENT TRANSPORTATION SYSTEM:** As our region grows, public transit is a key part of the solution to moving people from their homes to jobs and other destinations. Speed and reliability improvements often improve conditions for other modes as well, whether improving traffic signal phasing for general purpose traffic, or complementing a walking or biking trip with a quick transit ride. Better transit service performance is important to achieve the goals of *"King County Metro's Strategic Plan"*.
- **EXPANDING RIDERSHIP:** Helping riders reach their destination faster and on schedule makes transit a more attractive mode than private vehicle use. Speed and reliability are the most important qualities to riders and jurisdictions *"King County Metro Transit 2019 Rider and Non-Rider Survey"* found that about 65% of riders are satisfied with transit travel speeds and about 55% of riders are satisfied with timeliness (reliability). Like previous surveys, travel times and on-time performance have the strongest impact on overall satisfaction but receive lower ratings relative to customer's high standards for these elements. More customers that are satisfied by reliable service will increase ridership.
- **EQUITABLE AND SUSTAINABLE COMMUNITIES:** Metro aims to invest where the needs are greatest; address climate crisis and environmental justice; provide equitable and sustainable service; and provide fast, reliable, and integrated mobility services. Speed and reliability investments help to increase ridership by making transit a more attractive choice, reducing greenhouse gas emissions, and providing an alternative to driving a personal vehicle, according to *"King County Metro, Mobility Framework"* goals.
- **MAXIMIZE USE OF RESOURCES:** In many locations, it is not possible to add additional capacity to roadways to accommodate traffic demand. Transit helps maximize the use of the region's existing infrastructure by moving more people in less space than by personal vehicles. Improved transit speed and reliability allows Metro to focus more resources on moving riders and less on getting delayed buses back on schedule. Speed and reliability improvements can prevent the need for additional buses or operating costs to maintain the schedule in the future.







Source: For more information and to view these charts in detail, see the "King County Metro Transit 2019 Rider and Non-Rider Survey"

ROUTE 8 HIGHLIGHT

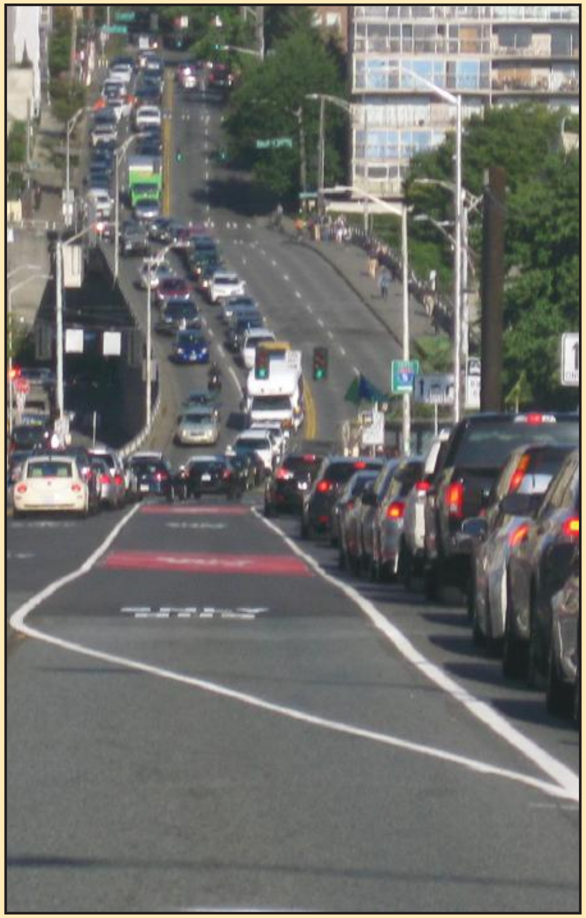
An example of effective speed and reliability improvements along a corridor is the Route 8 project, where Metro partnered with the Seattle Department of Transportation in 2018. The Route 8 connects Seattle Center to the Capitol Hill neighborhood and the Mount Baker Transit Center. With rapid growth in the South Lake Union neighborhood, the route was so consistently delayed that “the eight” became known in social media as “the late.” The goal of this project was to improve Route 8’s transit performance on Denny Way between the Uptown and Capitol Hill neighborhoods, which was the section particularly affected by congestion and other issues.

The implemented speed and reliability improvements included (see Section *“4. TRANSIT SPEED AND RELIABILITY TOOLS”* for description):

- Installation of transit queue jumps.
- Interior (offset) dedicated bus lanes lanes and channelization improvements.
- Left-turn restrictions to improve traffic flow.
- Parking restrictions.
- Installing bus bulbs at bus stops.

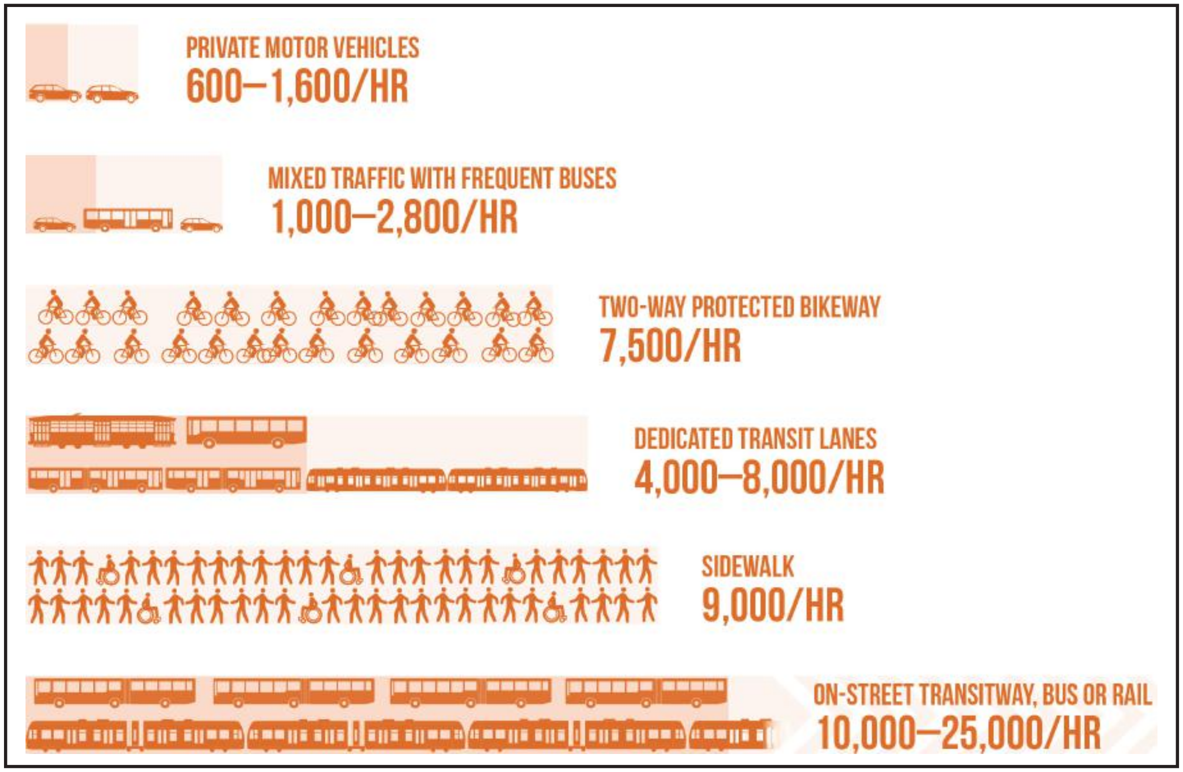
Transit travel times between Lower Queen Anne and Capitol Hill were analyzed approximately 1 year before and 1 year after project completion. The analysis showed that the improvements installed along Route 8 saved 5 minutes per trip for eastbound buses in the PM peak period. It also showed overall travel time savings up to 1 minute in all other time periods and in the westbound direction.

Metro studied the effects of the installation of a short bus-only lane on eastbound Denny Way between Fairview Avenue N and Stewart Street. It was found that the new bus lane saved up to 2 minutes per trip for buses during peak periods.



Denny Way, Route 8
Source: King County Metro Photo Gallery, 2018

- **MULTI-MODAL COMMUNITIES:** Speed and reliability improvements have the potential to positively impact the public realm for all modes of transportation. A transit system offers a major alternative to driving, supports walkable communities, and helps the community to maintain a healthy lifestyle. Reducing or removing parking, reclaiming historically auto-oriented roadway space for other shared use modes, and increasing pedestrian trips contributes to the success of a community and a sense of place.



The capacity of a single general-purpose traffic lane by mode at peak conditions with normal operations.
NACTO - Designing to Move People
Source: https://nacto.org/publication/transit-street-design-guide/introduction/why/designing-move-people/

The Commuter Toolkit, 200 People Travel In...
Source: I-SUSTAIN in collaboration with the City of Seattle.
www.i-sustain.com .

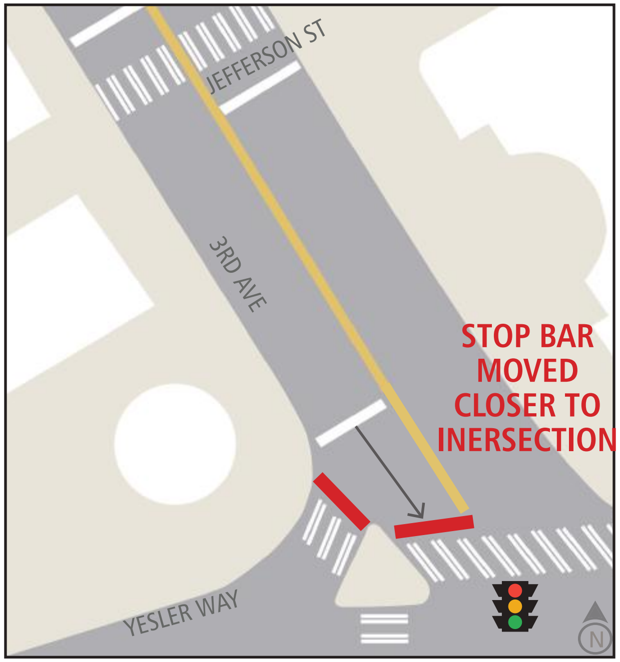
2.3.3 SCALABLE SOLUTIONS

One of the major benefits of speed and reliability improvements is that they can be scaled to meet local needs. A local jurisdiction can work with Metro to implement vastly different solutions that work within the wants and constraints of the City but achieve similar speed and reliability benefits. For example, while dedicated red bus lanes in one jurisdiction may be feasible, a less intensive but worthwhile speed and reliability benefit could be achieved in another jurisdiction with less intensive improvements, such as a short bypass lane with a signal queue jump or intersection geometry changes. The *"4. TRANSIT SPEED AND RELIABILITY TOOLS"* of this document allows you to review this range of strategies, including their benefits and costs.

2.3.4 BENEFITS TO OTHER MODES

Transit-related improvements often have benefits to other modes of transportation including to pedestrians. Below are some project examples:

- At the intersection of E Main Street and M Street in the City of Auburn, modifications to traffic signal operations from protected-only left-turn to protected-yield operation with a flashing yellow arrow will benefit other roadway users. This operational change is expected to reduce bus delay up to 30 seconds, and other vehicular traffic making this movement will also gain the benefit.
- At 3rd Avenue and Yesler Way in the City of Seattle, a stop bar was relocated to prevent buses from obstructing a mid-block crosswalk while waiting at the traffic signal at Yesler Way. This adjustment reduced potential conflicts between buses and pedestrians using the crosswalk, and resulted in safer bus operations and walking environment.
- On Rainier Avenue S in the City of Seattle, a new BAT lane was incorporated into a roadway re-channelization project as part of the City's Vision Zero Program. The City converted general-purpose travel lanes to BAT lanes in both directions at selected locations in the Rainier Beach neighborhood, which reduced AM peak delay by 38 seconds, impacting 57 busses per hour. The repurposing of general-traffic lanes and addition of left-turn lanes made the street safer for vehicle traffic, bicycles, and pedestrians by removing points of conflict.



3rd Avenue and Yesler Way Stop Bar Relocation (Illustration)
Source: Metro, 2021

Rainier Avenue S, Between S Kenny Street and S Frontenac Street
Source: Metro, 2021

2.4 SPEED AND RELIABILITY IN METRO CONNECTS

Speed and reliability is a major part of the Metro Connects vision and a major aspect of working with local jurisdictions to achieve their vision. Metro Connects proposes dedicating nearly one-third of the capital budget toward investments that improve transit speed and reliability on frequent service and RapidRide lines.

By keeping buses moving through congestion and on schedule, Metro can deliver more service and customers will have an attractive alternative to sitting in traffic.

VARYING LEVELS OF INVESTMENT

Metro Connects proposes different levels of investment to keep buses moving quickly and reliably to benefit transit riders. These levels include major investment features that target over 20% of route travel time savings, such as new bus-only lanes with integrated transit signal priority (TSP); moderate investment features that target 10 to 20% of route travel time savings, such as queue jumps, bus bulbs, and other speed and reliability improvements within the existing ROW; and minor investment features that target 5 to 10% of route travel time savings, for example spot improvements at key locations and signal retiming along a corridor.

SERVICE TYPE	TARGETED TIME SAVINGS	INVESTMENT TYPE
New RapidRide	20%+	Minor, Moderate and Major
Existing RapidRide	10-15%	Minor, Moderate and Major
Frequent	10-15%	Minor, Moderate and Major
Express	5-10%	Minor and Moderate
Local	3-5%	Minor

INVESTMENT TYPES

MINOR	MODERATE	MAJOR
EXAMPLE FEATURES	**EXAMPLE FEATURES**	**EXAMPLE FEATURES**
Spot Improvements at key locations and signal retiming throughout a corridor.	Business Access and Transit (BAT) lanes and other speed and reliability treatments within existing right-of-way.	New bus-only lanes and other speed and reliability treatments that may require additional right-of-way
5% TIME SAVINGS	**10% TIME SAVINGS**	**20% TIME SAVINGS**

PRIORITY ON FREQUENT SERVICE

While all of Metro's service types are envisioned to receive some speed and reliability investments, the highest levels will be focused where service is most frequent and where needs are the greatest by incorporating recommendations from the Mobility Framework.

New RapidRide lines will have the highest level of investment, with roughly half of service in bus-only lanes. Existing RapidRide lines and frequent service will benefit from extended and improved bus-only lanes and more extensive speed and reliability features that may require additional ROW.

Several express service lines will benefit from medium or low investment levels.

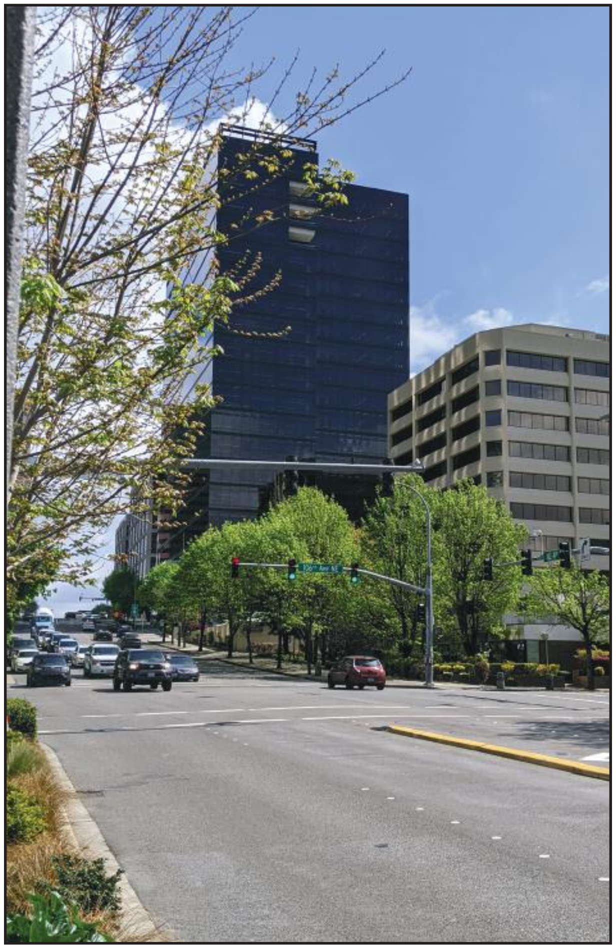
Many local service lines will receive low-level investments.

IMPLEMENTATION

To achieve its vision, Metro Connects calls for an investment of $2.5 billion in speed and reliability improvements on corridor projects through 2050. Metro Connects calls for an additional $4.2 billion investment in the RapidRide network, which includes investment in speed and reliability projects. Those investments will require leveraging additional grant funding and in-kind partnerships with local jurisdictions and WSDOT to create a complete network of infrastructure that keeps transit riders moving.

Some of these investments may include but are not limited to:

- Incorporating transit speed and reliability improvement design elements in capital projects led by local jurisdictions.
- Studying and funding operational changes to reduce the amount of time buses are stopped in traffic or at stops, thus improving reliability.
- Increasing staffing and technology to monitor and adjust service in real time to maintain spacing between buses and respond to service disruptions.
- Using new technology applications to inform roadway users of alternative routing options during incidents in real time.
- Working with partners to improve incident response options that keep buses moving through delays, such as installation of temporary bus-only lanes.



106th Ave NE and NE 4th St, Bellevue
Source: Speed and Reliability Team (Metro), 2021

- Making boarding faster and easier through all door boarding, off-board fare payment, and other similar improvements.
- Investing in large regional projects that would benefit transit in partnership with others, such as bridge or highway crossings. An inventory of candidate projects would be maintained, including new transit pathways and service con-nections, major crossings (e.g. bridges, overpasses), and transit bottlenecks.
- Building on Metro's existing Intelligent Transportation Systems architecture to support both the management of vehicles on the road to make service faster and more reliable, and customer information tools that would make the system easier to use.

This guide provides a framework for how Metro and partner local jurisdictions can work together to plan, design, and build projects that work toward the visions of both Metro Connects and local jurisdictions.

3. FRAMEWORK FOR PARTNERSHIP

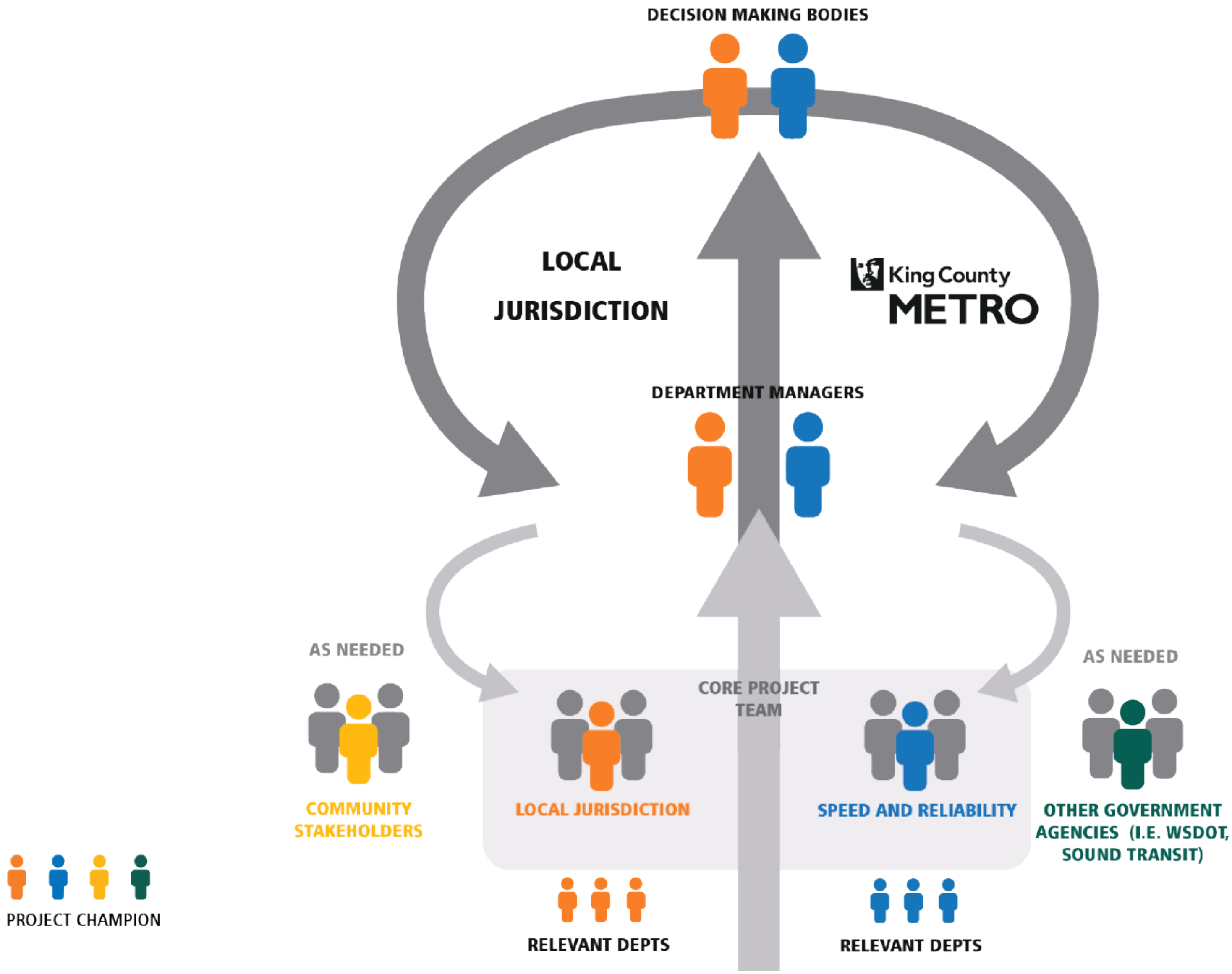
"*King County Metro's Strategic Plan*" defines "partnership" as "a relationship in which Metro and an organization, jurisdiction, or community work together to help advance opportunities and conditions for travelers to use alternatives rather than driving alone".

Partnerships enable Metro to move towards the Metro Connects long-range vision, its stated equity and sustainability goals, and a transit system that is safe, equitable, sustainable, and productive. Metro will accomplish this by leveraging public and private resources to design and deliver services, facilities, access, policies, program/product design, and incentives. Individual partnerships shall support Metro's system-wide goals and shared goals with partners.

Metro staff and operators discussing speed and reliability improvements along the Route 40 corrido
Source: King County Metro Photo Gallery, 2020

BUILDING CONSENSUS

Transit speed and reliability partnership projects require consensus among different departments and levels of government, especially when a local jurisdiction is constrained by staff and funding resources. This consensus can be built in all sizes of local jurisdictions but requires champions of transit and transit riders at every level of government, and close coordination among different departments. It is vital to spread awareness of the impact, importance, and overall benefit to the public of speed and reliability projects throughout local government—this awareness will help to build consensus.



3.1 METRO'S VISION FOR TRANSIT PARTNERSHIP IN THE REGION

3.1.1 SUPPORT METRO'S LONG-TERM VISION

Local jurisdictions are essential partners in the Metro Connects vision, both in developing projects, and in pursuing transit-supportive growth and policies. Metro Connects, Metro's long-range plan, envisions working with local jurisdictions and agencies to prioritize improving transit reliability on RapidRide and the Frequent Transit Network. If the plan's vision is achieved, Metro would dramatically expand the number of places people could go by transit and decrease the time it takes to get there.

Metro continues to collaborate with jurisdictions, transportation agencies, and the public to move toward this vision. Metro is expanding collaboration with local jurisdictions and stakeholders to improve transit through partnerships in a variety of areas: financial, land use, zoning, transit-supportive policies, traffic operations, transportation infrastructure and policies, grant coordination, as well as new and innovative kinds of partnerships.

Partnerships for speed and reliability improvements are amongst the most important of these. The level of planned investment in speed and reliability in Metro Connects requires Metro and local jurisdictions to work together at many different levels in an ongoing manner. Metro Connects is a living document and is expected to be updat-ed every six years, incorporating intermediate changes that occur on the ground and in local plans. This iterative process will contribute to a lasting consensus about the fu-ture of transit and will help cities realize their visions for the future as well.

Metro Connects, 2021

3.1.2 PARTNER ON SPEED AND RELIABILITY PROJECTS

Local jurisdictions have a range of opportunities to become involved in speed and reliability improvements, and initiation for partnerships may start from Metro or a local jurisdiction. Metro may initiate collaboration with the local jurisdiction through transit and capital planning. Local jurisdictions may initiate collaboration with Metro in the development of a local transit plan, long range plan, comprehensive plan, or capital plan. The goal of partnership is to plan and build infrastructure that will benefit Metro customers and the partner jurisdiction or agency.

Within the partnership, the roles taken on by Metro and the local jurisdiction or other agency partner shift depending on what the opportunity is. While there are many ways for local jurisdictions to provide feedback and resources on efforts driven by Metro, there are also many ways for Metro to provide input and feedback on efforts driven by local jurisdictions and agencies. Both partners need to seek the input of the other in a wide range of situations that enable an effective transit system.

As partners, both local agencies and Metro have an opportunity to apply for grants to fund speed and reliability improvements. Metro, as an agency, may apply to state (e.g. Regional Mobility Grant, applications on even year) or federal grants (e.g. Puget Sound Regional Council, applications on even year). Local jurisdictions have an addi-tional option to apply for grant funding via the Transit Improvement Board (applica-tions every year). Regardless of who is leading the application, Metro and local juris-dictions need to connect during the pre-planning phase to get support of each other.

I Line Engagement - Renton River Days
Source: Metro, 2019

RKAAMP Engagement- Partner Review Board
Source: Triangle Associates, 2019

CITY PLAN EXAMPLES

"The City of Kirkland Transit Implementation Plan" (2019) and the *"City of Kent Transportation Master Plan"* (2021) are examples of city-led plans and policies that identified transit projects, providing an opportunity for Metro and the cities to partner on speed and reliability improvements on key corridors.

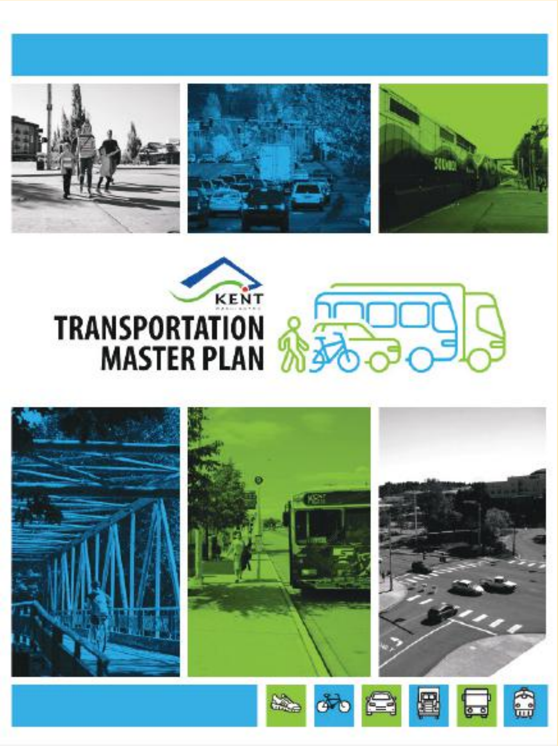


TABLE 2. *LOCAL JURISDICTION/OTHER AGENCY-INITIATED PROJECT PROCESS*

	METRO'S ROLE	LOCAL JURISDICTION'S ROLE	KEY TASKS
PLANNING	Collaboration in early phases and throughout conceptual planning, design, and implementation processes. Also, support local jurisdictions in seeking grant funding opportunities if needed, provide technical support on case by case basis, and provide transit data measurements.	Public outreach and equity-centered engagement are important components in ensuring project success. The level of public outreach will be scaled to the project size. Implementation lead on local transit-related policy such as: » Transit-supportive land use policy changes. » Solicitation from Metro for input early in the planning phase for capital improvement plan that identify potential speed and reliability improvements. » Project scope of work definition. » Development of conceptual plans and financial plans for design and implementation.	» **Plan for Transit in Long Range and Comprehensive Planning:** Local and regional long-range plans, such as comprehensive plans and transportation plans, can set the vision for transit service level and priority. The identification of important transit corridors and other areas for prioritized transit investment can help local jurisdictions and Metro be competitive in seeking and securing federal funding for transportation. » **Engage Speed and Reliability in Capital Improvement Plan (CIP)**: A local jurisdiction's capital improvement plan defines and prioritizes infrastructure projects. These projects often have both implications for and opportunities to include speed and reliability components. » **Integrate Transit in Small Area and Corridor Plans:** Medium-term plans for neighborhoods, districts, and corridors within communities can guide the integration of transit into the community and identify ways in which transit can complement future investments. Jurisdictional corridor plans can coordinate with Metro's prioritized corridors; communities can collaborate with Metro to incorporate speed and reliability recommendations.
DESIGN AND IMPLEMENTATION	Convey existing operational issues or potential future speed and reliability issues or opportunities within or surrounding the project area.	Actively solicit Metro's input on development entitlements and capital improvement project plans. Jointly seek opportunities to incorporate transit speed and reliability improvements into capital projects that would benefit transit riders.	» **Collaborate with Metro on Capital Improvements:** Local jurisdiction project proposals, as part of their CIP, may focus on other modes and the project outcome may not be transit-supportive. There should be collaboration with Metro to ensure the proposed changes will maintain the quality of transit service in the project area or will bring opportunities to integrate transit speed and reliability improvements to benefit transit riders and all modes. » **Incorporate Transit into Private Development:** Similar to capital improvements, private development often provides opportunities to integrate transit speed and reliability into the circulation networks of new projects. New development may also pose challenges to transit operations that communities can work through with Metro.
PERFORMANCE	Monitor transit performance and ridership and coordinate with local jurisdiction to make operational adjustments as necessary.	In most cases, local jurisdictions own and maintain the roadway and signal infrastructure. Coordinate with Metro to develop a key performance index for monitoring and evaluating.	» Balance benefits of speed and reliability improvements with needs of other transportation modes.

TABLE 3. *METRO-INITIATED PROJECT PROCESS*

	METRO'S ROLE	LOCAL JURISDICTION'S ROLE	KEY TASKS
PLANNING	» Long-range transit planning (Metro Connects, Mobility Framework) » Transit planning and service planning (Corridor Strategic Planning and Prioritization, RapidRide and Frequent Transit Network Corridors, Service Plan Network)	» Provide input through the Technical Advisory Committee for Metro Connects/ Long-range planning scaled to the project size. » Input on transit service planning	» **Coordinate Service Plan Network with Cities:** Metro closely coordinates service plans with cities and public transportation agencies to achieve the Metro Connects vision. Metro follows its Service Guidelines for restructuring, which include a detailed planning and community outreach process. Participating in coordinated service planning can ensure routes will have the long-term support of the community and help reinforce speed and reliability in the future. » **Engage Partners in Capital Planning:** Metro's capital planning includes developing corridors, hubs, spot improvements, technology, and partnerships with private providers. Metro, Sound Transit, and local partners have started to identify where major investments are needed to remove bottlenecks on corridors that have many riders and are slated for BRT service.
DESIGN AND IMPLEMENTATION	Prioritize high-ridership corridors for speed and reliability capital investments and work closely with local jurisdictions to plan, design, and implement. Support local jurisdictions to incorporate future changes that will benefit local communities as well as transit riders.	Actively engage with Metro in identifying potential speed and reliability improvements and seek opportunities to incorporate transit improvements in existing or planned capital projects. Support Metro in planning and lead/ support design and construction of improvements to benefit all users as well as transit riders.	» **Coordinate Early on Speed and Reliability Improvements:** Improvements are identified, planned, and implemented at various scales including spot/intersection, corridor-wide, transportation hub, or as part of a service restructure.
PERFORMANCE	Monitor transit performance and ridership. Evaluate the effectiveness of speed and reliability improvements and coordinate with local jurisdiction to make operational adjustments as necessary. Work with local jurisdictions to develop the key performance index for monitoring and evaluating for general public benefit as well as transit riders.	In most cases, local jurisdictions own and maintain the roadway and signal infrastructure. Local jurisdictions will continue to maintain the assets. Coordinate with Metro to develop a key performance index for monitoring and evaluating the speed and reliability improvement.	» Balance benefits of speed and reliability improvements with needs of other transportation modes » Overcome barriers to implementation of a speed and reliability improvement

3.1.3 USE RESOURCES EFFECTIVELY

Jurisdictions throughout the region vary in their abilities to apply resources to speed and reliability projects, yet every local jurisdiction can form an effective partnership with Metro. The key for effective partnership is to understand how to best leverage the resources a local jurisdiction has.

Resources include existing staff:

- How many engineers, planners, and other professionals are on staff to analyze issues, define solutions, and craft and review plans and projects?
- Is there staff dedicated to transit performance?

Resources also include local policies that support speed and reliability:

- Does a local jurisdiction have a transit plan, or the capacity to create one?
- What is the priority for transit within how a local jurisdiction manages its streets?
- Does a local jurisdiction have financial resources for studies and construction?

The following table (*"Table 4. USE OF RESOURCES"*) offers additional guidance for cities with different levels of resources.

JURISDICTION RESOURCE LEVEL	HIGHER	MEDIUM	LOWER
OPPORTUNITY	Opportunities for jurisdictions with staff dedicated to transit performance, resources to plan and execute projects, and extensive experience with speed and reliability projects are focused on working with Metro to implement their transit plans as well as to refine the coordination between jurisdiction staff and Metro.	Opportunities for jurisdictions with some amount of capacity to plan and execute transit projects and some experience with speed and reliability projects are focused on leveraging this capacity and growing this experience.	Opportunities for jurisdictions with limited resources for transit and no speed and reliability improvement experience are focused on introducing the idea of speed and reliability improvements into the jurisdiction's dialogue among staff, elected officials, and throughout the community.
WAYS TO WORK WITH METRO	– Implement local jurisdiction transit plan together as partners – Coordinate on speed and reliability processes – Convene a speed and reliability improvement working group – Pilot/innovate/test new speed and reliability concepts through speed and reliability project partnership with Metro – Concurrence on goals of local jurisdiction transit plan	– Develop transit plan in coordination with Metro – Expand range of speed and reliability tools being employed – Integrate speed and reliability review into local jurisdiction-driven plans and projects – Pilot/innovate/test new speed and reliability concepts through speed and reliability project partnership with Metro – Articulate trade-offs between transit and other community aspects – Increasing community awareness of speed and reliability improvements	– Launching a pilot speed and reliability project with Metro – Inviting Metro to review capital projects potentially affecting speed and reliability – Initiating a community conversation about transit

TABLE 4. *USE OF RESOURCES*

3.2 THE PARTNERSHIP PROCESS

GUIDING PRINCIPLES

Several guiding principles can enable successful partnering with Metro to implement speed and reliability improvements.

PEOPLE

A single point of contact is critical within a local jurisdiction or agency. Internal coordination and communication are just as important as coordination between Metro and the local jurisdiction.

LONG TERM VIEW

Transit, jurisdictions, and riders will be better off if speed and reliability improvements are incorporated on an ongoing basis rather than implemented once there is a known problem. Long-term and coordinated planned improvements set the stage for successful traffic operations that complement other users.

BE PROACTIVE

Both Metro and local jurisdictions should be proactive in involving one another in decisions affecting transit service and speed and reliability.

FREQUENT TRANSIT NETWORK

Metro Connects is heavily focused on improving the speed and reliability of frequent transit network. Speed and reliability improvements along high frequency network provide the most benefits for the local jurisdiction and transit riders.

COMMON SOLUTIONS

Work together with different stakeholders and riders to develop a solution everyone is interested in implementing.

EQUITY AND GEOGRAPHY

Metro Connects emphasizes investments in social equity and regionally important centers of activity.

LOOK AT THE TRADE-OFFS

Consider what trade-offs the jurisdiction and local transit riders are likely to accept. Trade-offs should be considered as they relate to the purpose and need of the project. These trade-offs are framed in the TOOLBOX section of this document.

CONSIDER A WIDE RANGE OF TOOLS

Use this guide to help you select the right tool for the right situation.

COMMUNITY ENGAGEMENT

The partner should incorporate community engagement that is equity-centered, supports lasting community relationships, and builds awareness of and access to services among priority populations.

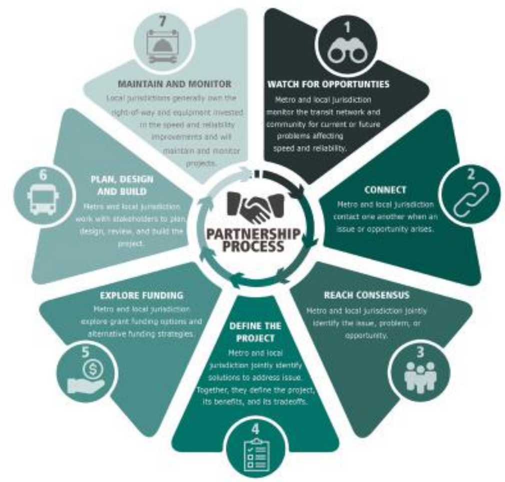
PROCESS

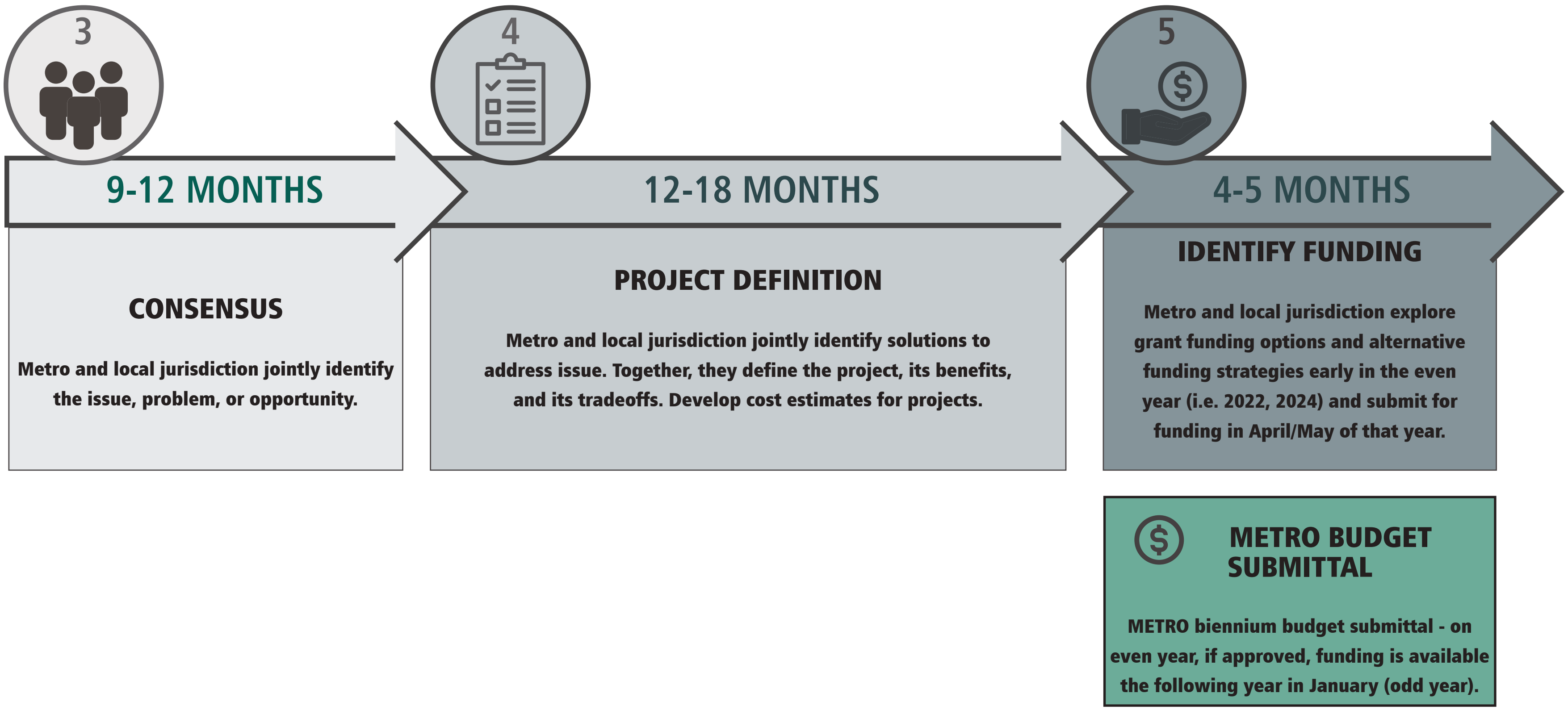
Implementing speed and reliability projects is most effective when Metro, local jurisdictions, and other stakeholders work within a common process. If the ROW is in WSDOT's jurisdiction, WSDOT will be included as the partner in the process. This process is a cycle of jointly identifying issues, developing solutions, implementing the solutions, and monitoring performance. Use the *"3. FRAMEWORK FOR PARTNERSHIP"* and *"4. TRANSIT SPEED AND RELIABILITY TOOLS"* sections of this document to identify issues, opportunities, and solutions at different points of the process.

METRO FUNDING TIMELINE

The following presents a typical timeline of coordination among Metro, local jurisdictions, and agencies to set priorities, plan projects, and request funding for speed and reliability projects. Once the budget is approved, project planning, construction, and delivery can take up to 3 years to complete a corridor project and up to 1 year to complete a spot improvement.

If Metro and partners miss this budget cycle, Metro can continue working with a local jurisdiction or agency while looking for other opportunities such as grant funding.





4. TRANSIT SPEED AND RELIABILITY TOOLS

This section describes different types of issues that can be solved with transit speed and reliability tools and what types of barriers or side effects may be associated with each strategy. For current and additional information on design practices please review documents mentioned in *"6. REFERENCE DOCUMENTS"*.

Source: Metro, 2021

4.1 CHALLENGES ADDRESSED BY SPEED AND RELIABILITY TOOLS

Identifying the root cause of traffic bottleneck or congestion is the first step before selecting which tool or combination of tools can be applied to alleviate or reduce the level of congestion. The table below summarizes typical issues that can impact bus travel time and reliability.

TABLE 5. *SPEED AND RELIABILITY CHALLENGES*

CHALLENGES		DESCRIPTION
CONGESTION	INTERSECTION	– Inefficient channelization and lane assignments can create unnecessary bus delay. If the traffic demand is higher than the lane capacity, intersection congestion can cause more delay to buses and can have an impact on bus stop operations or the ability for buses to make turns.
	ROADWAY	– A roadway operates above its capacity, either due to intersection traffic volume limits, parking maneuvers interrupting midblock traffic flow, merging traffic flow, or other physical roadway constraints.
	FREEWAY ON-RAMP	– Upstream intersections are affected by the congested on-ramp because queues restrict turning or through movements. Excess demand along access ramps to a freeway causes delay for buses attempting to enter the freeway.
DELAY	SIGNAL	– Inefficient signal timing plans may create unnecessary signal delay, such as lead/lag phasing, unused green time, and uncoordinated corridors. Also, buses may not be able to take advantage of signal coordination due to a bus stop being located between signals.
	RIGHT TURN	– A bus may be prevented from turning right by high pedestrian demand in the crosswalk or a queue of vehicles attempting to turn right caused by a congested receiving lane. A tight turning radius of intersection that requires slower turning speeds for the bus also causes delays.
	LEFT TURN	– High opposing vehicle demand and pedestrian volume limit the number of gaps available to turn left at an intersection with a permissive left-turn phase. Protected left-turn does not always provide enough time.
	OTHER TRAFFIC RELATED	– A lack of turn-only lanes impedes through movement of buses. Speed humps or other traffic calming improvements cause additional deceleration and acceleration for buses, and bicycle lanes can create additional conflict points.
OPERATIONS	INEFFICIENT ROUTE DESIGN	– A higher frequency of stops increases the amount of time spent serving stops due to additional acceleration, deceleration, and time required to open and close the doors. Additionally, an inefficient route design that incorporates unnecessary turns creates turning delay.
	INTERRUPTIONS LEAVING BUS STOP	– Stops are provided out of the travel lane on higher traffic streets, which can make merging back into the travel lane difficult because gaps in traffic may be minimal.
	BUS ZONE DWELL TIME	– High ridership, crowded buses, and fare payment at the front door all add dwell time delay.
	BUS STOP CAPACITY	– Multiple buses attempting to serve a stop at once can lead to additional delay as some buses must wait to reach the stop.
SAFETY	PEDESTRIANS CONFLICTS	– High pedestrian demand in the crosswalk without protected right turn signal, may create a potential conflict where an operator would not see a crossing pedestrian.
	CYCLISTS CONFLICTS	– Bicycles can delay transit where buses must merge into the bike lane to reach a bus stop. Also, operators need to be aware of bicycles that are out of their sightline in mixed traffic.
	MOTORISTS CONFLICTS	– High traffic volumes can create numerous conflict points with transit vehicles when the bus needs to merge into a lane and/or after serving the bus stop at pull out.

4.2 BARRIERS

There are various barriers to implementing speed and reliability improvements. Key barriers that Metro has identified are technical: how to incorporate these improvements into the limited ROW with many competing modes, and political: how to gain support from both the community and the local government to implement the projects.

Local jurisdictions face pressure to deliver improvements and invest in all modes of transportation. While implementing transit-supportive strategies, local jurisdictions will need to determine how local streets and roadways can best accommodate all modes of travel. In order to alleviate some of the competing demands a local jurisdiction faces, Metro aims to partner with local jurisdictions to provide benefits through transit service expansion, routing changes, and capital investments.

BARRIER: BALANCING TRANSIT WITH OTHER MODES

Local jurisdictions and Metro have to overcome a lot of barriers while implementing speed and reliability improvements. Curbside management decisions include various and often competing demands for the curb: transit riders, business owners, drivers, residents, shared vehicles, ride hail, those making deliveries, or others . These barriers can be addressed by curbside BAT lanes with dedicated operational hours for transit and deliveries. Acceptable changes in general purpose traffic operations will need to be determined by the local jurisdiction and communicated to Metro. The local jurisdiction and Metro can work together to develop strategies to provide transit benefits while maintaining operations for other roadway users at an acceptable level.

Transit speed and reliability improvements may at times conflict with pedestrian needs. This can occur, for example, when roadways are widened to accommodate queue jump lanes and bus-only lanes, and when TSP extends the waiting time for pedestrians crossing the main transit corridor. Wider roadways that necessitate longer pedestrian crossing times may be mitigated by updating signal timing plans that balance both pedestrian and transit needs.

Metro aims to balance the needs of bicycles by fostering connectivity and integration, while reducing points of conflict. Co-location of transit stops with bicycle amenities can improve both modes of transportation as it allows for better connectivity and integration between modes. Metro is currently developing *"King County Metro, Bus Stops along Bikeways Guidelines"*. To decrease conflicts between transit and bicycles, different design strategies can be used. The preferred option for incorporating bicycle lanes into transit infrastructure is a separated bikeway. However, when no space is available for dedicated bikeways, a shared bus-bicycle lane strategy can be implemented when buses are traveling at relatively low speeds.

5th Avenue, Seattle
Source: Metro, 2020

Parking removal is one method to leverage existing ROW to implement a bus lane as well as bus facilities such as bus bulbs, bus pull outs, bus islands, and bus stops. This is done to reduce the overall cost by limiting or eliminating the need to purchase ROW for speed and reliability investments.

Metro will need to work with the local jurisdiction to engage stakeholders affected by the parking removal. The removed parking could be relocated to side streets while incorporating a time limit to the parking space to improve parking turn-over. Documentation of the existing and future on-street parking demand and supply can assess the feasibility of relocating parking within a transit corridor. Additional strategies include relocating the parking to another location by converting a travel lane to parking.

BARRIER: EXPAND LOCAL AND POLITICAL SUPPORT

Public and political support for transit speed and reliability improvements varies from project to project. Potential political barriers are rules, policies, and legislation that prioritize general traffic to the detriment of transit.

To gain public support Metro and the local jurisdictions can work together to ensure the public understands the benefits of speed and reliability improvements, while recognizing that there will be trade-offs. Typical ways to engage public are conducting surveys, open houses, meetings with communities or other stakeholders, etc.

Some transit improvements are more successful if there is adequate enforcement. For bus lanes, enforcement helps prevent use by general purpose vehicles and improves transit travel speeds and reliability. Automated camera enforcement of bus lanes is currently allowed within the City of Seattle at selected locations, per Washington State law. With approval from the Washington State Legislature and local agency concurrence, the use of automated enforcement cameras could be expanded to other locations.

NE 65th Street, Seattle
Source: SDOT, 2020

4.3 TOOLBOX

The Toolbox section is organized into four major categories:

- Street and Intersection Design
- Bus Stops and Routing
- Traffic Regulations, and
- Signals

The Speed and Reliability Toolbox provides a high-level introduction to each of the tools. More in-depth information can be found in the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"* and *"National Association of City Transportation Officials (NACTO) Transit Street Design Guide"*. Each tool is summarized individually and includes implementation guidance and examples that have been completed throughout the county (the list of examples included is not exhaustive). Traffic impact analysis might be needed to better understand the impacts of the improvement.

The matrix shown on the adjacent page can be used to identify which tools can be used to address each of the issues discussed in *"4.1 CHALLENGES ADDRESSED BY SPEED AND RELIABILITY TOOLS"*. The estimated level of cost ($-$$$$) and level of coordination with Metro (low, medium, high) are summarized in the matrix as well. The estimated level of cost includes all phases from planning to construction. Many of the tools can and should be used in combination with others to improve their effectiveness. Traffic impact analysis might be needed to better understand the impacts and effectiveness of the improvement.

ICON INVENTORY

Icons are used through the illustrations to clearly communicate the Speed and Reliability strategy being utilized.

BUSES ONLY — BUS ONLY LANE

BUS

BICYCLE

CHANNELIZATION CHANGE

SIGNAGE ADDITION

TURN ONLY

NO PARKING

SIGNAL CHANGE

SEND SIGNAL

RECEIVE SIGNAL

SIGNAL PHASING

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

STRATEGY	CHALLENGES: CONGESTION – INTERSECTION	CONGESTION – ROADWAY	CONGESTION – FREEWAY ON-RAMP	DELAY – SIGNAL	DELAY – RIGHT TURN	DELAY – LEFT TURN	DELAY – OTHER, TRAFFIC RELATED	OPERATIONS – INEFFICIENT ROUTE DESIGN	OPERATIONS – LEAVING BUS STOP	OPERATIONS – DWELL TIME	OPERATIONS – BUS ZONE CAPCITY	SAFETY – PEDESTRIANS	SAFETY – CYCLISTS	SAFETY – MOTORISTS	COST	COORDINATION	PAGE LOCATOR
A. Street and Intersection Design																	40
Dedicated Bus Lane	◆◆◆	◆◆◆		◆◆◆	◆◆◆	◆◆◆		◆◆	◆◆	◆◆◆	◆◆		◆	◆◆	$ - $$$$	High	42
Queue Bypass (Short Bus Lane)	◆◆◆	◆◆	◆◆		◆◆	◆◆	◆◆	◆◆	◆◆			◆	◆		$ - $$$$	High	52
Roadway Channelization	◆			◆	◆◆	◆◆		◆	◆			◆	◆	◆	$	Low/Medium	55
Turn Radius Improvements		◆			◆◆	◆◆									$$$	Medium	56
Speed Hump Modifications							◆◆								$ - $$	Low	58
B.Bus Stops and Routing																	60
Bus Stop Location	◆			◆				◆	◆◆	◆	◆	◆◆	◆◆		$$ - $$$	Medium	62
Route Design	◆	◆		◆				◆◆◆	◆	◆	◆				$$	High	64
Bus Stop Lengthening									◆	◆◆	◆◆◆				$$	High	66
Bus Bulbs									◆	◆◆	◆◆				$$ - $$$	High	68
Boarding Islands									◆	◆◆	◆◆		◆◆		$$ - $$$	High	70
C. Traffic Regulations																	72
Turn Restrictions/Exemptions	◆			◆	◆◆	◆◆	◆	◆	◆			◆	◆	◆	$	Low	74
Parking Removal/ Alterations		◆◆							◆◆						$	Low	76
D. Signals																	78
Passive Traffic Signal Retiming	◆◆	◆		◆◆	◆	◆		◆◆				◆	◆	◆	$ - $$	Low	80
Transit Signal Priority (Active)	◆◆◆			◆◆◆	◆◆◆	◆◆◆	◆◆◆	◆◆◆							$ - $$	Low	82
Signal Phase Modification	◆◆	◆		◆	◆		◆◆					◆			$ - $$$	Low-Medium	86
New Signal Installation	◆◆	◆		◆	◆		◆◆					◆			$ - $$$$	Low-Medium	90
Queue Jumps	◆◆◆	◆◆	◆◆		◆◆	◆◆		◆◆	◆◆			◆	◆		$ - $$$	Medium	94

Benefits: ◆ LOW ◆◆ MEDIUM ◆◆◆ HIGH

4.3.1 STREET AND INTERSECTION DESIGN

This section describes the tools that improve speed and reliability through stop location and spacing and/or changes to route design: the physical design of streets and intersections. Roadway widening can be prohibitively expensive and impractical in an urban environment, but there are many options available to improve transit operations by making modifications within the existing ROW.

There are several types of dedicated bus lanes that can be used as a strategy to maximize bus speeds or to help buses bypass bottleneck locations or highly congested areas. Dedicated bus lanes can be cost prohibitive, but there are many other tools that can be applied to the existing street or intersection like modifications to roadway channelization, accompanying signage, modifications to the turn radius, and changes to existing speed humps.

Battery Street and 4th Avenue, Seattle
Source: Metro, 2021

DEDICATED BUS LANE

GENERAL

CURBSIDE

INTERIOR (OFFSET)

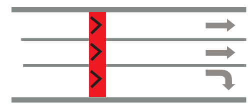
MEDIAN/LEFTSIDE

CONTRAFLOW/REVERSIBLE

QUEUE BYPASS (SHORT BUS LANE)

ROADWAY CHANNELIZATION

TURN RADIUS IMPROVEMENTS



SPEED HUMP MODIFICATIONS

DEDICATED BUS LANE

GENERAL

$ - $$$$

OVERVIEW OF STRATEGY

A roadway lane dedicated exclusively or primarily to the use of buses. Bus lanes are typically considered in the following situations:

- On urban streets with relatively high bus and general traffic volumes, where many buses and their passengers are subject to delay.
- Curbside bus lanes, or BAT lanes, typically operate as dedicated bus lanes with exceptions for general traffic right-turns.
- In corridors with BRT or other premium bus service, where maximizing bus speeds and reliability is a priority.
- On shorter stretches of roadway, allowing bes to bypass a bottleneck or to move to the front of a queue.

Bus lanes may operate full time or only during peak periods. Additional information is included in Section 8.1 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

This section can be referenced for all Dedicated Bus Lane types on Pages 44-51.

BENEFITS

Bus lanes can improve bus travel times and bus travel time variability. The magnitude of the benefit depends on a number of factors, including the ability of buses to avoid delays from right-turning traffic, illegal stopping and parking activity in the lanes by other vehicles, and the level of congestion that existed on the roadway prior to the implementation of the bus lanes.

OPERATIONAL CONSIDERATIONS

Specific operational considerations are discussed for each type of bus lane. A queue jump may be added at the end of the bus lane when the lane is constricted. A continuous bus lane is more effective when compared to intermittent bus lanes along a corridor. A minimum lane width of 11 feet is desired for transit to operate on public streets; lane widths less than 11' wide may be allowed after following variance process that considers the operating context of the lane and input from the Transit Safety department.

IMPLEMENTATION GUIDE

BALANCE OPERATIONS OF ALL ROADWAY USERS: When converting a lane to bus use only, there should be considerations of how to balance transit speed and reliability benefits with operations of other roadway users and whether there could be some traffic diversion to other parallel streets.

CHECK BUS FREQUENCY & RIDERSHIP: Buses must be frequent enough to justify dedicated roadway space and prevent the appearance of an empty and unused lane. At a minimum bus frequency should be at least 15 minutes off peak and 10 minutes during peak periods and the bus routes using the bus lane should serve at least 2,000 hourly riders. Future/planned bus volumes may be considered for justification of a new bus lane.

DETERMINE BUS LANE OPERATING CHARACTERISTICS: Operating characteristics, such as full-time versus part-time lanes, right-turn prohibitions, shared use, and visibility, should be determined to improve overall support and success of the bus lane.

$ - $$$$

DEDICATED BUS LANE

GENERAL

LOCAL APPLICATION EXAMPLES

Westlake Avenue N, Seattle: A curbside lane is provided all-day for buses on Westlake Avenue North.

Also shows an all-day left side bus lane in the northbound direction.
Source: Metro, 2020

COST CONSIDERATIONS

PLANNING AND COORDINATION

Between $25,000 and $125,000: Because bus lane projects are implemented over relatively long lengths of roadway in comparison to the intersection focus of most other types of tools, stakeholder engagement, traffic analysis, and similar efforts will be needed to address a corresponding large area.

CAPITAL COSTS

Between $10,000 and $50,000 per 300-foot block of arterial per direction: These costs range from installing new striping and pole-mounted signing, red bus lanes, to providing overhead signing, or reconstructing the roadway median. These costs assume no roadway widening is needed.

MAINTENANCE COSTS

Maintenance costs would be relatively low if the bus lane is created by restriping an existing lane, in which case there may be some added costs to maintain the striping and new signs. If the bus lane is created by widening the roadway or creating a new facility in the roadway median, then the costs would be high relative to other strategies due to the new pavement area requiring maintenance. The local roadway jurisdiction will need to be responsible for bus lane maintenance; Metro cannot maintain facilities it does not own.

BARRIERS AND SIDE EFFECTS

Specific barriers and side effects are described for each type of bus lane.

ALTERNATIVES AND COMPANION STRATEGIES

All Bus Operations tools can be paired with bus lanes. Prohibiting right-turns by general traffic results in better bus lane operations (as buses avoid waiting behind right-turning vehicles queued at a red light or waiting for pedestrians to clear the crosswalk) and gives Metro considerable flexibility in where bus stops are located.

Passive traffic signal timing adjustments can be considered with bus lane applications to keep buses progressing in the peak direction of travel. TSP also works well in combination with bus lanes (see *"TRANSIT SIGNAL PRIORITY (ACTIVE)" on page 84*). Bus-only signal phases may be required to serve bus turning movements that would conflict with through traffic if made from the bus lane. Pre-signals can be used to mimic the benefits of a bus lane in locations where constraints make it infeasible to continue a physical bus lane.

It may be beneficial to shift routes serving parallel streets onto the street with a bus lane to use the lane more efficiently; in these cases, bus stops may need to be lengthened to accommodate the increased bus volumes. Red-colored pavement markings can be used on bus lanes to improve their conspicuity, which helps reduce violations of the bus lane by other vehicles. However, red-colored pavement markings are expensive and may not be appropriate for peak-only bus lanes.

DEDICATED BUS LANE
CURBSIDE

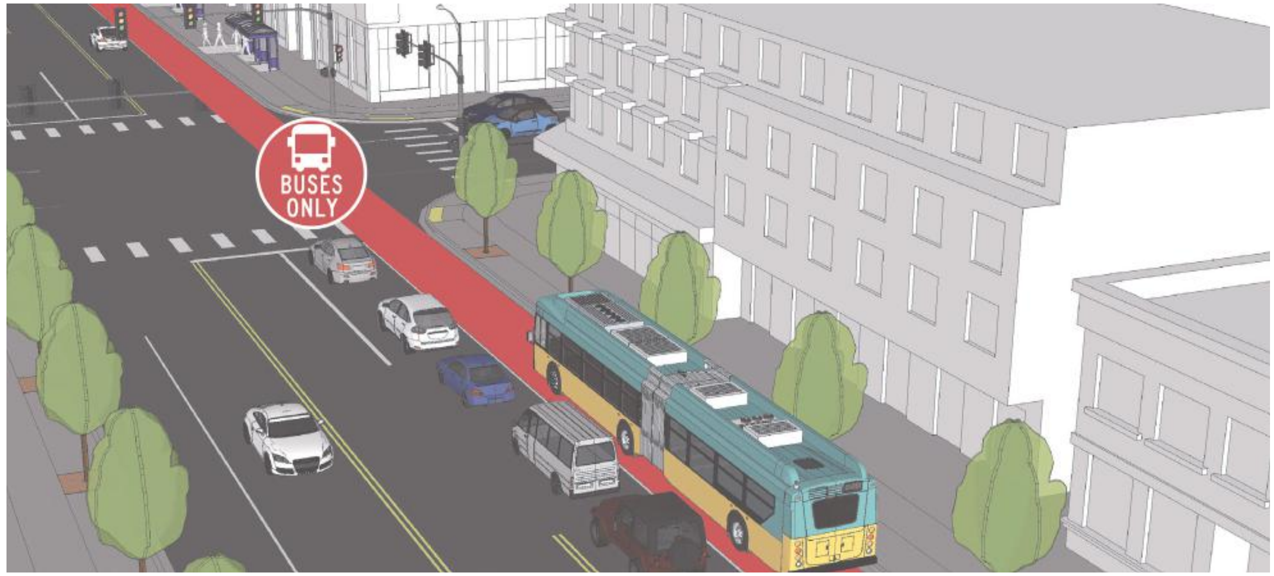
$ - $$$$

OVERVIEW OF STRATEGY

A bus lane located in the rightmost lane of the existing roadway and adjacent to the right curb. This type of bus lane provides speed and reliability benefits without the need for extensive capital improvements beyond signing and pavement markings. BAT lanes are the most common type of the curbside lanes used only by right-turning vehicles and buses. Additional information is included in Section 8.2 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

See *"Dedicated Bus Lane GENERAL" on page 43* for a general discussion of benefits. Because of the interference caused by right-turning traffic stopped for pedestrians in crosswalks, curbside bus lanes will produce smaller benefits for buses than other bus lane types with high vehicle right-turn volume. To combat potential illegal driving, parking, or stopping activity in the lane, restrictions of specific time or place of use can be implemented on the curbside through signage.



IMPLEMENTATION GUIDE

DETERMINE DESIGN CHARACTERISTICS: Consider key design characteristics and how they fit within the roadway needs.

$ - $$$$

DEDICATED BUS LANE
CURBSIDE

LOCAL APPLICATION EXAMPLES

108th Street, Bellevue: A curbside lane is provided all-day for buses on 108th Street in Bellevue

Source: Metro, 2021

Blanchard Street, Seattle: A curbside bus lane connects the 3rd Avenue transit spine to Westlake Avenue in the South Lake Union neighborhood.

Source: Metro, 2017

OPERATIONAL CONSIDERATIONS

Curbside bus lanes with far-side bus stop location are preferred to avoid intermittent blockages approaching intersection. A signal queue jump may be added if there is no receiving lane after the intersection.

COST CONSIDERATIONS

See *"Dedicated Bus Lane GENERAL" on page 43* for a discussion of costs. If an existing lane is being converted to a bus lane, the capital costs are typically lower for this type of bus lane because only signing and pavement marking changes would be needed.

BARRIERS AND SIDE EFFECTS

A key constraint is the potentially large number of competing users that also have a stake in how the curb space is used. Competing uses include bus stops, right-turning traffic, parking, deliveries, passenger pickup and drop-off, bicycles, service and maintenance vehicles, and usage as a temporary sidewalk when an adjacent building is under construction. Some of these competing uses may be able to be accommodated from other locations—for example, on the opposite side of the street, on side streets, or off the street.

ALTERNATIVES AND COMPANION STRATEGIES

Enforcement may be necessary to deter the use of the curbside lane for unauthorized parking, deliveries, and passenger pick-ups and drop-offs. Queue jumps and pre-signals are options for creating a virtual bus lane when a physical curbside bus lane needs to end due to downstream constraints on the use of the curb space.

DEDICATED BUS LANE

INTERIOR (OFFSET)

$ - $$$$

OVERVIEW OF STRATEGY

A bus lane in the interior of the roadway that is typically located to the left of the curb (parking) lane but can also be in another non-curb lane. This type of bus lane is typically used to preserve curb space for other uses, such as parking, deliveries, or right-turning traffic. Additional information is included in Section 8.4 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

See *"Dedicated Bus Lane GENERAL" on page 43*. Interior bus lanes provide the option for using the curb lane as a right-turn-only lane at intersections (with any bus stop located on a far-side bus bulb). This offers more flexibility for accommodating right-turns without significantly affecting bus operations. Thus, interior bus lanes with curb-lane right-turn-only lanes will operate similarly to curbside bus lanes that prohibit right-turns. Buses traveling in interior bus lanes adjacent to parking lane may experience brief delays associated with vehicle parking maneuvers that buses in curbside bus lanes would not experience, but they are less likely to experience the need to leave the lane to go around vehicles illegally stopped in the lane. General traffic flow benefits from interior bus lanes because parking movements occur on the bus lane rather than a general traffic lane, resulting in smoother general traffic flow between intersections.

IMPLEMENTATION GUIDE

DETERMINE DESIGN CHARACTERISTICS: Consider key design characteristics and how they fit within the roadway needs. Implementing interior bus lanes will likely require a combination of creative transit and traffic engineering strategies . As a result, this strategy is one where it is essential to coordinate with Metro to develop mutually satisfactory solutions.

$ - $$$$

DEDICATED BUS LANE

INTERIOR (OFFSET)

LOCAL APPLICATION EXAMPLES

Columbia Street, Seattle: An interior bus lane is provided on Columbia Street between 2nd and 1st Avenues.

Source: Metro, 2020

Battery Street, Seattle: An interior bus lane is provided on Battery Street between 3rd and 6th Avenues adjacent to a curb lane used for parking, bus layover, and right-turns.

Source: Metro, 2021

OPERATIONAL CONSIDERATIONS

Consideration needs to be given to how bus stops will work with offset bus lanes. Bus bulbs or islands may be required.

COST CONSIDERATIONS

Interior bus lanes may require higher capital and maintenance costs than curbside bus lanes due to the potential need for overhead signs to make the bus lane more visible to other roadway users.

BARRIERS AND SIDE EFFECTS

The main potential constraint for interior bus lanes is the loss of roadway capacity; thus, this is primarily a strategy to be considered in locations where policy environments support prioritizing transit operations over general purpose traffic level of service. permit some degradation of roadway operations. It may be necessary to use a combination of traffic control strategies (e.g., turn restrictions and other traffic pattern changes) at busy intersections and short sections of curbside bus lanes to provide two through lanes or dual turn lanes where needed to serve traffic operations requirements.

ALTERNATIVES AND COMPANION STRATEGIES

See the list of generally applicable companion strategies in *"Dedicated Bus Lane GENERAL" on page 43*. Interior bus lanes adjacent to a parking lane work well in combination with bus bulbs (See *"BUS BULBS" on page 68*), which can also help increase the amount of available on-street parking because parking does not need to be removed before or after a stop to give buses access to a curbside stop. Traffic control strategies such as left-turn restrictions at key intersections can help improve traffic flow in the remaining general-purpose lanes.

DEDICATED BUS LANE

MEDIAN/LEFTSIDE

$ - $$$$

OVERVIEW OF STRATEGY

Left side bus lane is adjacent to the left curb on one-way streets or adjacent to the median on two-way streets. This type of bus lane is typically applied in special-purpose situations where a more conventional location is infeasible.

Median Lanes reserved for the exclusive use of buses. These lanes are the middle of a roadway and are often separated from other traffic by curbs or landscaped islands. These types of bus lanes remove interference from other roadway users. Additional information is included in Section 8.5 and 8.7 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

See *"Dedicated Bus Lane GENERAL" on page 43*. Left-side and median bus lanes avoid right-turning traffic interferences that can be encountered with more conventional bus lanes. Typically, left-turns are prohibited from left-side bus lanes or left-turning traffic can cross the bus lane into a left-turn bay; therefore, buses do not experience significant interference with left-turning traffic.

The benefit of the median lanes physically separated from general traffic by curbs or islands is that the potential for unauthorized use is very low, except for the possibility of vehicles accidentally turning left into the bus lanes at a signalized intersection.

IMPLEMENTATION GUIDE

DETERMINE DESIGN CHARACTERISTICS: Consider key design characteristics and how they fit within the roadway needs. Key design characteristics include degree of separation, station location, general traffic left-turn accommodations, bus turning accommodations, pedestrian access, and crossing movements. See *"AASHTO's Guide for Geometric Design of Transit Facilities on Highways and Streets"* for more detailed design guidance and the general bus lane section.

CONSIDER FEASIBILITY: Determine potential roadway and traffic impacts using modeling software to understand potential trade-offs and implementation feasibility.

$ - $$$$

DEDICATED BUS LANE

MEDIAN/LEFTSIDE

As a result, median bus lanes provide improvements in bus travel time reliability and remove most potential sources of bus delay other than traffic signal delays.

OPERATIONAL CONDIERATIONS

Buses used on routes with left-side bus lanes might need special vehicles with doors on both sides. A left side bypass lane is usually paired with a queue jump signal to allow the buses to serve a far side bus stop. For safety reasons, it is advisable for buses not to cross more than two traffic lanes to serve a bus stop from the median bus lanes, thus the placement of downstream bus stop will need to be considered at the conceptual level plan unless there are doors on both sides of the buses.

COST CONSIDERATIONS

Left-side bus lanes will experience slightly higher capital and maintenance costs than curbside bus lanes due to the need for signs to inform motorists on side streets about the presence of the left-side lane.

Median bus lanes are typically the more expensive bus lane option due to the extensive street reconstruction required to adequately separate the bus facility from general traffic and the need to provide stations and pedestrian access to those stations within the street median.

LOCAL APPLICATION EXAMPLES

Westlake Avenue and Mercer Street, Seattle: A left-side bus lane in the northbound direction helps buses bypass congestion due to high volumes of general-purpose traffic turning right. A queue jump signal at the intersection helps buses merge back over to the curb lane and serve a far-side bus stop.

Source: Metro, 2019

RapidRide G Line: The RapidRide G Line, planned to open in 2024, will feature median bus lanes along a portion of the line along with special coaches with doors on the left side.

Madison Street/12th Avenue/E Union Street
Source: Madison BRT RapidRide G Line Presentation (SDOT)

BARRIERS AND SIDE EFFECTS

See *"Dedicated Bus Lane GENERAL" on page 43*. When conventional buses will be serving bus stops along a left-side bus lane, sufficient roadway space needs to be available to provide an ADA-compliant boarding island.

For median bus lanes, after cost, the primary constraint is the availability of ROW to accommodate both median bus lanes and stations. Depending on the degree of separation of the bus lanes from other traffic and the need to accommodate bus turns from the bus lanes, median bus lanes typically require three to four lanes of total ROW width. In addition, enough through and turning general traffic lanes need to be maintained at intersections, and width may also be required for bicycle facilities, on-street parking, or other design features. General traffic left-turns may reduce the amount of green time available for bus movements compared to bus operations in a curbside or interior bus lane, resulting in more bus delay at signals. The constraints associated with bus-only signal phases will also be applicable.

ALTERNATIVES AND COMPANION STRATEGIES

If bus stops are to be provided along a left-side bus lane, boarding islands may be required. Median lanes require a bus-only signal phase for turning movements, and may require one for through movements, as well.

DEDICATED BUS LANE

CONTRAFLOW/REVERSIBLE

$ - $$$$

OVERVIEW OF STRATEGY

A bus lane provided in the opposite direction of normal traffic flow on a one-way or divided street. This allows buses to use more direct routing through a one-way street grid, to keep both directions of a route on the same street, to take advantage of available capacity in the opposite direction of travel, or a combination of these.

Another type of single bus lane is the reversible bus lane. It serves buses operating in both directions. Additional information is included in Sections 8.8 and 8.9 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

Contraflow bus lanes on one-way streets typically operate free of turning-traffic, parking, and delivery conflicts and tend to be self-enforcing. Part-time contraflow lanes allow buses to avoid traffic congestion in the normal-flow lanes.

The major benefit of the reversible lane is that turns from the bus lane are typically prohibited, which provide benefits similar to those of median bus lanes, interior bus lanes, or curbside bus lanes with right-turns prohibited, depending on the design of the reversible lane.

IMPLEMENTATION GUIDE

DETERMINE DESIGN CHARACTERISTICS: Consider key design characteristics and how they fit within the roadway needs. Key design characteristics include location of the lane within the roadway and use of signage and pavement markings to delineate the lane from other roadway users. See *"AASHTO's Guide for Geometric Design of Transit Facilities on Highways and Streets"* for more detailed design guidance.

CONSIDER FEASIBILITY: Reversible bus lanes may be an option where ROW constraints prevent the use of bus lanes for both directions of travel. Key design characteristics include the type and timing of lane control to be used, turning restrictions needed, and pedestrian signage and notifications. See Section 8.9 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"* for additional guidance.

$ - $$$$

DEDICATED BUS LANE

CONTRAFLOW/REVERSIBLE

LOCAL APPLICATION EXAMPLES

5th Avenue, Seattle: A contraflow lane is provided on 5th Avenue between Jackson Street and Marion Street.

Source: Metro, 2021

Columbia Street and 3rd Avenue, Seattle: A contraflow bus lane provides a pathway for eastbound buses between Alaskan Way and 3rd Avenue.

Source: Metro, 2020

OPERATIONAL CONSIDERATIONS

Operator training may be required to familiarize them to use those types of bus lanes. Route design should be considered as routes with high numbers of turns would not be good candidates for reversible bus lanes.

COST CONSIDERATIONS

Contraflow bus lanes would have costs similar to curbside bus lanes. When adding a contraflow lane to an existing one-way street, traffic signals will need to be modified to provide displays in two directions. Part-time contraflow lanes may require overhead lane control signals or daily installation and removal of pylons (both an additional capital and maintenance cost relative to other bus lane types).

Reversible bus lanes are typically more expensive to construct than similar types of non-reversible bus lanes, due to the signal system required to control bus access.

BARRIERS AND SIDE EFFECTS

Contraflow lanes require the conversion of general traffic lanes to bus-only, which is restricted by ROW or may require the parking removal. Contraflow bus lanes on one-way streets may require prohibiting parking and deliveries on the side of the street used by buses and thus have similar potential issues as curbside bus lanes.

Part-time contraflow lanes typically require a strong directional split of traffic (e.g.,2/3 or more of the roadway's traffic in the peak direction) and the ability to prohibit left-turns during hours.

Restrictions to turning movements across the reversible bus lane may be needed to eliminate the potential for crashes between buses and turning motorists. Two-directional, single-lane operation that alternates direction can greatly reduce the bus frequency that can operate in the bus lane. Converting a curb lane to a reversible bus lane may have impacts on adjacent land uses like those of seen in *"Dedicated Bus Lane GENERAL" on page 43*.

ALTERNATIVES AND COMPANION STRATEGIES

Depending on the way the contraflow bus lane is developed, turning movement restrictions may be required to prevent potential conflicts between buses and other motor vehicles. Red pavement markings may be desirable to improve the conspicuity of lanes for vehicles and pedestrians. Bus signal faces may be required to control contraflow buses at signalized intersections.

Reversible bus lanes separated from general traffic only by striping are preferably highlighted in some way, such as with red pavement markings. When signals are used to control bus access to the reversible bus lane, transit signal faces are typically used to indicate to buses when they may proceed.

QUEUE BYPASS
(SHORT BUS LANE)

$-$$$$

OVERVIEW OF STRATEGY

A relatively short bus lane that allows buses to move to the front of the line at a bottleneck, where they then merge into the adjacent general traffic lane. Additional information is included in Section 8.6 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

The magnitude of the benefit depends on how much delay general traffic experiences at a bottleneck, which in turn depends on the degree to which roadway demand exceeds capacity. The benefit might be a time savings on the order of 1 minute at a freeway ramp meter to 10 minutes or more in the case of a severe capacity constraint on an arterial roadway. Travel time variability would also be expected to improve.

OPERATIONAL CONSIDERATIONS

Merging back into traffic after the intersection can be difficult, especially if a queue jump is not implemented along with the queue bypass.

IMPLEMENTATION GUIDE

DETERMINE DESIGN CHARACTERISTICS: Consider key design characteristics and how they fit within the roadway needs. The main implementation criterion is that the queue bypass lane should start before the point that buses reach the back of the general traffic queue to allow buses to proceed without delay.

$-$$$$

QUEUE BYPASS

(SHORT BUS LANE)

LOCAL APPLICATION EXAMPLE

Denny Way approaching Stewart Street, Seattle:
A short bus lane was installed to allow eastbound Route 8 buses to bypass a chronic bottleneck location.

Source: Metro, 2018

COST CONSIDERATIONS

The overall project cost will often be lower than for full-featured bus lanes because queue bypass projects tend to be shorter, but the cost will be similar to other types of bus lanes when calculated on a per-mile basis. Capital and maintenance costs will depend on whether new pavement is required to create the lane or whether an existing lane is converted to bus use only.

BARRIERS AND SIDE EFFECTS

When the bottleneck is created intentionally, such as at a ramp meter, there needs to be sufficient ROW available to provide a bypass lane long enough for buses to avoid the queue in most circumstances. When the bottleneck is created by a roadway capacity constraint, it might be possible to take a general traffic lane to create the queue bypass lane because this has the effect of moving the general traffic merge point upstream, but typically does not affect general traffic delay (the time spent waiting in the queue simply occurs at a different point on the roadway). However, as the back of the queue also moves upstream, there needs to be sufficient space to store the queue without it spilling back into upstream intersections.

ALTERNATIVES AND COMPANION STRATEGIES

The alternative and companion strategies included in *"Dedicated Bus Lane GENERAL" on page 43* also apply. Queue jumps and pre-signals are related strategies, but these rely on traffic signal control to merge buses into the general traffic lane.

ROADWAY CHANNELIZATION

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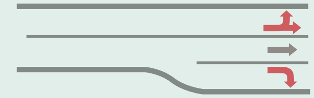
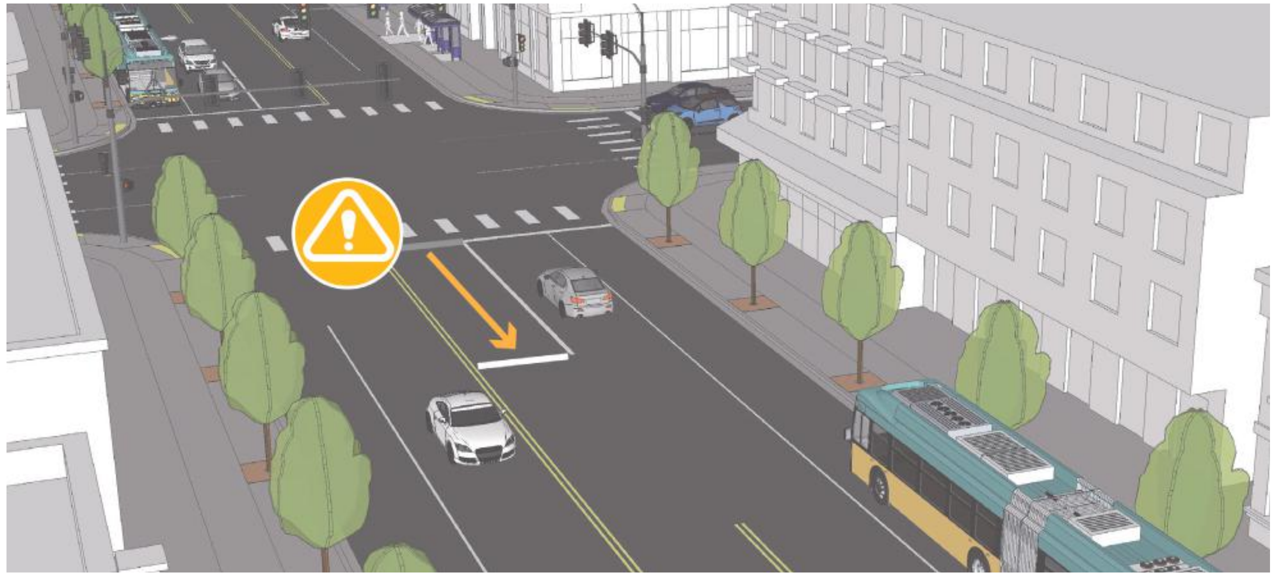


OVERVIEW OF STRATEGY

Modification of roadway channelization in support of bus operating characteristics. This could include rechannelization to delineate travel lanes or relocating the stop bar.



BENEFITS

Rechannelization improvements can improve travel speeds along roadway segments and reduce intersection delay by reducing delay associated with turning movements, clarifying lane operations, and improving intersection operations.

OPERATIONAL CONSIDERATIONS

Re-allocation of roadway space needs to consider the trade-offs to other roadway users and impacts to intersection operation. Lanes that buses will operate in should be at least 11′ wide, although narrower lanes can be considered thorough an engineering and safety evaluation process.

Relocating stop bars at signalized intersections may impact existing loop detectors; detectors may need to be reinstalled at another location or replaced with another detection technology. Stop bar setbacks between 10-15′ from the crosswalk tend to see motorists stopping behind the crosswalk rather than the stop bar. Consider other measures if a stop bar set back over 15′ is needed.

IMPLEMENTATION GUIDE

IDENTIFY THE CONDITION CAUSING DELAY: identify the condition or conditions causing delay and determine if a channelization or signage improvement would address the concern.

COORDINATE WITH METRO: coordinate with Metro to develop a solution to the condition impacting speed and reliability. Solutions will likely be highly site-specific.

$$$$

ROADWAY CHANNELIZATION

LOCAL APPLICATION EXAMPLES

Pine Street and Boren Avenue, Seattle: Metro worked with SDOT to implement a stop bar setback for the eastbound left-turn pocket (with supporting white hatching between the stop bar and the crosswalk) to provide sufficient space for buses making a southbound right-turn from Boren Avenue onto Pine Street.

Source: Metro, 2020

Campus Parkway NE and NE 12th Avenue, Seattle: Metro worked with SDOT to install a "LEFT-TURN ON RED ALLOWED AFTER STOP" sign at the one-way street to reduce delay and prevent intersection blockages.

Source: Metro, 2019

COST CONSIDERATIONS

PLANNING AND COORDINATION

$5,000 to $10,000: These costs would vary based on the amount of study needed to determine the appropriate solution.

CAPITAL COSTS

Between $5,000 and $25,000 per intersection: These costs depend on the type of improvement. Capital costs would include new signage and/or restriping the roadway.

MAINTENANCE COSTS

There would likely be minimal added maintenance costs associated with any additional signage or pavement markings. The roadway jurisdiction generally needs to be responsible for maintenance of these types of improvements.

BUS OPERATIONS COSTS

There would be savings in travel time and improvements to travel time variability.

OTHER USER COSTS

Costs to other roadway users will depend on the trade-offs involved.

BARRIERS AND SIDE EFFECTS

Changes in roadway channelization will need to consider the availability of roadway space, which could restrict the improvements that could be made.

ALTERNATIVES AND COMPANION STRATEGIES

Many of the traffic control tools could be paired channelization and signage improvements, but improvements to channelization and signage can be used as stand-alone improvements to reduce projects costs while achieving improvements in speed and reliability. Roadway channelization is also often used to improve turn radius.

TURN RADIUS IMPROVEMENTS

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OVERVIEW OF STRATEGY

Modifying the turn radius of intersections to make turning movements easier for buses and to reduce delay.

BENEFITS

Intersections that make turning movements difficult for buses can increase delay and travel times for buses. Turn radius modifications can improve travel delay for buses near the intersection where the improvement is made, and can also improve safety at the intersection if the bus was riding over the curb or encroaching into opposing travel lanes in order to make the turn movement.

OPERATIONAL CONSIDERATIONS

Modifying the turn radius of an intersection can reduce bus maintenance needs if the bus was riding over the curb frequently to make the turn. Front-mounted bicycle racks should be tested in the open position as part of analyzing the turn movement radius. For more information, please refer to *"National Association of City Transportation Officials (NACTO) Transit Street Design Guide"*.

IMPLEMENTATION GUIDE

IDENTIFY THE CONDITION CAUSING DELAY: Identify the specific intersection with turn radius concerns causing delay and determine if minor restriping or parking removal/alteration is sufficient or if the curb needs to be physically altered.

COORINDATION WITH METRO: Coordinate with Metro to develop a solution to the turn radius concern impacting speed and reliability. Solutions will be highly site-specific. Conduct an Autoturn analysis or coach test in the field. Consult Metro for appropriate selection of design vehicle and other Autoturn parameters. Metro has specific guidance for modelling Metro coaches in AutoTurn, see Section 3.3 in *"King County Metro, Transit Route Facilities Guidelines"*. This guidance should be followed when designing turn radius improvements.

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TURN RADIUS IMPROVEMENTS

LOCAL APPLICATION EXAMPLES

NE 65th Street and 62nd Avenue NE, Seattle: Metro partnered with SDOT to reconstruct the intersection corner to provide an adequate turning radius for buses. This modification allowed Route 62 to use a more-efficient turn-around route at the route terminal.

Source: Metro, 2017

3rd Avenue and Columbia Street, Seattle: In anticipation of future two-way bus operation on Columbia Street, existing curb bulbs near the west leg of the intersection were cut back to accommodate buses making a southbound right-turn while other coaches were waiting to make an eastbound left-turn. This modification was included in a larger roadway reconstruction project, so the additional cost was minimal.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Low to moderate: This is to develop a concept to address the turn radius challenge.

CAPITAL COSTS

Between $12,000 and $40,000 per corner. These costs depend on the type of solution. Costs for pavement markings will be lower while intersection modifications will have higher capital costs. ROW may need to be purchased to provide the required space.

MAINTENANCE COSTS

There would be minimal added maintenance costs.

BUS OPERATIONS COSTS

There would likely be savings from reductions in delay at the intersection. Safety improvements can reduce collision claim costs and disruptions to service.

OTHER USER COSTS

Improved turn radius for coaches can increase vehicle speeds, which could create safety concerns.

BARRIERS AND SIDE EFFECTS

Pedestrian crossings could become longer at intersections where the curb radius is increased. Improvements to crossings could help mitigate this impact.

ALTERNATIVES AND COMPANION STRATEGIES

This can be a stand-alone tool or can be implemented as part of a package of speed and reliability improvements.

SPEED HUMP MODIFICATIONS

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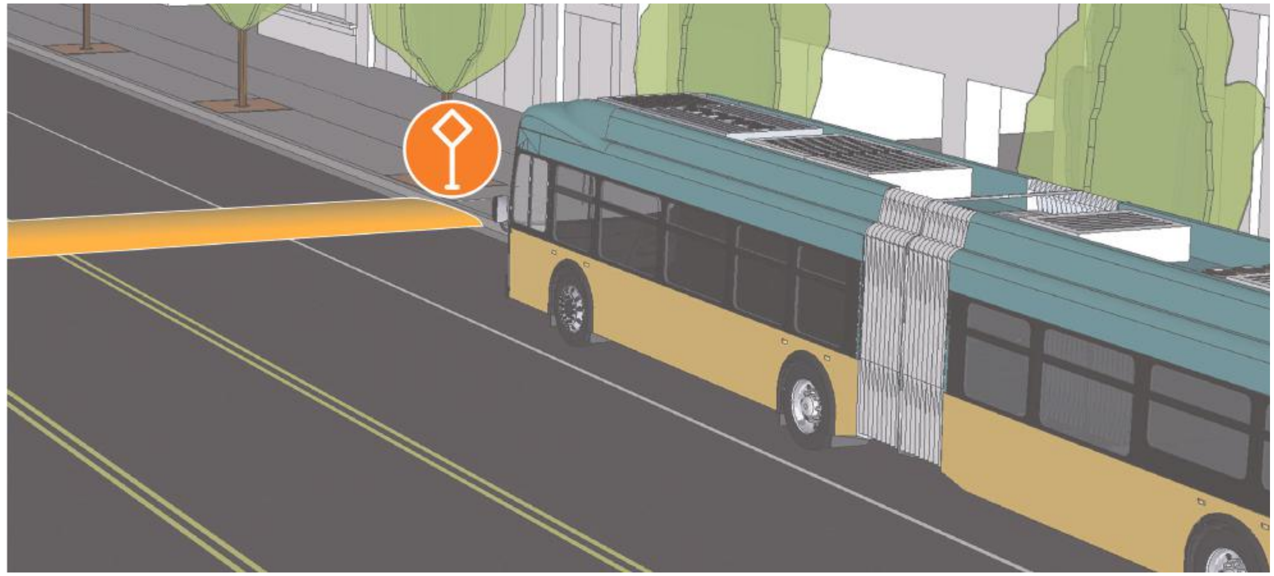
OVERVIEW OF STRATEGY

Speed bumps/humps along bus routes are replaced with bus-friendlier versions to reduce the amount of deceleration needed as noted in the Implementation Guidance section. Additional information is included in Section 7.1 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.



BENEFITS

Traffic-calming speed bumps/humps force buses to slow to speeds that are lower than the posted speed to avoid jolting passengers and damaging the bus's suspension. Buses accelerate more slowly than automobiles; therefore, they experience more delay from speed humps. Replacing speed humps with bus-friendly designs can retain the desired traffic-calming effect while improving bus passengers' comfort, increasing bus fuel economy (by avoiding the need to accelerate after the hump), and reducing noise impacts in the vicinity of the speed hump. Emergency vehicles will also benefit from bus-friendly speed hump designs.

IMPLEMENTATION GUIDE

COORINDATION WITH METRO: Develop an approach to removing or replacing non-transit-friendly speed humps.

LOCAL JURISDICTION: Develop policies discouraging or preventing speed hump use on bus routes or designated transit streets. Alternative traffic-calming strategies should be investigated first in coordination with Metro.

IMPLEMENTATION: Design speed bumps that are transit-supportive:

- Not installed near bus stops since passengers may be moving to or from their seats,
- Provide as long a distance as possible (e.g., 22 ft) between the slope up and the slope down or be designed such that buses avoid the bump (e.g., a speed cushion),
- Provide at least 600 ft between successive bumps
- Be located so that buses can traverse them at a 90-degree angle (e.g., not near bus stops).

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SPEED HUMP MODIFICATIONS

LOCAL APPLICATION EXAMPLES

119th Avenue SE, Bellevue: Three sets of "cushion" style speed humps installed along the 119th Avenue SE. Speed cushions are similar to speed bumps in that they slow traffic down but minimize delay for transit and emergency response vehicles.

Source: City of Bellevue, 2021

Boyer Avenue E, Seattle: Speed humps installed along Boyer Avenue E, which is a Minor Arterial, are designed in a "cushion" style where larger vehicles are able to straddle the humps. Although Boyer Avenue does not have regular revenue transit service, it is used often for reroutes during closures or construction around the Montlake and University bridges.

Source: Metro, 2021

OPERATIONAL CONSIDERATIONS

Speed hump modifications would have a positive impact on bus operations by reducing damage to the suspension and the amount of deceleration/acceleration that is required.

COST CONSIDERATIONS

PLANNING AND COORDINATION
Moderate: Neighborhood outreach could be needed when changing an existing speed hump to a bus-friendlier design. Emergency responders may be supportive of speed hump changes that allow faster emergency vehicle response times.

CAPITAL COSTS
Between $5,000 and $15,000. These costs are to remove or replace the speed hump.

MAINTENANCE COSTS
A bus-friendlier design may reduce pavement damage caused by buses decelerating and traveling over a speed hump.

BARRIERS AND SIDE EFFECTS

Existing roadway design manuals may use standards for speed humps that are not bus friendly.

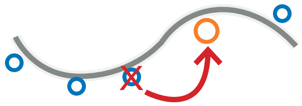
ALTERNATIVES AND COMPANION STRATEGIES

Speed hump alterations can be implemented as a stand-alone improvement or as part of a package of speed and reliability improvements along a road or route.

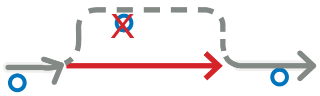
4.3.2 BUS STOPS AND ROUTING

This section describes the tools that improve speed and reliability through stop location and spacing. Bus stops or stations are generally situated to maximize passenger convenience and access to transit, but the location of these facilities can have significant implications to transit speed and reliability. This section describes potential bus stop adjustments from the speed and reliability perspective.

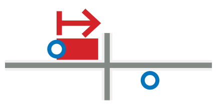
Roosevelt Way NE from NE 65th Street to NE 42nd Street, Seattle
Source: Metro, 2021



BUS STOP LOCATION

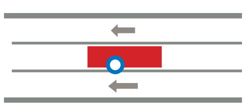


ROUTE DESIGN



BUS STOP LENGTHENING

BUS BULBS



BOARDING ISLANDS

BUS STOP LOCATION
CONSOLIDATION OR RELOCATION

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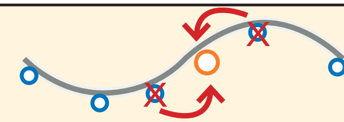
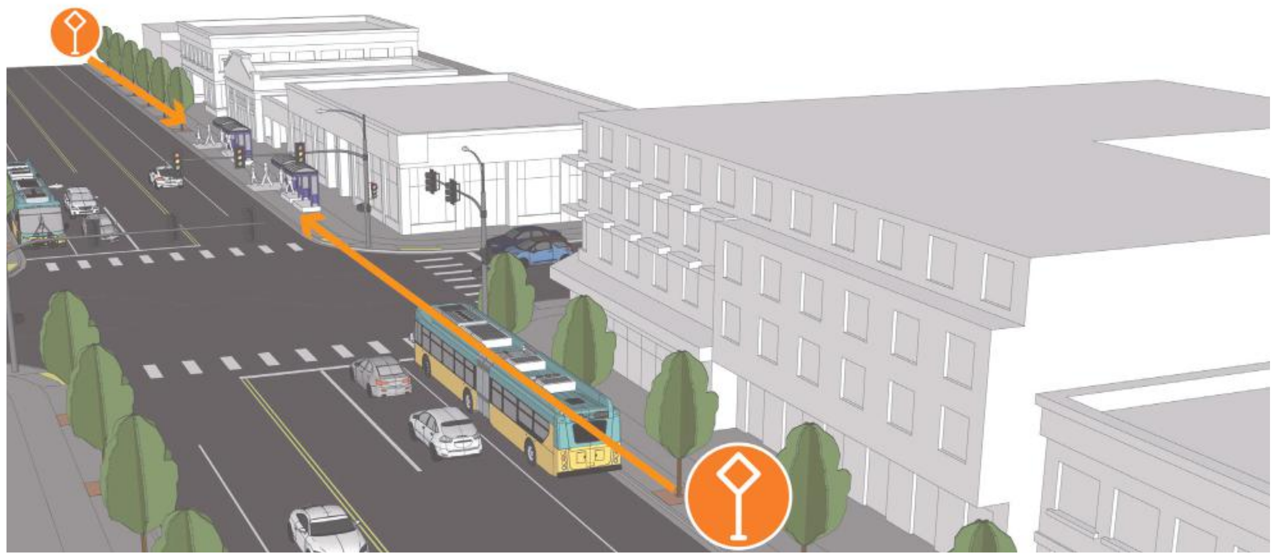


OVERVIEW OF STRATEGY

Bus stop relocation involves moving a stop from its existing location at an intersection to a different location (usually from near- to far-side). Far-side stops at signalized intersections produce better bus travel time reliability. Bus stops should be spaced to balance the benefit of increased access to a route against the passenger delay that an additional stop would create.



BENEFITS

Reducing the number of stops or relocating a stop along a route can reduce the amount of delay associated with acceleration/ deceleration, door opening and closing, traffic signal delay, and merging into traffic. Additional information is included in Sections 5.1 and 5.2 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

OPERATIONAL CONSIDERATIONS

Far-side stops are generally preferred but may not be ideal when there is only one lane of traffic because this can cause traffic backups into the intersection, creating potential safety and operational issues.

If a new stop is needed when rebalancing bus stops, it is preferable to not site it between two busy intersections within proximity.

IMPLEMENTATION GUIDE

CONSIDER ROADWAY AND BUILT ENVIRONMENT CONSTRAINTS: Any existing barriers to relocating the bus stop should be considered as well as how existing land uses might be impacted in the location that the bus stop is being moved. Bus stops that are already near community centers, hospitals, senior housing, or other community assets may be challenging for relocation.

CUSTOMER ACCESS CONCERNS: Consider customer access needs to relocated bus stop, including compliance with ADA access requirements and ease of transfers between bus routes.

LOOK FOR GUIDANCE by consulting *"King County Metro, Transit Route Facilities Guidelines"* for additional information on stop spacing standards.

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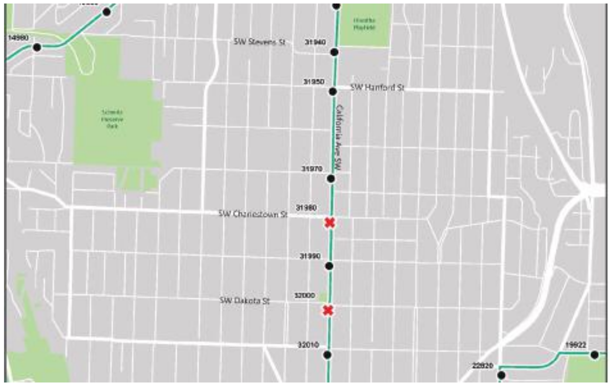
BUS STOP LOCATION
CONSOLIDATION OR RELOCATION

LOCAL APPLICATION EXAMPLE

Route 50: 27 bus stops were removed/consolidated in March 2020.



Source: Metro, 2020

100th Avenue North and NE 124th Street, Kirkland: The project includes signal phasing and timing modifications, channelization adjustments, and the relocation of the southern SB bus stop on 100th Avenue NE (serving Metro Routes 230, 231, and 255) fifty feet south in order to mitigate potential queuing with the additional left-turn movement.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Low to moderate: Dependent on the size of the effort. Passenger volumes, stop spacing, and pedestrian infrastructure would need to be analyzed for each stop studied. Extensive public outreach may be required in advance to educate the public, adjacent property owners, and other stakeholders about the benefits of stop rebalancing/relocation (e.g., loss of parking, passengers congregating).

CAPITAL COSTS

Between $15,000 and $75,000. This consists of removing bus stop poles and shelter from the old site, installing the new stop, and making any required ADA improvements, such as a landing pad. Capital costs could be higher if more civil work is needed to provide new roadway paving for buses and/or new sidewalks. A new or relocated bus stop may need a new shelter with footing, and other amenities.

MAINTENANCE COSTS

Maintenance costs could potentially be reduced due to fewer overall bus stops.

BUS OPERATIONS COSTS

There would be some savings from reductions in bus travel time and travel time variability.

OTHER USER COSTS

Efficient bus stop consolidation may improve general purpose traffic flow. Pavement damage due to bus stopping activity will cease at the closed stops.

BARRIERS AND SIDE EFFECTS

Features of the existing built environment may be affected, such as reducing sidewalk space for the new stop and passenger amenities, and/or impacts to street trees, fire hydrants, lamp posts, etc.

The movements of all users in the roadway including right-turning traffic at intersections and on sidewalks should be considered when relocating a stop. There could also be impacts to access if parking and loading zones are removed, or if driveways, alleys, or other access points are blocked.

Implementation of route-wide or city-wide stop rebalancing can be met with resistance from the public.

Stop rebalancing may affect long-term operations at bus stops by consolidating passengers into fewer bus stops. Potentially increasing the amount of time it takes for a bus to serve the stop may reduce the stop's capacity to serve buses.

ALTERNATIVES AND COMPANION STRATEGIES

Stop relocations/rebalancing are often implemented as part of a package of improvements for an intersection, route, or street, including route design changes, TSP, bus-only signal phases, queue jumps, bus bulbs, and bus lanes.

ROUTE DESIGN

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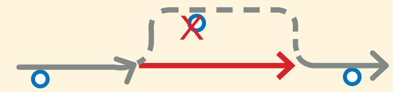
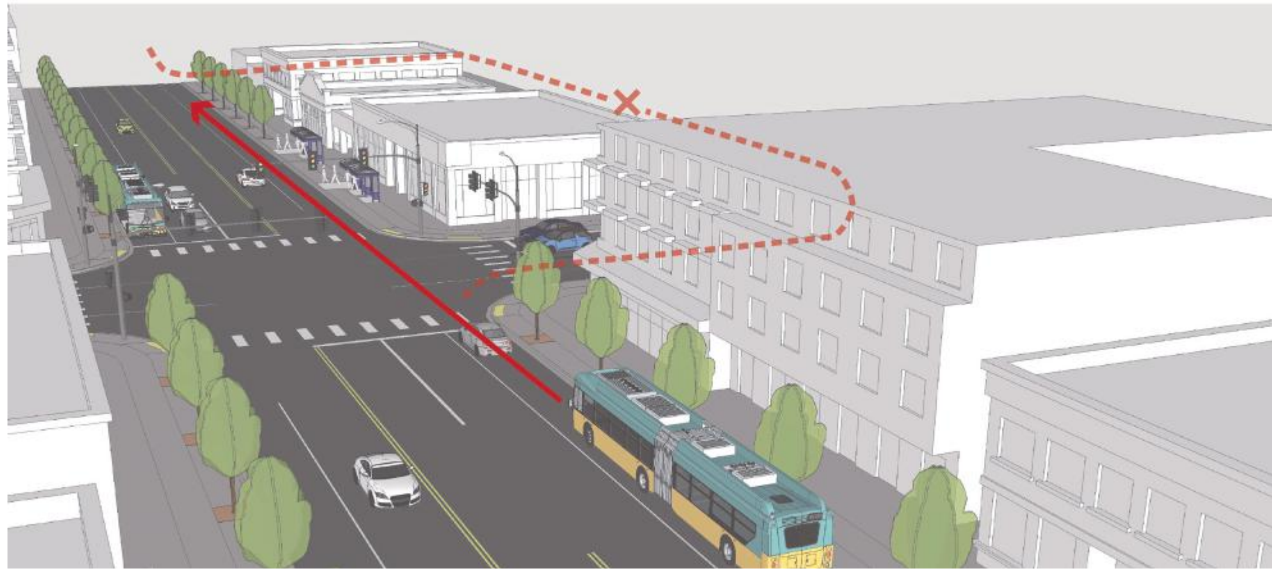


OVERVIEW OF STRATEGY

Routing that made sense in the past may not meet the needs of current passengers due to changes in land use, development, traffic volumes, passenger demands, etc. Route design adjustments could include changes such as straightening a route to avoid a difficult left-turn, rerouting around a major chokepoint or source of delay such as a freeway on-ramp, or routing to take advantage of a faster pathway nearby. Additional information is included in Section 5.3 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.



BENEFITS

The time saved by more efficient route design can be used to offset travel time increases due to traffic congestion or increased ridership.

OPERATIONAL CONSIDERATIONS

The ability of the bus to make the required turning movements should also be considered (i.e., turning radii along the route should be sufficient for buses). Impacts to safety from introducing buses to a different street or for riders accessing rerouted services should also be considered. The pavement condition and the ability of the pavement to sustain bus loading will need to be evaluated along any new routing.

IMPLEMENTATION GUIDE

COORDINATION WITH METRO: Re-routing ideas need to be closely coordinated with Metro staff with input from the Service Planning, Transit Route Facilities, Safety, Speed and Reliability, and Operations groups. Routing changes may require public outreach and approval by the King County Council, depending on the scope of the changes.

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ROUTE DESIGN

LOCAL APPLICATION EXAMPLES

4th Avenue and Pine Street, Seattle: Metro worked with the City of Seattle to make routes more reliable by realigning South King County routes to 6th Avenue and providing protected left-turn to Pine Street.

Source: Metro, 2020

12th Avenue NE and NE 65th Street, Seattle: Metro worked with Sound Transit and the City of Seattle to improve transfer speed and convenience by routing buses so they can serve zones immediately adjacent to Roosevelt Light Rail Station. This reduces walking times during transfers and minimizes street crossings.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Moderate: Comparing the number of passengers who may benefit from a faster or more reliable trip to the number of passengers who would have to change their trip, use a new stop, or walk a longer distance to access a route is required. Detailed data analysis may be needed to closely review the magnitude of existing delay and traffic analysis to determine potential time savings from alternative routes. Metro may need to conduct outreach to riders and other stakeholders who would be affected by the change.

CAPITAL COSTS

Between $15,000 and $60,000 per stop. Capital costs consist of removing infrastructure (e.g., bus stop poles, shelter) from stops that will be closed and installing infrastructure at new stops.

MAINTENANCE COSTS

Bus stop maintenance costs may change depending on the net difference in the number of stops affected by the route realignment. Stop amenity upgrades that are installed in conjunction with developing new bus stops may increase maintenance costs.

BUS OPERATIONS COSTS

Low: Route mileage and the number of stops made at intersections could decrease, which may lower bus expenses related to these factors (e.g., fuel costs).

OTHER USER COSTS

The net effect on pavement damage would depend on the net change in the number of bus stops and the type of pavement.

BARRIERS AND SIDE EFFECTS

Routing changes can have an impact on the daily lives of riders and other stakeholders. Often, opinion can be divided between people who support a change and those who are opposed. If community support for a route change is not achieved, further route re-designs could be needed after rider complaints.

Another potential barrier is the need to ensure that people continue to have adequate access to transit. This means that pedestrian infrastructure must exist to allow people to access other nearby bus stops if stops are closed because of a route realignment.

ALTERNATIVES AND COMPANION STRATEGIES

Route alignment changes may require stop relocations. If it is infeasible to reduce turning delays through rerouting, other strategies can be considered to minimize the delay like bus-only turn lanes, passive signal timing changes, phase reservice, reverse queue jump, TSP, bus-only signal phases, and pre-signals.

BUS STOP LENGTHENING

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OVERVIEW OF STRATEGY

Bus stop lengthening allows a stop to serve more (or longer) buses simultaneously. Additional information is included in Section 7.2 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

If more buses need to use a stop at one time than space exists, the other buses have to wait in the street until space opens up at the stop. This situation delays both buses and general traffic. Increasing the bus stop length to provide the appropriate capacity can reduce travel time variability.

OPERATIONAL CONSIDERATIONS

Space for buses to pull in and out of a bus stop may need to be provided. Typically, 25' of clear space is needed between the bus stop and parking or other obstructions. Additional space may be needed if features such as parking and bike lanes exist on the roadway.

IMPLEMENTATION GUIDE

COORINDATION WITH METRO: Coordinate with Metro to estimate hourly bus stop capacity and existing and future bus frequencies using this stop in order to determine appropriate level of bus stop capacity and develop strategy for addressing bus capacity issues.

DETERMINE FEASIBILITY: Determine if lengthening a stop is physically or politically feasible by reviewing nearby access points and other barriers.

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BUS STOP LENGTHENING

LOCAL APPLICATION EXAMPLE

4th Avenue S and S Jackson Street, Seattle: Metro coordinated with SDOT to extend the near-side bus zone to allow for 3 (or more) buses to serve the zone at time by removing a low steel railing on the southern half of the block. This is one of the busiest bus zones in Seattle, serving hundreds of bus trips and thousands of passengers per day.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION
Low: Lengthening a stop will need to be coordinated with Metro. It may also be desirable to engage adjacent property owners in advance about potential negative impacts to them (e.g., loss of parking).

CAPITAL COSTS
Between $5,000 to $100,000. These costs consist of moving parking signs and making any required ADA improvements such as a landing pad. The need for concrete paving at the bus stop to reduce bus-caused pavement damage may also be considered. Costs will be higher when curb lines or parking meters need to be moved to accommodate a longer stop.

MAINTENANCE COSTS
No significant change in costs.

BUS OPERATIONS COSTS
There could be savings from improvements in travel time and reliability.

OTHER USER COSTS
There could be reduced delay for motor vehicles that would otherwise be blocked by buses waiting to serve a stop. There is also the potential for on-street parking loss.

BARRIERS AND SIDE EFFECTS

Bus stop lengthening may result in a loss of on-street parking. It may not be feasible if driveways, alleys, or intersections are located close to the stop. If one stop requires lengthening, other stops with similar boarding/alighting operations may also require lengthening.

ALTERNATIVES AND COMPANION STRATEGIES

Bus stop lengthening may need to be considered when stops are consolidated because the increased passenger activity at the remaining stops will prolong bus dwell times and thus reduce the number of buses that a bus stop can accommodate during an hour. Bus stops may also need to be lengthened if longer buses are used on a route. If a bus stop cannot be lengthened at its current location, it may need to be relocated.

BUS BULBS

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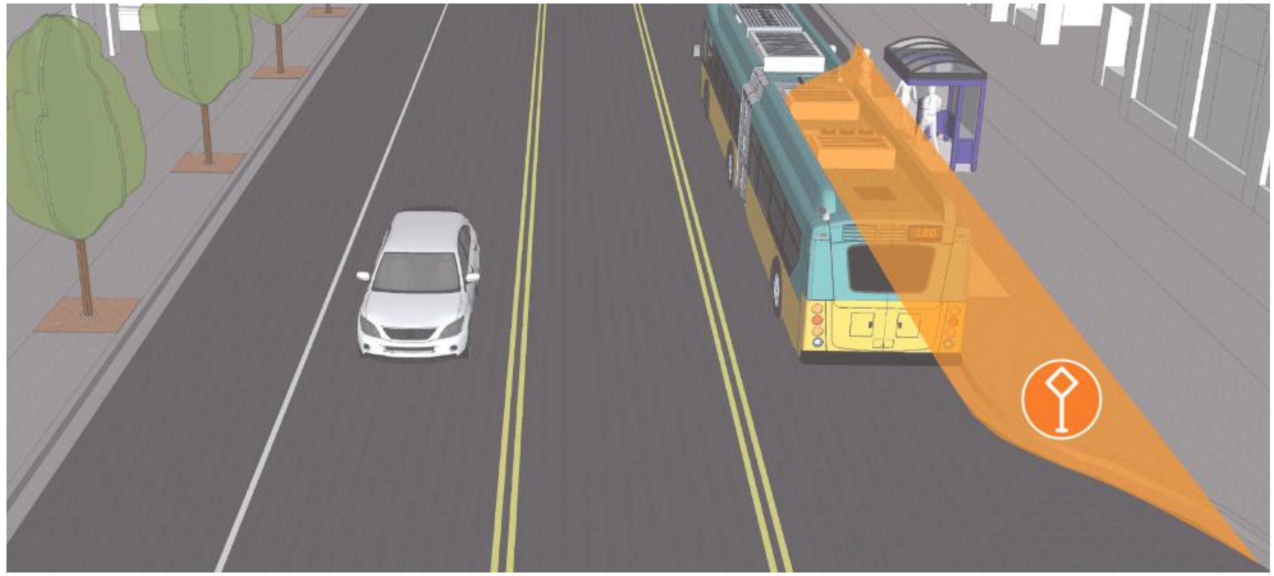
OVERVIEW OF STRATEGY

Bus bulbs extend the curb and sidewalk out to the edge of the parking lane to allow buses to stop in the travel lane and avoid delay from reentry into traffic when leaving the stop. Additional information is included in Section 7.5 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.



BENEFITS

Bus bulbs are used to reduce the reentry delay that buses experience when leaving a stop and can also make bus stopping patterns more predictable for other roadway users. At intersections, bus bulbs can shorten the pedestrian crossing distance and improve their safety. Bus bulbs can provide a better bus stop waiting environment and better adjacent sidewalk flow by giving passengers a place to wait off the sidewalk. Bus bulbs can also increase the amount of on-street parking by allowing parking lanes to continue to the bus bulb.

OPERATIONAL CONSIDERATIONS

Consider whether median treatments (c-curbing, posts, or small islands) are needed to prevent vehicles from using a two-way left-turn lane or opposing lane for passing. A bus bulb may preclude the future installation of a bus lane.

IMPLEMENTATION GUIDE

DETERMINE FEASIBILITY: conditions supportive of bus bulbs should be present, such as the presence of full-time curbside parking, near-side or midblock stop locations, relatively low traffic speeds, low to moderate traffic volumes, two or more travel lanes in the direction of travel (desirable), relatively high sidewalk or crosswalk usage or relatively high passenger volumes at the stop, relatively low right-turning vehicles volumes.

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BUS BULBS

LOCAL APPLICATION EXAMPLES

E John Street and 10th Avenue E, Seattle: A bus bulb installed near Capitol Hill Station provides a closer transfer to the station and additional customer amenities and waiting area.

Source: Metro, 2019

Olive Way and Summit Avenue E, Seattle: A bus bulb constructed in coordination with the City of Seattle.

Source: Metro, 2019

COST CONSIDERATIONS

PLANNING AND COORDINATION

Moderate: Civil engineering plans will need to be developed to address street drainage modifications. Outreach to adjacent businesses may be needed, particularly when installing shelters that may block views of businesses' signs from the street.

CAPITAL COSTS

Up to $200,000: The largest portion of these costs involve drainage changes and, potentially, utility relocations. There will be added costs if a bikeway needs to be relocated around the bus stop.

MAINTENANCE COSTS

No significant changes are expected. Consider maintenance requirements in the design of the bus bulb. Shelter cleaning requires a maintenance vehicle to be parked within a close distance of the shelter while the cleaning is being performed. Providing a passenger or commercial load zone immediately adjacent to the bus bulb can provide this function.

BUS OPERATIONS COSTS

There would be savings from reductions in bus travel time and improvements to travel time variability.

OTHER USER COSTS

On streets with one lane of travel per direction, bus bulbs would likely increase vehicular delay, with the extent of the delay dependent on bus frequencies, dwell times, traffic volumes, and whether the stop is located at a signalized intersection (e.g., traffic might need to stop anyway).

BARRIERS AND SIDE EFFECTS

Bus bulbs affect street drainage patterns, and drainage may need to be reworked to prevent water ponding issues. When used at intersections, they reduce the turning radius available for larger vehicles, which may require restrictions on right-turns or moving the side-street stop bar away from the intersection to provide more room for larger turning vehicles. If bicycle facilities exist, consideration will need to be given to how to route bicycles around stopped buses. Bus bulb construction should be ADA-compliant. Parking removal may also be needed when installing a bus bulb.

ALTERNATIVES AND COMPANION STRATEGIES

Bus bulbs can be used in combination with interior bus lanes. Alternatively, yield- to-bus tools can be used to address reentry delay.

BOARDING ISLANDS

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OVERVIEW OF STRATEGY

Boarding islands are dedicated waiting areas for riders that streamline transit service and improve accessibility by enabling in-lane stops. Additional information is included in Section 7.6 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

BENEFITS

Boarding islands allow for protected bicycle lanes to coexist with transit stops. Bus islands are necessary along bus lanes provided on the left side of the street except when coaches with left-side doors are used. Boarding islands make other tools feasible while maintaining good access to bus service.

OPERATIONAL CONSIDERATIONS

Boarding islands installed near intersections may constrain bus turning movements at the intersection; consider future routing plans, and probable construction/event/ emergency reroutes.

IMPLEMENTATION GUIDE

COORINDATION WITH METRO: Metro is developing *"King County Metro, Bus Stops along Bikeways Guidelines"* for local jurisdictions to refer to before constructing boarding islands.

DETERMINE IF SUPPORTIVE CONDITIONS EXIST: Conditions supportive of installing a boarding island should be present, such as sufficient space, passenger generator or transfer point nearby, other speed and reliability tools (queue jump, bus lanes, etc), and ability to accommodate bicycles.

CONSIDER DESIGN AND AMENITIES: Determine which supporting infrastructure is necessary and whether ADA improvements are needed.

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BOARDING ISLANDS

LOCAL APPLICATION EXAMPLES

Roosevelt Way NE from NE 65th Street to NE 42nd Street, Seattle: Metro worked with the City of Seattle to include boarding islands in a project to re-pave and add bike lanes to Roosevelt Way.

Source: Metro, 2021

108th Avenue NE and NE 2nd Street, Bellevue: Metro worked with the City of Bellevue to install a boarding island.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION
Low to moderate: Pedestrian and ADA access to the island needs to be considered and incorporated into the island design. Modular bus platform systems are quick to implement and could be installed as a temporary pilot to test the bus bulb location.

CAPITAL COSTS
Between $200,000 and $245,000. These costs depend on the necessary modifications to implement the boarding island. Pedestrian fencing, bollards, and MUTCD object markers may be required. Concrete paving at the bus stop to reduce bus-caused pavement damage may also be needed. Costs can be significantly reduced if boarding island construction can be incorporated into a larger roadway overlay or reconstruction project.

MAINTENANCE COSTS
There would be no additional maintenance costs unless items such as pedestrian fencing, bollards, etc. are needed.

BUS OPERATIONS COSTS
There would be no direct bus operations costs.

OTHER USER COSTS
Boarding islands may reduce delays to right-turning traffic from buses when used in combination with a channelizing island.

BARRIERS AND SIDE EFFECTS

The main barrier to implementing a boarding island is constrained ROW. Sufficient space needs to be available on the island to provide the minimum required ADA clear area for each bus loading area provided at the stop.

ALTERNATIVES AND COMPANION STRATEGIES

This strategy supports bus-only signal phases (for example, a bus left-turn from a right-side lane), queue jumps, most forms of bus lanes, and other strategies that can be used in combination with queue jumps and bus lanes. For example, a short bus lane could be highlighted with red-colored pavement. Boarding islands also provide a safe alternative for accommodating protected bike lanes in the bus stop areas. For more information please refer to *"King County Metro, Bus Stops along Bikeways Guidelines"*.

4.3.3 TRAFFIC REGULATIONS

Traffic regulation tools are operational modifications that require minimal capital investment. Enforcement is often a key component for the effectiveness of these types of tools. When designing these types of improvements, look for opportunities to make regulations self-enforcing, such as using red curb paint to emphasize parking restrictions or using multiple highly visible signs to reinforce a turn restriction.

SW Alaska Street and California Avenue SW, Seattle
Source: Metro, 2021

TURN RESTRICTIONS/EXEMPTIONS

PARKING REMOVAL/ALTERATIONS

TURN RESTRICTIONS/EXEMPTIONS

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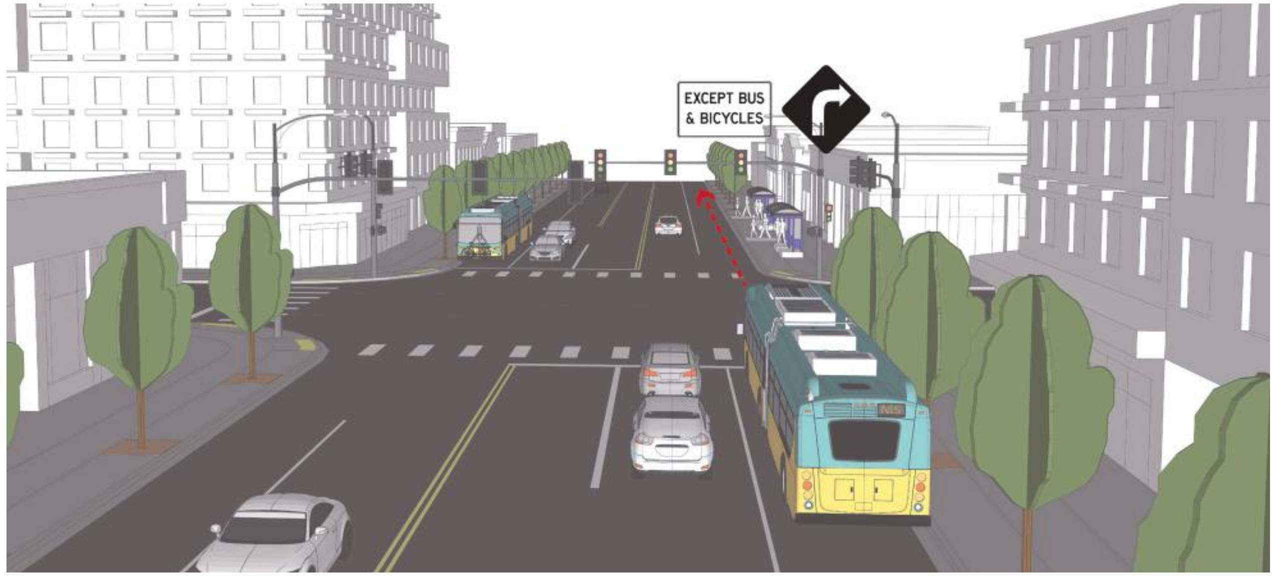
OVERVIEW OF STRATEGY

This tool is used to allow buses to make one or more movements at the intersection that are prohibited for general purpose traffic. Buses may be allowed to make movements that have been prohibited for other vehicles. Turning restrictions and exemptions can be implemented full time or only during peak periods. For more information, see Sections 6.1 and 6.2 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.



BENEFITS

Allowing buses to make turning movements that are prohibited for other vehicles can allow for more direct routing that can save travel time. Prohibiting turning movements can increase capacity for both buses and general purpose traffic by prohibiting turning movements that cause high levels of delay.

OPERATIONAL CONSIDERATIONS

For movement restriction exemptions, potential operational considerations include the ability of the bus to make the turn that is being allowed.

Turn restrictions can be in effect 24/7, or during a peak period only. Exemptions can also be extended to bikes and/or trucks.

IMPLEMENTATION GUIDE

ANALYSIS APPROACH: Collect traffic data and run intersection LOS to understand outcome of the proposed operational changes to both transit and general purpose traffic as needed. Identify alternate routes for general purpose traffic.

COORDINATE WITH METRO: For movement restriction exemptions, discuss the reason(s) behind the existing turn prohibition. Determine the appropriate implementation strategy and if needed, focus the scope for any traffic impact analysis.

OUTREACH TO NEIGHBORHOOD: The need for neighborhood outreach is considered on a case-by-case basis. Outreach may be completed as part of a package of larger corridor improvements.

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TURN RESTRICTIONS/EXEMPTIONS

LOCAL APPLICATION EXAMPLES

Alaskan Way and Columbia Street, Seattle: Westbound right-turn movement restricted to prevent general-purpose traffic interference with bus stop and left-turn movement.

Source: Metro, 2021

5th Avenue S and S Jackson Street, Seattle: Northbound, Eastbound, and Westbound left-turns are restricted to buses only; signage for the NB left-turn restriction was recently upgraded to improve compliance.

Source: Metro, 2019

COST CONSIDERATIONS

PLANNING AND COORDINATION

Moderate: A traffic impact analysis could be required to evaluate the proposed change and the potential safety issues. If infrastructure needs to be modified to allow the turning movement (e.g. removing a median) it would increase the project cost.

CAPITAL COSTS

Up to $20,000 per movement. These costs depend on the specific site characteristics. In some locations, only new or replacement signs may be needed; other locations may require modifications to pavement markings, traffic signal heads, or curb lines and medians.

MAINTENANCE COSTS

Low: Maintenance needs would depend on the modification made but could include signals or signs and pavement markings.

BUS OPERATIONS COSTS

May reduce travel time and travel distances.

OTHER USER COSTS

Depending on the method of implementation of a movement restriction exemption, there could be additional travel delay for other vehicles. This tool may reduce delay to through-traffic and sometimes other movements at the intersection. The reduced delay would typically offset any additional travel time experienced by diverted traffic in locations where through traffic volumes are high relative to the diverted traffic volumes.

BARRIERS AND SIDE EFFECTS

Traffic impacts to other vehicles may be an issue if bus service is frequent. Impacts to pedestrian or bicycle movements could be a concern if the intersection is in a pedestrian- or bicycle-heavy corridor. A formal exception to a roadway agency's access management policy may be required.

ALTERNATIVES AND COMPANION STRATEGIES

At unsignalized intersections, if the turn prohibition is due to a lack of gaps in the opposing traffic, and a traffic signal exists a relatively short distance downstream of the intersection, reverse queue jump may be an option for creating a gap. When a turn lane is provided for bus use only, red-colored pavement markings may be considered to help reinforce the bus-only message. Enforcement may be required to maintain motorist respect for the traffic control.

At signalized intersections, bus-only signal phases are suggested to be considered in conjunction with a turn exemption. Right-turn except bus lanes are commonly used with queue jump and queue bypass strategies.

PARKING REMOVAL/ALTERATIONS

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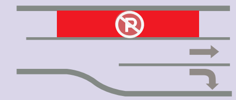
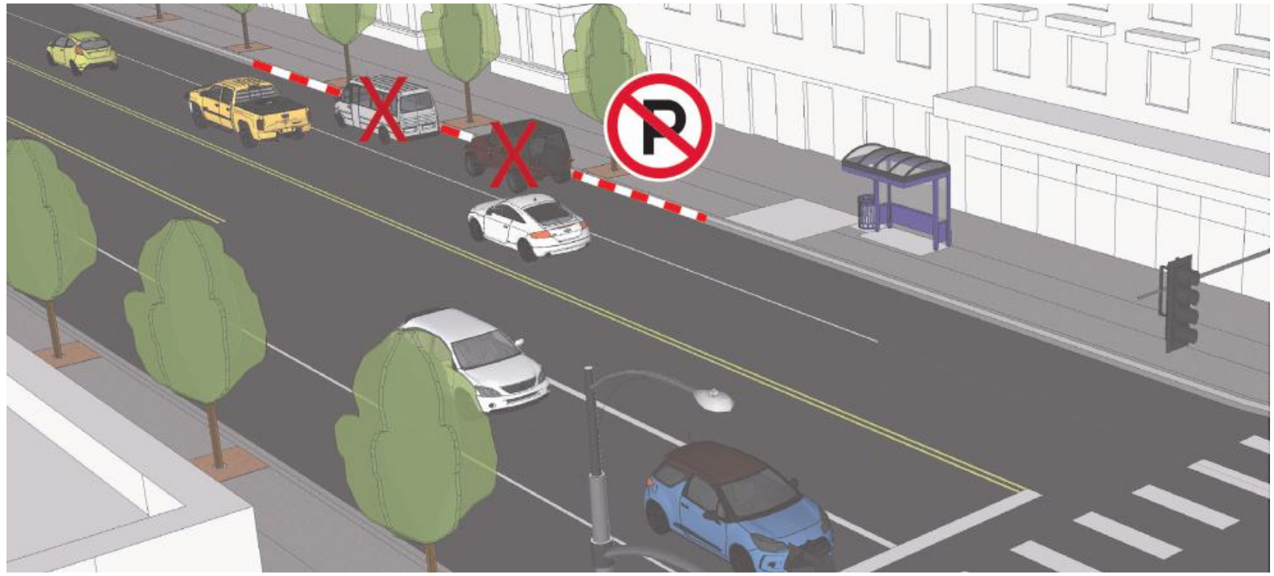


OVERVIEW OF STRATEGY

Removal or alteration of parking in targeted areas to provide additional roadway space for buses. This can include providing additional space to increase lane widths, to install a bus lane, or to expand a bus stop.



BENEFITS

Parking removal can permit wider lanes or reduce parking encroachment for transit use. This can reduce travel times and delay near the improvement, particularly near bus stops where parking creates a pullout. Parking removal or alterations can also improve safety for buses and other roadway users.

OPERATIONAL CONSIDERATIONS

Parking can be rearranged or altered (replaced by loading zones) to reduce the loss of parking. Parking restrictions can be in effect 24/7 or during peak periods only. Travel lane widths need to be evaluated; parking lanes are often 7-8’ wide which is not adequate for bus operations.

IMPLEMENTATION GUIDE

COORINDATION WITH METRO: Coordinate with Metro to develop parking alterations or removal concepts that could reduce conflicts with transit. Solutions will likely be site-specific.

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PARKING REMOVAL/ALTERATIONS

LOCAL APPLICATION EXAMPLES

SW Alaska Street and California Avenue SW, Seattle: Eastbound parking restrictions were reinforced with red curb paint and “no stopping” signs, helping buses travel through a narrow pinch point in the middle of the block.

Source: Metro, 2021

W McGraw Street and 7th Avenue W, Seattle: Westbound parking on W McGraw Street was blocking sightlines for southbound buses trying to turn left, forcing buses to pull into the intersection to see oncoming traffic. Therefore, about two parking spots were restricted and trees were trimmed to help buses safely make the turn, improving transit reliability.

Source: Metro, 2019

COST CONSIDERATIONS

PLANNING AND COORDINATION

Low to moderate: This is to develop concepts for parking changes or removal. Outreach to nearby property owners may also be necessary. Also, implementing policy guidance on how parking is provided within the street network may be needed.

CAPITAL COSTS

Between $1,000 and $25,000: There would be some capital costs associated with removal or restriping of parking. Some new signage may also be necessary.

MAINTENANCE COSTS

There would be minimal added maintenance costs. Loss of Pay-to-Park (metered) spaces may incur a loss of revenue to the City.

BUS OPERATIONS COSTS

There would likely be some savings in travel time and delay for buses.

OTHER USER COSTS

There could be some loss or reductions in parking. If paid parking is removed or altered, there could be some of loss of parking meter revenue. Other roadway users could benefit from increased safety.

BARRIERS AND SIDE EFFECTS

It can be difficult to remove or reduce parking, particularly in locations where parking is already minimally provided or in residential areas. Public perception to parking removal can be negative, making it difficult to implement projects that involve changes to parking. Support from the community for parking removal is often difficult to obtain. Policy measures that describe how parking is prioritized among other competing needs for roadway space can help provide guidance when implementing this type of project (i.e., policy stating that parking needs are prioritized after adequate space has been provided for transit, nonmotorized users, freight, and general purpose traffic). Extending outreach to the neighboring local jurisdiction where parking changes are proposed is important. Implementation can be easier, if possible, to only modify parking (i.e., restrict parking during peak periods only) and/or replace it in another location rather than removing it completely.

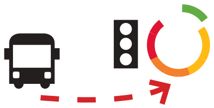
ALTERNATIVES AND COMPANION STRATEGIES

Parking removal or changes can be paired with many of the speed and reliability tools (in some cases, parking removal may be considered as a side effect of making a speed and reliability improvement). Parking removal/alteration is also often used to improve turn radius.

4.3.4 SIGNALS

This section describes tools that modify signal timing, phasing, and indications. Traffic signal improvements are targeted towards a specific location to benefit transit operating in mixed traffic including special features reserved only for transit vehicles. In many cases these tools also will decrease congestion and improve general traffic flow. Traffic signal configurations and timings will generally need to follow the prescriptive guidelines outlined in The Manual on Traffic Control Devices (MUTCD).

Montlake Boulevard NE and NE Pacific Place, Seattle
Source: Metro, 2021



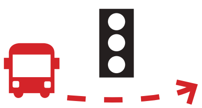
PASSIVE TRAFFIC SIGNAL RETIMING

TRANSIT SIGNAL PRIORITY (ACTIVE)

SIGNAL PHASE MODIFICATION

GENERAL

BUS-ONLY SIGNAL PHASE



NEW SIGNAL INSTALLATION

GENERAL

PRE-SIGNAL

QUEUE JUMP

GENERAL

REVERSE

PASSIVE TRAFFIC SIGNAL RETIMING $-$$

OVERVIEW OF STRATEGY

Existing signal timing plans can be optimized (on periodic or ongoing basis) to reduce delay for traffic on intersection approaches used by buses. The signal timing is followed whether or not a bus is present; therefore, the adjustments are passive.

Signal timing can be adjusted specifically to benefit buses, such as shorter cycle lengths or more green time for the approaches used by buses. Changes that result in better operations for general purpose vehicles may also benefit buses.

BENEFITS

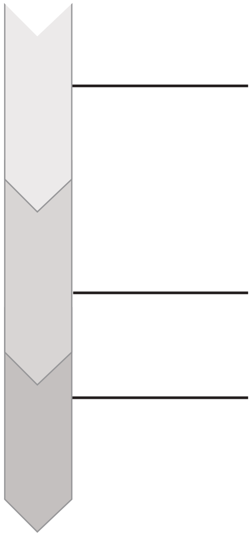
Adjusting or optimizing signal timing plans reduces bus delay at signalized intersections.

OPERATIONAL CONSIDERATIONS

When adjusting traffic signal timing plans bus stops location should be taken into account to ensure that the timing plans have enough time to serve the stop. Additional information is included in Section 6.4 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

New signal timings may trigger the implementation of updated traffic operations standards, such as longer pedestrian crossing time and LPIs.

IMPLEMENTATION GUIDE



DEVELOP INTERNAL PROCESS FOR IDENTIFYING CANDIDATE SIGNALS: Both Metro and local jurisdictions can develop an internal process for identifying and reporting signal timing issues that affect bus operations. Local jurisdictions should also consider bus operations when retiming traffic signals. Signal progression for buses is a potential strategy for high-passenger-volume corridors where a net person-delay benefit may be feasible. It can also be considered in local jurisdictions that wish to prioritize non-automobile traffic.

DEVELOP SIGNAL TIMING PLAN: Collect data and model the changes to traffic operations of the signal timing modifications.

IMPLEMENT AND ADJUST: Implement the signal timing modifications and monitor traffic operations. If further modifications to the signal timing plan are needed, adjustments of the signal timing plan can be made.

$-$$ PASSIVE TRAFFIC SIGNAL RETIMING

LOCAL APPLICATION EXAMPLES

NE 4th Street and 108th Avenue NE, Bellevue: Signal timing was adjusted to bring up the eastbound left-turn phase after the eastbound through phase. Buses are now less often stuck in eastbound through traffic, saving 26 seconds in the AM peak period.

Source: Metro, 2021

Kent-Covington Signal Retiming Project: Signal timing on 3 corridors and 16 signals was adjusted to provide better through progression, taking time away from turning movements on to freeways. This reduced transit delay by 3-6% corridor wide.

Source: Metro, 2019

COST CONSIDERATIONS

PLANNING AND COORDINATION

Between $3,000 and $6,000 per intersection: Costs could include collection of traffic data (buses, bicyclists, pedestrians, and automobiles), and developing the traffic model to evaluate the initial timing plan and the effects of that plan. Planning and coordination costs would also include implementing and adjusting the final plan.

CAPITAL COSTS

There would be no new capital costs to implement this tool unless cabinet rewiring or a signal controller upgrade is required to facilitate the changes.

MAINTENANCE COSTS

There would be no new maintenance costs to implement this tool.

BUS OPERATIONS COSTS

There would be potential savings from reductions in traffic signal delay. Timing signals to allow buses to progress can also help reduce bus travel time variability.

OTHER USER COSTS

Potential changes in delay (both up and down) for other intersection users, as discussed in the Benefits section; however, the outcome should be an overall improvement on a person-delay basis.

BARRIERS AND SIDE EFFECTS

Allocating more green time to intersection approaches used by buses may reduce delay for motorized vehicles, bicyclists, and pedestrians on those approaches, but could increase delay on the other approaches where green time is shortened.

The amount of signal timing that can be reallocated may be constrained by the amount of time required to serve vehicles on other approaches (dependent on traffic volumes and the number of lanes) and by the minimum time required to serve pedestrian movements (dependent on the crossing width and the minimum pedestrian walk times specified in the Manual on Uniform Traffic Control Devices [MUTCD] and local agency policy). Also, if all signals in a corridor are coordinated (i.e., operate as group, allowing traffic movements to be synchronized between intersections), a common cycle length must be used. Making a change to one intersection would normally require all the other intersections' cycle lengths to be changed identically.

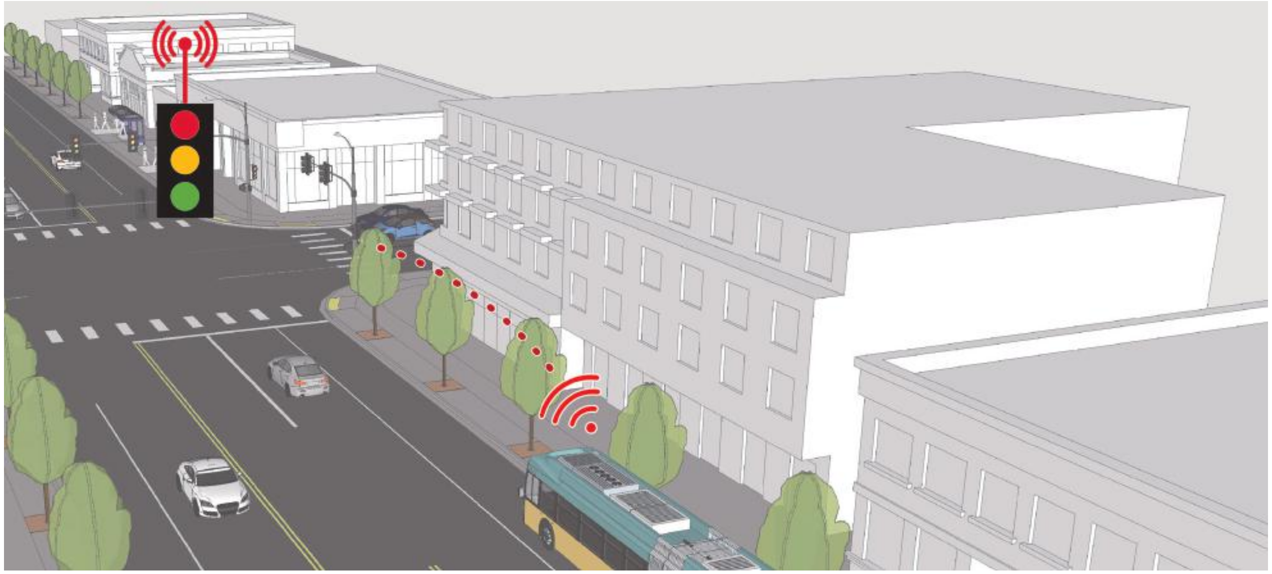
ALTERNATIVES AND COMPANION STRATEGIES

Passive signal timing adjustments can be implemented in conjunction with other signal timing strategies that react to the presence of a bus, including phase reservice, TSP, bus-only signal phases, queue jumps, and pre-signals.

TRANSIT SIGNAL PRIORITY (ACTIVE) $-$$

OVERVIEW OF STRATEGY

Traffic signal timing changes in response to signal from a bus to reduce delay passing through an intersection. TSP strategies include green extension, red truncation (early green), phase insertion, sequence change, and phase skipping. Additional information about Metro's policies on TSP can be found in *"King County Metro TSP Policy & Strategies"*.



BENEFITS

TSP reduces the amount of delay that buses experience at traffic signals. When implemented along corridors, TSP may improve travel time variability.

OPERATIONAL CONSIDERATIONS

TSP is typically used at intersections operating at LOS C, D, or E. Bus volumes through the intersection should be between 8-25 buses per hour; if bus volumes are higher a bus would be expected on most signal cycles and passive traffic signal timing adjustments should be considered instead.

All Metro buses, excepted contracted services such as DART and Access, have equipment necessary to operate on the King County TSP system. The system can identify whether buses are on schedule or late and request different levels of priority in response. All new TSP installations will use King County's next-generation TSP system using center-to-center (C2C) connections and existing city-owned communications networks.

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TRANSIT SIGNAL PRIORITY (ACTIVE)

LOCAL APPLICATION EXAMPLES

RapidRide C and D Lines in Seattle: Metro and SDOT implemented a lateness-based conditional transit signal priority, using a hybrid travel time and reliability strategy. Late buses can request more-aggressive TSP timings such as phase skipping, while on-time or early buses can request green extensions or early greens.

RapidRide C Line - TSP, Alaska St and Fauntleroy St, Seattle, Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Low to moderate: This is to model and evaluate the initial timing plan, come to agreement on strategies and business rules, implement the TSP settings in the signal controllers, and evaluate and fine-tune the TSP operations. Costs would be higher if communication needs to be brought to the signal cabinet or if the local agency's central system needs to be upgraded to receive and process TSP messages from King County.

CAPITAL COSTS

Costs are estimated at $40,000 per intersection, assuming communication is available to the signal cabinet, central system TSP integration has already been performed with the local agency, and the existing controller supports TSP. For central system integration, add $20,000 per city. For signal controller upgrade, add an additional $10,000 per intersection.

MAINTENANCE COSTS

Assume $500 per intersection per year for system monitoring, responding to issues, and periodic retiming of TSP settings. Ideally, TSP settings are optimized every 6 years.

BUS OPERATIONS COSTS

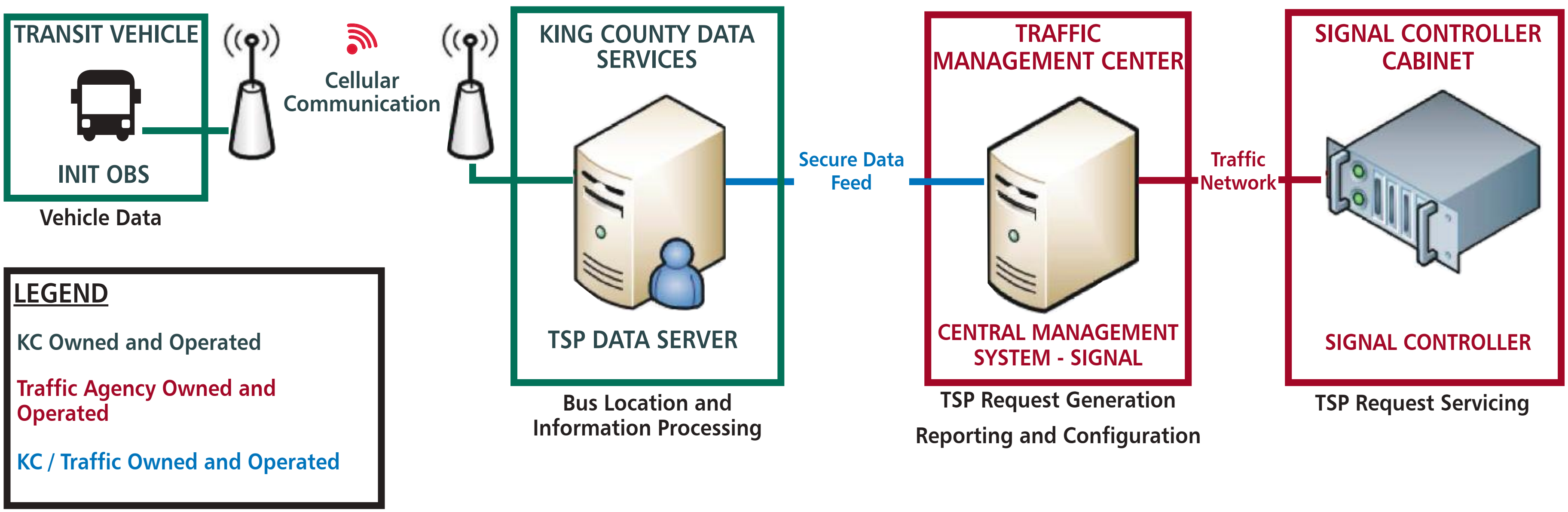
Reducing bus travel time and variability can shorten the schedule cycle time and decrease operating costs if a bus can be removed from the schedule or an additional bus can be prevented from being added to the schedule due to increasing traffic congestion.

OTHER USER COSTS

Depending on the TSP strategies used, vehicular traffic on the approaches served by TSP may experience a small average delay reduction due to TSP, while vehicular traffic on the approaches not served by TSP may experience a negligible-to-small delay increase. If the cycle time and pedestrian walk times are not changed, pedestrian delay would be unchanged. Phase skipping can significantly increase vehicular and pedestrian delay for those approaches that are skipped.

TRANSIT SIGNAL PRIORITY (ACTIVE) $-$$

PROPOSED CONCEPT - CENTRALIZED TSP



PLANNING CONSIDERATIONS

To operate TSP under King County's centralized TSP system, planned to be available in 2022, the following requirements must be met:

- The traffic signal controller at the intersection must be connected to the agency's central system with fiber or other high-speed connection.
- The traffic agency must have a vendor-provided centralized TSP server or module and have integrated it with King County's TSP location feed.
- The traffic signal controller software must be compatible with the agency's central TSP module; a controller upgrade may be required.

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TRANSIT SIGNAL PRIORITY (ACTIVE)

IMPLEMENTATION GUIDE

CONSIDER OTHER TOOLS: Evaluate the possibility of implementing other lower-cost, quicker-to-implement strategies such as stop relocation, stop rebalancing, and passive traffic signal timing adjustments.

EVALUATE TRANSIT SIGNAL PRIORITY FEASIBILITY: A Synchro model can be used to determine intersection LOS and feasibility for TSP. A simulation study may be needed to evaluate corridor operations with and without TSP, or a planning-level estimate of 5% travel time savings can be used. If TSP is a new strategy, the required infrastructure will need to be planned and designed.

DETERMINE STRATEGY AND BUSINESS RULES: TSP can be planned to maximize overall travel time savings, maximize reliability, or a hybrid approach. For a travel time strategy, the objective will be to provide TSP for as many buses and as many intersections as possible. For a reliability strategy, the objective will be to get as much benefit as possible out of an individual TSP request and reserve those requests for late buses or to help close headway gaps. Local agencies may be willing to offer more-aggressive TSP settings if they are called less often. A hybrid strategy may use different TSP request levels for on-time vs. late buses. Business rules are developed to determine which buses are eligible for TSP based on route, direction, time of day, lateness, etc. The strategy and business rules to use for a corridor or individual intersections must be agreed upon between Metro and the local agency prior to development of detailed timings and implementation.

MONITOR TRAFFIC OPERATIONS: After a signal timing plan has been implemented in the field, monitor traffic operations for both general purpose traffic and transit, and determine if modifications are needed.

BARRIERS AND SIDE EFFECTS

A key requirement for TSP to be successful is that buses actually be able to reach the intersection in a predictable manner. If an intersection approach operates over capacity (LOS F), it may make matters worse to adjust the signal timing when the bus is blocked by other vehicles because the bus cannot get to the intersection and may not be granted priority again until the signal recovers from the first granting of priority.

ALTERNATIVES AND COMPANION STRATEGIES

The potential need for stop relocations should be considered when implementing TSP because some applications work better with some stop locations than with others (e.g., green extension with far-side stops). TSP can also be combined with most signal-related strategies, including passive signal timing adjustments, traffic signals, bus-only signal phases, turn lanes serving buses only, queue jumps, and pre-signals. Bus lanes compliment TSP well because the bus lanes provide a more-predictable arrival time at the intersection and can potentially have less impact in signal operations while achieving the desired benefit.

SIGNAL PHASE MODIFICATION

GENERAL

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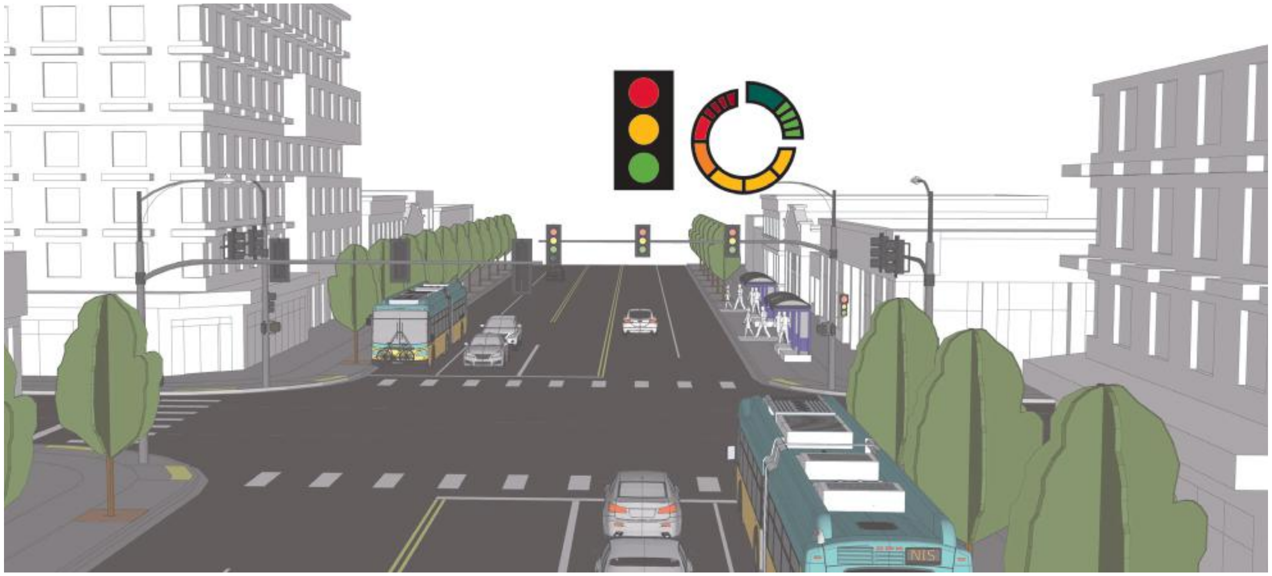
OVERVIEW OF STRATEGY

Modifications to the signal phasing at an existing signalized intersection to facilitate difficult movements for buses. For example, modifying a signal to include a protected left-turn phase instead of a permissive turn phase.



BENEFITS

Signal phase modification can provide travel time savings and travel time variability benefits by making difficult movements at a signalized intersection easier for buses. Signal phase modifications can also have potential safety benefits when permissive phases are converted to protected phases. General purpose vehicles making the same movement may also experience a reduction in delay at the intersection.

OPERATIONAL CONSIDERATIONS

Impacts to other roadway users need to be evaluated and considered. National and local standards for signal operations need to be followed.

IMPLEMENTATION GUIDE

COORDINATION WITH METRO: Coordinate with Metro before implementing a signal phase modification. Training information may need to be provided to transit operators.

ANALYSIS APPROACH: A traffic analysis using a tool such as Synchro may be needed to evaluate the potential benefits to transit movements and potential impacts to traffic making other traffic users.

IMPLEMENT AND ADJUST: Implement the signal phase modification and monitor operations for general purpose traffic and transit.

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SIGNAL PHASE MODIFICATION

GENERAL

LOCAL APPLICATION EXAMPLES

4th Avenue and Pike Street, Seattle: A right-turn signal phase was added to help buses turn and reduce pedestrian conflicts.

Source: Metro, 2015

5th Avenue and Denny Way, Seattle: Signal phasing was converted from north-south split phasing to phasing with concurrent north-south movement. This allows more green time to be provided to transit movements in 4 directions and reduces pedestrian delay.

Source: Metro, 2018

COST CONSIDERATIONS

PLANNING AND COORDINATION

Low to moderate: A traffic impacts analysis could be required to evaluate intersection operations before and after implementation of the signal.

CAPITAL COSTS

Between $50,000 and $100,000. Costs could vary depending whether a new signal pole, mast arm, or cabinet are needed to support the operations change.

MAINTENANCE COSTS

Additional maintenance costs are none to minimal. Installing new signal equipment may reduce maintenance costs.

BUS OPERATIONS COSTS

There could be potential savings from reductions in travel time and improvements to travel time variability.

OTHER USER COSTS

There could be some minor increased delay to other roadway users.

BARRIERS AND SIDE EFFECTS

Modifying the signal phasing could result in additional delay to other roadway users at other intersection approaches. It may be necessary to develop clear policy guidance that identifies which mode gets priority because reallocating signal time to transit may impact the delay of another mode.

There would need to be adequate time in the existing signal cycle to reallocate to a new phase. The amount of time that can be reallocated to the modified phase would be constrained by the amount of time required to serve vehicles and pedestrians on other approaches. If a longer cycle length is needed and the signal is part of a coordinated system, the entire system may need to be retimed.

ALTERNATIVES AND COMPANION STRATEGIES

Companion strategies include passive traffic signal timing adjustments, phase reservice, and TSP. Transit signal faces and bus-only signal phases could be used as an alternative if the volumes of vehicles making the same movement cause bus delay.

SIGNAL PHASE MODIFICATION

BUS-ONLY SIGNAL PHASE

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OVERVIEW OF STRATEGY

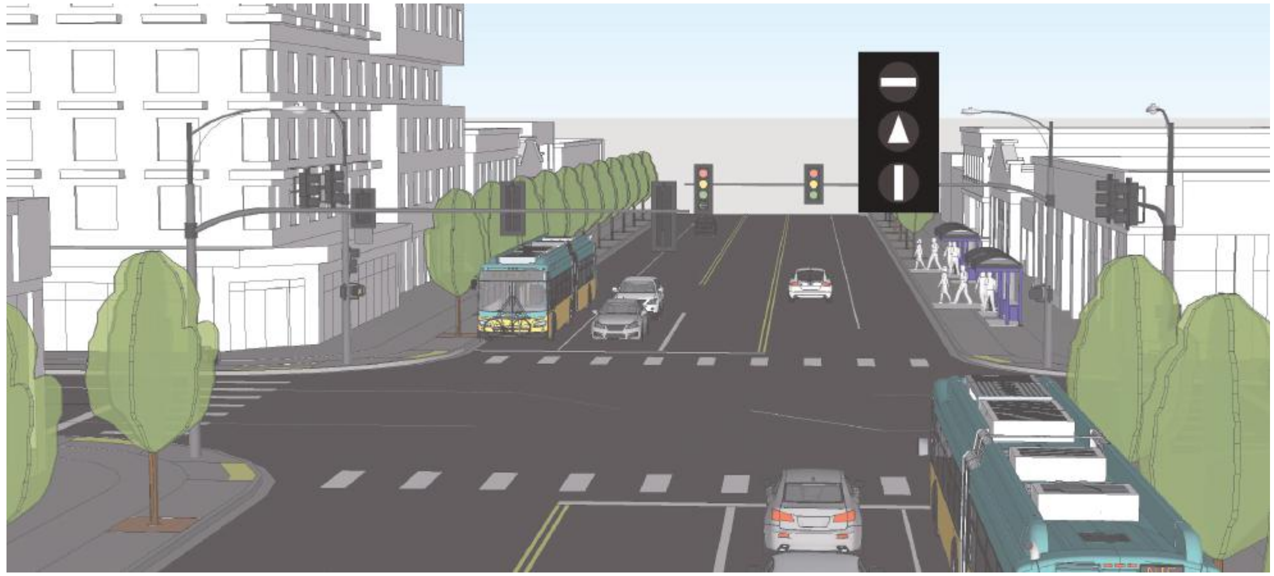
A traffic signal phase included in the traffic signal cycle to serve bus movements that cannot be served or are not desired to be served concurrently with other traffic. Bus-only signal phases help support other tools by allowing buses to make nonstandard movements at an intersection. Without bus-only signal phases, some tools might not be feasible while others would be less effective.

BENEFITS

Bus-only signal phases typically support other strategies to achieve maximum effectiveness. This tool allows buses to make turning movements that are prohibited for other roadway users which may reduce travel time or travel time variability.

OPERATIONAL CONSIDERATIONS

Training may be needed for operators on routes with bus-only signal phases for unconventional movements. This would help to reduce any confusion for operators to maximize speed and reliability benefits. Bus-only signal phases may require a bus-only lane with standard vehicle detection (loops, video, etc.). A disadvantage of a bus-only signal phase is that buses may need to wait longer for the specific phase to come up in the signal cycle.



IMPLEMENTATION GUIDE

UNDERSTAND THE NEED AND CONSIDER OTHER USERS: Bus-only signal phases are a potential option when bus turning movements need to be made from unconventional locations. Designs may need to take into consideration conditions where other intersection users need to be warned about the unconventional movement (e.g., "Bus Signal" signs, accessible pedestrian signals, a special sign depicting the bus maneuver, dotted pavement markings), and the conditions listed in the Barriers and Side Effects description will need to be checked and potentially addressed prior to proceeding. Using LRT-style signal displays for bus-only phases is recommended to avoid confusion and violations from general purpose traffic. Guidance for implementing this tool with median bus lanes, right-side bus lanes, and left-side bus lanes is provided in Section 6.9 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

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SIGNAL PHASE MODIFICATION

BUS-ONLY SIGNAL PHASE

LOCAL APPLICATION EXAMPLES

Fairview Avenue N and N Valley Street, Seattle: A bus-only signal phase allows C-Line buses to go westbound through the intersection; a movement that is prohibited to other traffic.

Source: Metro, 2021

Montlake Boulevard NE and NE Pacific Place, Seattle: A bus-only phase allows buses to make a left-turn from the right-side bus-only lane.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Low to moderate: A higher level of coordination with Metro would be required for the first implementation, particularly if a signal controller upgrade is needed to support the bus signal phase and signal heads. Public outreach may also be needed to minimize the risk of collisions resulting from unfamiliarity with the new signals from other roadway users. Operator training is recommended just prior to activating a new bus-only signal phase.

CAPITAL COSTS

Between $50,000 and $100,000. These costs depend on whether bus detection infrastructure would need to be installed and whether a signal controller upgrade would be needed. Accessible pedestrian signals may also be required.

MAINTENANCE COSTS

There would be no direct impact to maintenance costs.

BUS OPERATIONS COSTS

When used to serve unconventional turning movements, the strategy may reduce delays associated with buses weaving across traffic lanes to a location where a conventional turning movement can be made.

OTHER USER COSTS

The time required to serve a bus-only signal phase would likely increase delay for at least some other vehicles using the intersection.

BARRIERS AND SIDE EFFECTS

The signal controller would need to have an unused signal phase available to serve the bus-only phase. Turn radii would need to be sufficient to allow the movement for the bus, which could result in the need to set the stop bar for general purpose vehicles back from the intersection. There could be traffic impacts to other vehicles at the intersection, which could be evaluated through a traffic impacts analysis.

ALTERNATIVES AND COMPANION STRATEGIES

Bus-only signal phases could be implemented in conjunction with movement restriction exemptions, TSP, queue jumps, pre- signals, bus-specific signals, queue bypasses, median bus lanes, contraflow bus lanes, and single-lane reversible bus lanes.

NEW SIGNAL INSTALLATION

GENERAL

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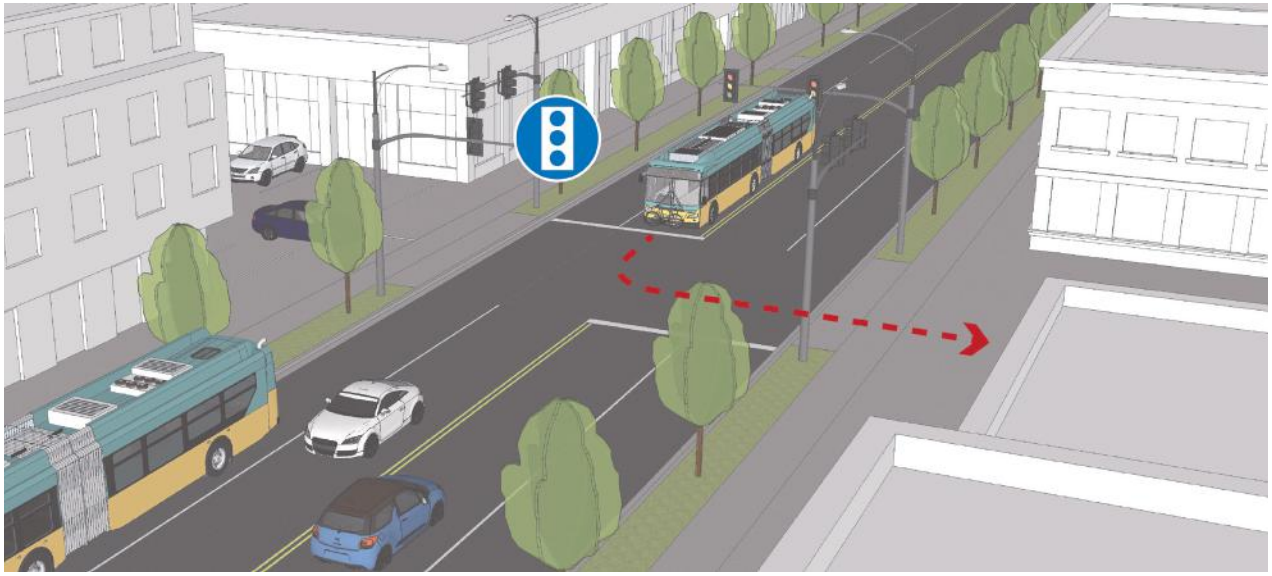
OVERVIEW OF STRATEGY

An intersection that is signalized primarily to serve bus movements rather than general traffic. This could be necessary in locations where buses experience significant delays when making turns at an unsignalized intersection along a major roadway, but the minor street-traffic volumes may not be sufficient to meet the MUTCD's volume-based traffic signal warrants. Additional information is included in Section 6.12 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.



BENEFITS

Traffic signals specifically for buses are typically installed to reduce delay from buses turning left onto, turning left from, or crossing major streets. A traffic signal could reduce bus travel time and improvements to travel time variability; specific benefits are highly site- specific and would need to be determined by a traffic impacts analysis. Pedestrian mobility can also benefit because a traffic signal provides a new signalized crossing opportunity.

OPERATIONAL CONSIDERATIONS

Operational considerations for this tool are similar to those for a standard traffic signal.

IMPLEMENTATION GUIDE

CONSIDER ALTERNATIVES: Rerouting buses to avoid a problematic intersection should be considered prior to installing a traffic signal primarily for buses.

ANALYSIS APPROACH: Rely on local jurisdictions for making decisions on installing new traffic signals and conducting the signal warrant analysis. If necessary, conduct a traffic analysis to evaluate the need for a signal and benefits/impacts for transit and other roadway users. Consider potential passive signal priority measures in this analysis.

EVALUATE POLICY RESTRICTIONS: An experimentation request to the FHWA could be required if the signal would not be recommended by MUTCD warrants.

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NEW SIGNAL INSTALLATION

GENERAL

LOCAL APPLICATION EXAMPLES

Airport Way S and Central/Atlantic Bases, Seattle: A regular traffic signal installed at the transit base driveway helps departing buses begin their trip on-time.

Source: Metro, 2021

Northgate Transit Center, Seattle: Metro coordinated with the city of Seattle to install a new traffic signal phase at the north end of the Northgate Transit Center to allow buses to exit the transit center without having to wait for a break in oncoming traffic.

Source: Google Maps (2020)

COST CONSIDERATIONS

PLANNING AND COORDINATION

Moderate to high: A traffic impacts analysis could be required to evaluate intersection operations before and after implementation of the signal. If an experimentation request is needed, additional study requirements could be necessary. Other traffic control measures could also be needed, such as signage; motorist outreach programs may also be necessary. Communication may need to be provided to the new traffic signal.

Cities that rely on King County Roads to provide services to operate and maintain cities traffic signals will collaborate with King County Roads to work with Metro to identify requirements, project outcomes, and clarify roles and responsibilities during planning, design, and implementation.

CAPITAL COSTS

High: >$400,000. These costs are to install a new traffic signal and potentially make ADA- related improvements such as curb ramps, if not already provided.

MAINTENANCE COSTS

Maintenance costs would include operating and maintaining the signal.

BUS OPERATIONS COSTS

There could be potential savings from reductions in travel time and improvements to travel time variability.

OTHER USER COSTS

There would likely be increased delay for other roadway users.

BARRIERS AND SIDE EFFECTS

Policy to support the implementation of a signal without meeting MUTCD warrants could be necessary. The new traffic signal could also affect roadway operations, particularly if the major roadway currently provides good traffic progression.

ALTERNATIVES AND COMPANION STRATEGIES

Traffic signals, specifically for buses, could be implemented using transit signal faces to control bus movements and would typically be used in conjunction with bus-only signal phases. TSP could also potentially be provided, if bus volumes are within the range appropriate for TSP. Reverse queue jump may be an alternative strategy if a signal specifically for buses is not feasible.

NEW SIGNAL INSTALLATION

PRE-SIGNAL

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OVERVIEW OF STRATEGY

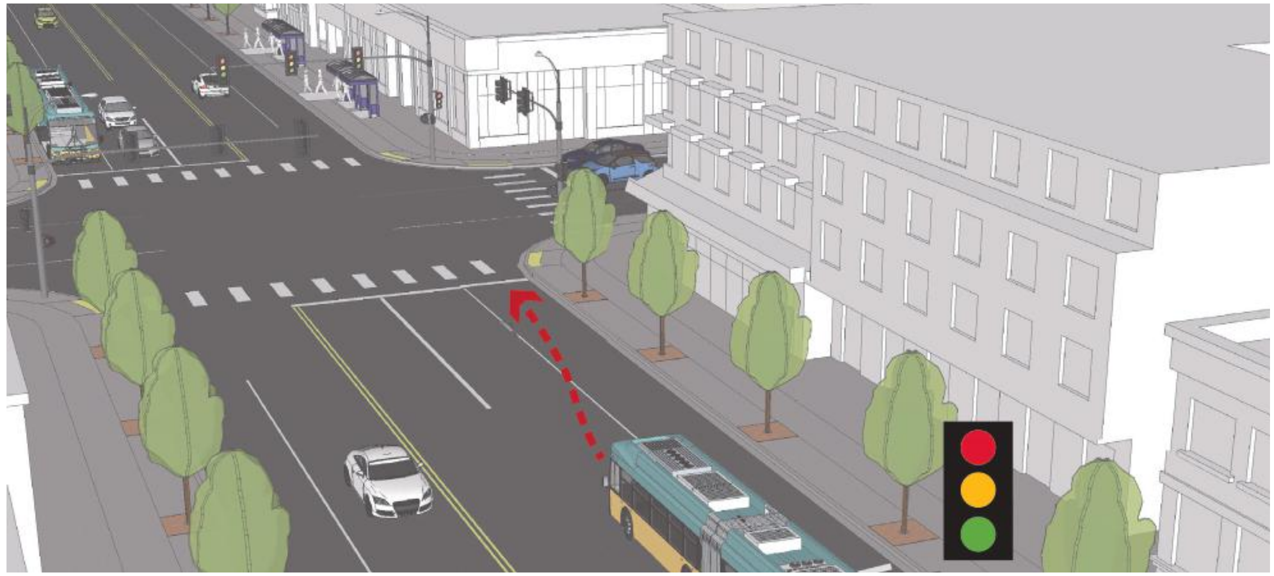
A new traffic signal is installed for the purpose of holding back or metering the flow of general traffic from any direction, which can help create downstream roadway space for buses. Pre-signals can be passive (running fixed time or on every cycle) or active (activates only when an approaching bus is detected).

BENEFITS

Pre-signals can result in significant potential time savings when the pre-signal allows buses to bypass the queue of an over-capacity intersection. The magnitude of time savings depends on the level of congestion. Pre-signals can also be used primarily to facilitate bus movements into or across general purpose traffic lanes. Travel time variability is also reduced by pre-signals.

OPERATIONAL CONSIDERATIONS

There are no major operational considerations for this tool.



IMPLEMENTATION GUIDE

ENSURE APPROPRIATE SUPPORTING INFRASTRUCTURE IS IN PLACE: The presence of a bus lane or an extended bus pullout may be needed to support a pre-signal.

ANALYSIS APPROACH: The pre-signal should operate full time unless there are overriding reasons not to do so. To obtain maximum benefit for buses, locate bus stops either immediately prior to the pre-signal or on the far side of the intersection. Additional guidance is provided in Chapter 6.11 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.

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NEW SIGNAL INSTALLATION

PRE-SIGNAL

LOCAL APPLICATION EXAMPLES

Mt Baker Transit Center, Seattle: At Rainier Avenue S and S Forest Street (Mount Baker Transit Center), the signal is timed to help keep traffic on Rainier Avenue from filling up the short block between Forest Street and McClellan Street. This strategy helps buses exiting the Transit Center.

Source: Metro, 2021

Aurora Avenue N and N 46th Street, Seattle: A special signal is installed to stop traffic approaching on the on-ramp to Aurora Avenue when a southbound bus approaches in a bus lane on Aurora Avenue. This helps buses negotiate a difficult merge where the bus lane and on-ramp traffic come together.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Moderate: A traffic impacts analysis could be needed to identify the optimal location for the pre-signal. A signal timing plan would need to be developed for the pre-signal and coordinated with the downstream signal. Planning and coordination costs associated with transit signal faces and special bus phases would also be applicable.

CAPITAL COSTS

Between $50,000 and $250,000 if new signal equipment is needed for the pre-signal.

Up to $50,000 if a traffic signal already exists and the pre-signal effect can be achieved through signal timing and detection adjustments.

MAINTENANCE COSTS

These costs are to maintain and operate the pre-signal.

BUS OPERATIONS COSTS

There would be potential savings from travel time and variability reductions.

OTHER USER COSTS

There would be no change in general traffic delay as long as the presence of driveways and side streets do not require that the pre-signal be moved to a less-optimal location.

BARRIERS AND SIDE EFFECTS

Pre-signals have similar barriers and side effects as bus lanes because pre-signals are a support strategy for bus lanes. Pre-signal placement may be limited by the presence of side streets and/or driveways.This may impact intersection throughput by relocating the queue from the intersection farther upstream. If the pre-signal facilitates the conversion of a general-purpose lane to a bus lane, the queue in the general-purpose lane would become longer.

ALTERNATIVES AND COMPANION STRATEGIES

A bus lane is usually a prerequisite for employing a pre-signal. The bus lane can be controlled by transit signal faces providing a bus-only signal phase. TSP can potentially be applied both at the pre-signal and the downstream signal.

Queue jumps (priority is provided at the signalized intersection) and queue bypasses (priority provided without traffic signals) are related strategies.

QUEUE JUMP

GENERAL

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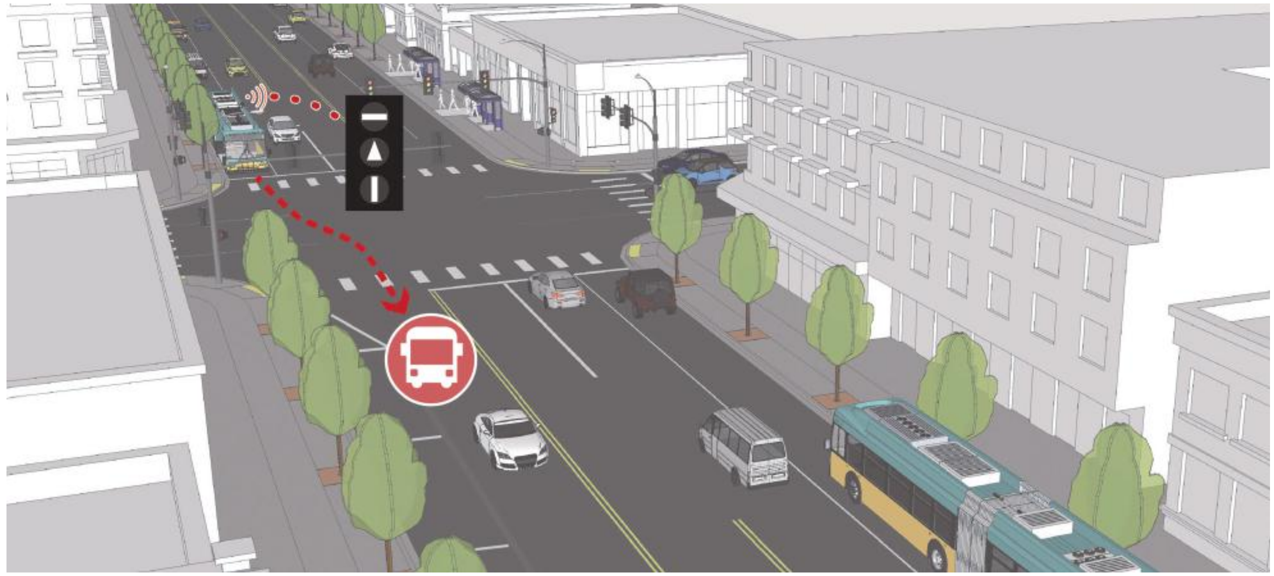
OVERVIEW OF STRATEGY

Buses get priority to move ahead of queued vehicles at a signalized intersection and proceed in advance of the through traffic. Queue jumps are a combination of roadway infrastructure and traffic control strategy, and can be provided in a number of ways, including shared right-turn lanes, left lanes, short bus lanes, and shoulder bus lanes.



BENEFITS

Queue jumps can save buses significant amounts of time by allowing the bus to bypass the intersection queue and/or serve a bus stop sooner. Pedestrians can benefit from queue jumps if right-turns are controlled with a restricted turn phase, which reduces interactions with right-turning traffic. Right-turns restrictions may reduce delay by allowing pedestrians to begin crossing earlier with the bus. Pedestrian phases can usually run with a queue jump phase and can serve dual-purpose as an LPI.

Queue jumps are also beneficial in locations where buses have a downstream merge, a near-side stop in a pullout, or need to change lanes in advance of a left-turn.

IMPLEMENTATION GUIDE

CONSIDER ROADWAY AND BUILT ENVIRONMENT CONSTRAINTS: There are some characteristics that should be considered when implementing a queue bypass, which include bus stop location, queue jump lane length, pedestrian and nonmotorized usage at the intersection, right-turning vehicles, and throughput. Detailed information on implementation is included in Section 6.10 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"* and *"AASHTO's Guide for Geometric Design of Transit Facilities on Highways and Streets"*.

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QUEUE JUMP

GENERAL

LOCAL APPLICATION EXAMPLES

23rd Avenue E and E Madison Street, Seattle: A queue jump for southbound buses assists with downstream merge into a single lane. The queue jump lane is shared with right-turning traffic and a right-turn signal allows the right-turns to clear the lane prior to the bus queue jump.

Source: Metro, 2021

7th Avenue N and Harrison Street, Seattle: A queue jump was installed at the intersection for the northbound direction of travel. This queue jump allows buses to merge more easily approaching SR99 once they have served the near-side bus zone. This is important because the roadway quickly narrows from three lanes on 7th Avenue to a single on-ramp to northbound SR99.

Source: Metro, 2020

OPERATIONAL CONSIDERATIONS

Loop or video detection are preferred to activate the queue jump phase when a bus is present and ready to proceed through the intersection. TSP detection can be used although it cannot be considered completely reliable. Receiving lanes are preferred but not required. A right-side queue jump can operate as an overlap with the adjacent phase while a left-side queue jump should operate as its own phase. This is because operators have a better view of traffic approaching on their left.

COST CONSIDERATIONS

PLANNING AND COORDINATION

A traffic impacts analysis with modeling will help to understand the effect of the queue jump on intersection operations due to signal retiming. Operator training should be provided prior to queue jump activation.

CAPITAL COSTS

$15,000- $75,000 without ROW; $100,000 to $250,000 when combined with a queue bypass lane. Costs for signage are low, but construction and ROW acquisition costs could increase it. There could also be signal-related costs if other tools are used in combination with the queue jump lane, like a bus-only signal phase or TSP. Accessible pedestrian signals may be required. Older/smaller cabinets may need to be replaced to accommodate the queue jump phase and detection equipment.

MAINTENANCE COSTS

Low to moderate to maintain extra signs and pavement and any detection equipment.

BUS OPERATIONS COSTS

Bus travel time saving will increase as the intersection operates closer to capacity.

OTHER USER COSTS

There could be a small increase in average delay to adjacent traffic if phase is reduced to provide an early green for buses. There would likely be increased delay to right-turning traffic if right-turns are restricted to a protected right-turn phase only or if right-turns are relocated to another intersection.

BARRIERS AND SIDE EFFECTS

The need to provide a sufficient queue lane is a potential barrier to implementation. The space is often taken from general purpose traffic and/or could require ROW acquisition.

ALTERNATIVES AND COMPANION STRATEGIES

Queue jumps can be implemented in combination with bus stop relocations, movement restriction exemptions, right-turn restrictions, phase reservice, and TSP. A bus-only signal phase can support a queue jump and may be paired with transit signal faces. Red colored paint to indicate ‘bus only’ can also be used with queue jumps.

QUEUE JUMP
REVERSE

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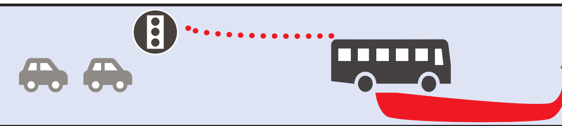
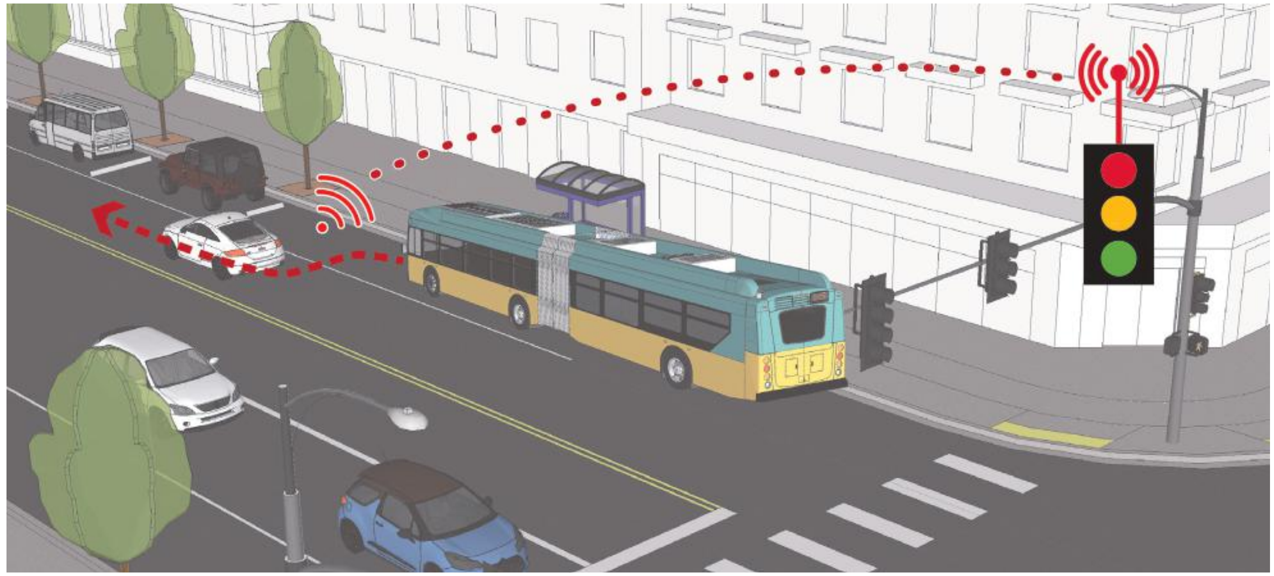


OVERVIEW OF STRATEGY

This tool includes communication between nearby signals and the bus to create gaps in traffic to expedite a difficult movement. For example, a bus turning left at an unsignalized intersection would trigger a call for a left-turn phase at a nearby downstream intersection to create a gap in traffic that the bus can use to turn left. This strategy may include a bus signaling an upstream intersection to turn red, creating a gap in traffic for a bus exiting an pull-out stop. Additional information is included in Section 6.6 of the *"TCRP Report 183- A Guidebook on Transit-Supportive Roadway Strategies"*.



BENEFITS

Delay and schedule variability can be reduced for buses by creating gaps in traffic for difficult merging or turn movements. The delay benefit to buses is site-specific but may be higher in high traffic volume.

OPERATIONAL CONSIDERATIONS

The reverse queue jump needs to respond quickly to a bus request to be useful. It may be necessary to configure pedestrian overlap phases so that pedestrian clearance does not need to be provided prior to the reverse queue jump phase. A yellow trap condition may need to be mitigated if there are permissive left-turns at the intersection.

IMPLEMENTATION GUIDE

EVALUATE POTENTIAL FOR OTHER SOLUTIONS: Other possible solutions could be considered before implementing a reverse queue jump for certain scenarios, such as when a left-turn movement at an unsignalized intersection is difficult. In these scenarios, the need for installing a traffic signal or pre-signal could be considered.

DEVELOP DESIGN PLANS: If reverse queue jump is selected for implementation, design plans will be needed to implement the needed infrastructure, such as the detection connection to the traffic signal.

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QUEUE JUMP

REVERSE

LOCAL APPLICATION EXAMPLES

Bothell Way NE and NE 153rd Street, Bothell: A loop installed at the end of the bus stop pullout activates a signal phase that stops northbound traffic on Bothell Way and creates a gap for the bus.

Source: Metro, 2021

24th Avenue NW and NW 61st Street, Seattle: Wireless magnetometers installed near the NB and SB bus stops activate the pedestrian signal when a bus is ready to leave the bus stop.

Source: Metro, 2021

COST CONSIDERATIONS

PLANNING AND COORDINATION

Moderate: A traffic impacts analysis could be needed to determine whether a reverse queue jump is the most appropriate strategy and what the impacts would be. If the strategy is determined to be feasible, design and signal timing plans would need to be developed for the detection connection to the downstream traffic signal.

CAPITAL COSTS

Up to $100,000: These costs are for implementing the infrastructure to detect the bus and communicate with the signal controller at the downstream or upstream traffic signal.

MAINTENANCE COSTS

There would be a small increase in costs related to the detection system, if new.

BUS OPERATIONS COSTS

There would be potential savings from reductions in traffic signal delay and improvements to travel time variability.

OTHER USER COSTS

Delay may increase for traffic stopped to accommodate the reverse queue jump. Prohibiting right-turns on red may increase delay for that movement.

BARRIERS AND SIDE EFFECTS

This strategy requires a nearby traffic signal to provide the needed phase to create a gap (e.g., a protected left-turn or all-red phase), the ability to prohibit right-turns on red from the cross street at that traffic signal, no or few driveways between the traffic signal and the unsignalized intersection, and a means of detecting buses. The ability to serve the left-turn phase or red light early may be constrained by the requirement to provide a minimum pedestrian crossing time on the crosswalk.

ALTERNATIVES AND COMPANION STRATEGIES

This strategy can be paired with a turn restriction to prevent vehicles turning right on red and filling the gap in traffic. This strategy can also be paired with TSP to serve the reverse queue jump phase sooner than usual.

5. CASE STUDIES

The following case studies describe the process of building a speed and reliability improvements in partnership between cities and Metro by walking through a successful project and referring to the steps identified in Section *"3. FRAMEWORK FOR PARTNERSHIP"*.

Kent Station
Source: King County Metro Photo Gallery, 2020

5.1 RENTON, KENT, AUBURN AREA MOBILITY PROJECT

5.1.1 FORMING PARTNERSHIP

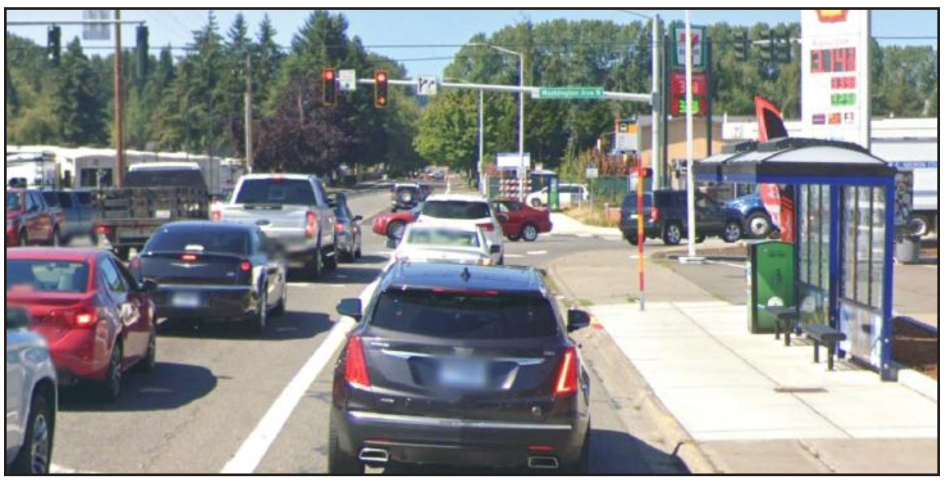
This case study describes a speed and reliability improvement project in the cities of Renton, Kent, and Auburn to support a Metro service network restructure led by service planners that went into effect in September 2020. The planning work to identify speed and reliability improvements project began in 2019 and was completed in June 2021.

WATCHING FOR OPPORTUNITIES

Renton Kent Auburn Area Mobility Project (RKAAMP) provided an opportunity to proactively identify new speed and reliability improvements while building partnership opportunities with the local agency staff and other stakeholders. The RKAAMP service network restructure was intended to improve transit connections and attract new riders to the transit network.

Initially, Metro capital planners began identifying potential improvements by analyzing and mapping bus delay data, collecting feedback from operators on the existing bus routes, and conducting coach tests on proposed new routes. While capital planners were developing initial concept plans, service planners were conducting the community outreach process on the proposed routing changes. Capital planners informed service planners on the feasibility of the roadway infrastructure to support proposed bus routing changes. Likewise, changes to the proposed bus network due to community and stakeholder feedback required changes to the associated set of speed and reliability improvements. This iterative process was important to ensure the list of projects carried forward to the implementation was relevant to the proposed service network restructure.

Kent Station
Source: King County Metro Photo Gallery, 2020



Washington Avenue N/W James Street, Kent, WA
Source: Google Maps, 2020

CONNECTING

An initial list of potential speed and reliability improvements was developed and shared with the local cities. Based on the cities' feedback and additional information provided, projects were evaluated and adjusted as needed. Some improvements were modified or removed from consideration as the proposed service network restructure was refined and finalized.

IDENTIFYING THE PROBLEM AND OPPORTUNITY

Metro and its consultant team led the development of conceptual plans and shared technical analysis with city partners to solicit their input. The consultants' findings and recommendations helped to inform further discussions with the cities to gain their support and approval of the proposed speed and reliability projects. Washington State Department of Transportation (WSDOT) was engaged in the discussion of projects located on state highways. Based on the outcome of the technical analysis, with support from cities and WSDOT, there were seven (7) RKAAMP projects carried forward to implementation.

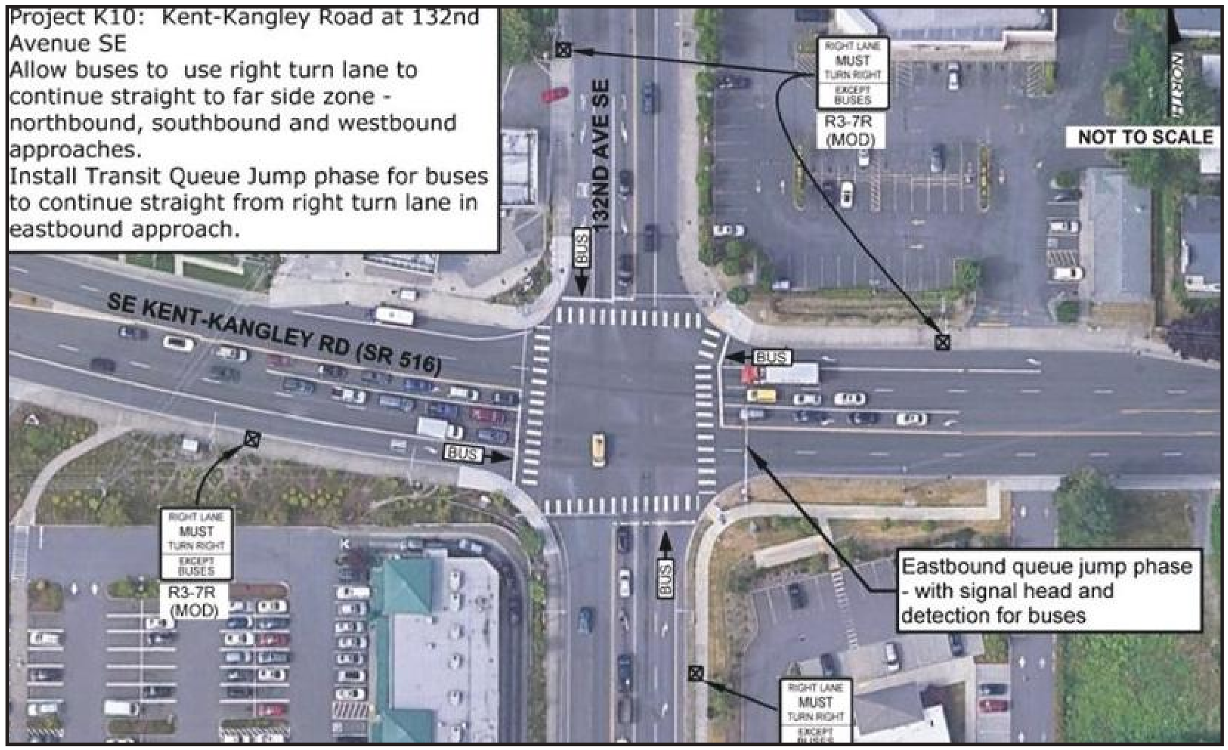
DEFINING THE PROJECT AND ITS BENEFITS AND TRADE-OFFS

Operating the RKAAMP's new and revised routes efficiently on city streets was the primary objective of this effort. In turn, these improvements would result in maintaining and/or improving transit service reliability. More predictable bus travel time will make buses more competitive in comparison to other modes. More people taking transit will lead to continued ridership growth.

5.1.2 TOOLS IMPLEMENTED

QUEUE JUMPS AND QUEUE BYPASS LANES

At one intersection in Kent, Kent-Kangley Road and 132nd Avenue NE, it was identified that buses could use right-turn lanes to bypass through traffic queues and access far side bus stops in pullouts in the northbound, southbound, and westbound directions. Allowing buses to make a through movement from these right-turn lanes could reduce delay at the intersection.



132nd Avenue SE/SE Kent-Kangley Road (SR 516) Improvements Diagram
Source: Diagram by Katherine Casseday Consulting, Aerial from Google Maps (2020)

In the eastbound direction, there is a near-side stop and it was identified that a queue jump signal would be required to allow buses to bypass through traffic queues.

The City of Kent and Metro jointly developed an implementation plan and clarified agencies' roles and responsibilities. Metro, through its contractor, would install roadway channelization and signage, and the City of Kent would install the traffic signal equipment and other related elements for the queue jump signal improvement.

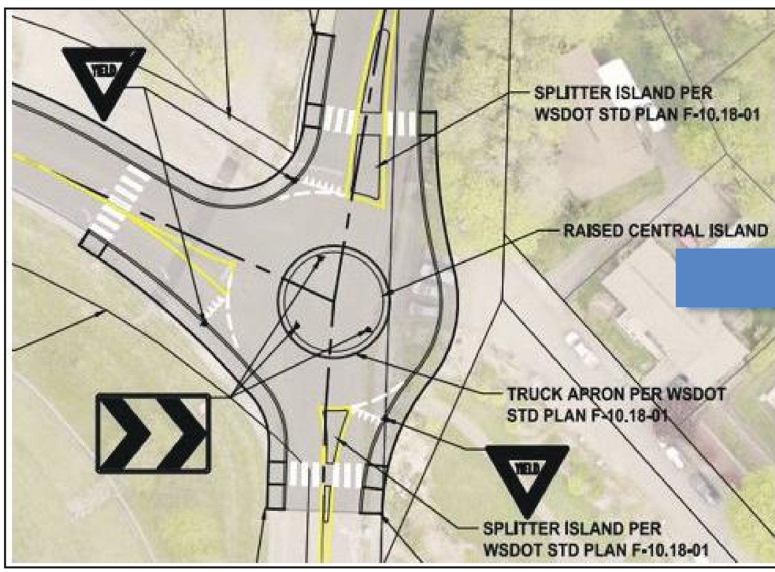
CHANNELIZATION AND SIGNAL IMPROVEMENTS

At several intersections in Renton, Kent, and Auburn, minor adjustments to channelization and traffic signal configuration were identified that could reduce delay to bus movements.

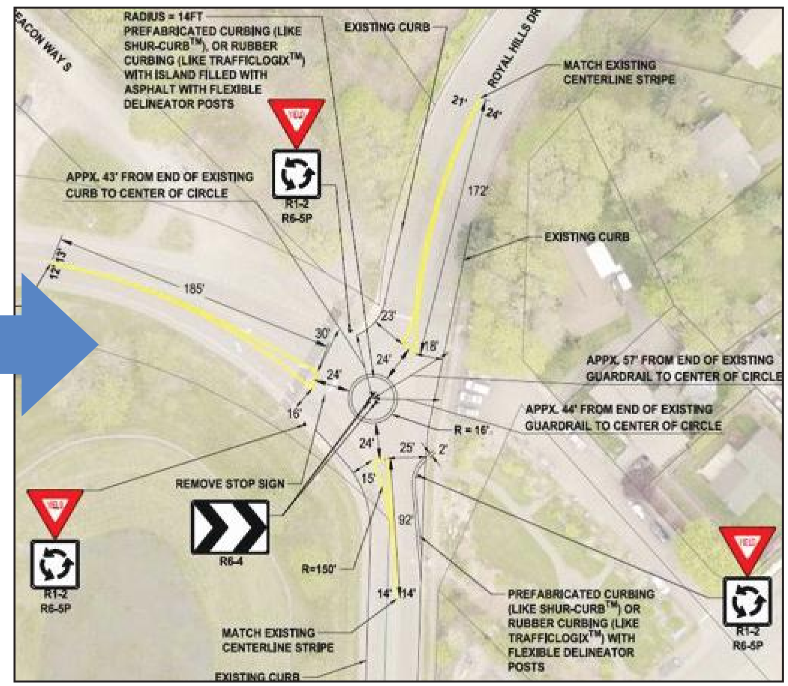
Metro, through its contractor installed signing and roadway channelization. For traffic signal modification, when new signal equipment was needed, Metro purchased the equipment and the cities installed it using in-house crews.

ROUNDABOUT IMPROVEMENT

At the intersection of S Puget Drive and Royal Hills Drive SE in Renton, an improvement was identified to convert a stop-controlled intersection into a mini roundabout with new crosswalks and upgraded curb ramps. With the new RKAAMP service, buses approach the intersection from all three directions; the roundabout would significantly reduce overall bus delay, reduce vehicle speeds, and improve the pedestrian environment. The City of Renton is planning to construct a full-featured roundabout with new sidewalks at this location when funding is available.



Original Design of Full Roundabout
Source: Diagram by Katherine Casseday Consulting, Aerial from Google Maps (2020)



[*Planned Improvement*]
Source: Diagram by Katherine Casseday Consulting, Aerial from Google Maps (2020)

In partnership with Metro, the City has agreed to support an interim roundabout using paint, signs, and rubberized curb for the center island. ADT on the busiest approach to the roundabout is around 9,500 with much of the traffic making turns, so a roundabout is an ideal treatment at this intersection.

FUNDING THE PROJECT

The RKAAMP project was funded with a combination of cities' in-kind services and local funds from Metro's Spot Improvements for Service Restructure program. In late 2020, one of Metro's Regional Mobility Grant projects came under budget, and with WSDOT approval, some of the RKAAMP project scope was added to the Metro Regional Mobility Grant (RMG) project.

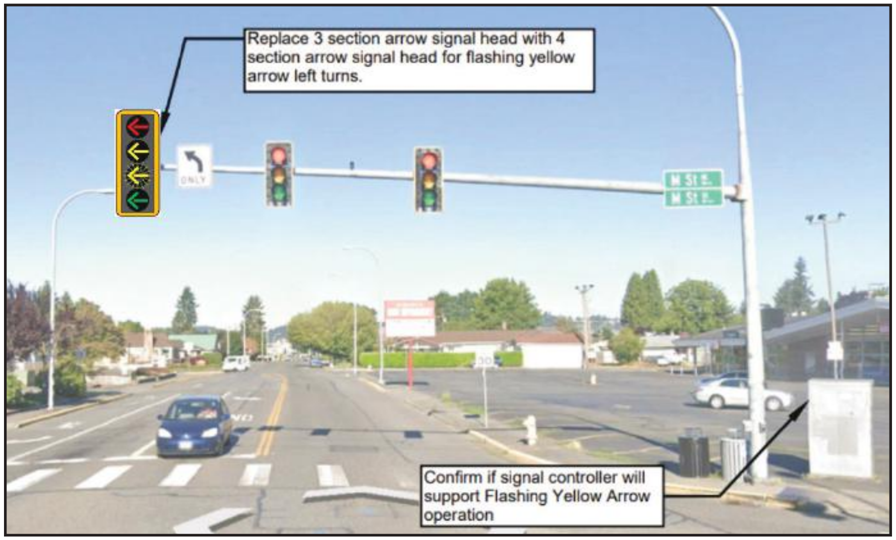
BUILDING THE PROJECT

Although, the original goal of the RKAAMP Speed and Reliability Project was to complete the improvements on or before the September 2020 service change, the COVID-19 pandemic and reduced city resources delayed the implementation, and many improvements could not be installed during winter weather conditions. Construction of these projects is targeted for completion by Summer 2021.

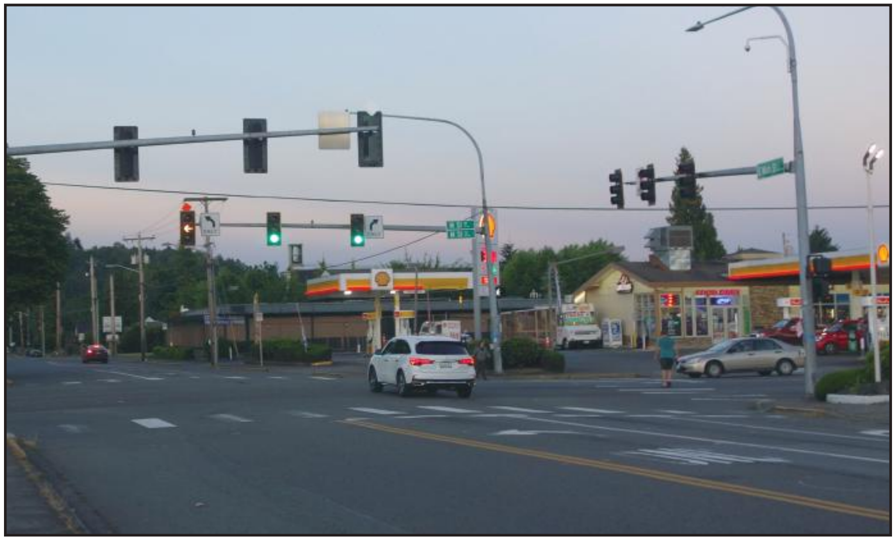
5.1.3 LESSONS LEARNED

Lessons learned from the RKAAMP project included:

- Smaller cities may have limited resources to help Metro design and implement transit speed and reliability projects.
- Creative delivery strategies can be used to help overcome resource limitations, for example for this project, Metro procured equipment while the city crews installed it.
- Close coordination with service planners was needed to help gauge risk of changes to bus route plans. Modification to conceptual plans may be required at the last minute when route planning changes; the risk of implementing these improvements prior to the finalizing the service routing needs to be clearly communicated to the service planners.



Main Street/M Street, Auburn, WA
Source: Diagram by Katherine Casseday Consulting, Aerial from Google Maps (2020)



Main Street/M Street, Auburn, WA (After)
Source: Metro, 2021

5.2 98TH AVENUE NE AND FORBES CREEK DRIVE QUEUE JUMP

5.2.1 FORMING PARTNERSHIP

This case study describes a spot improvement that was installed in the City of Kirkland, in coordination with a bike lane project led by the City.

WATCHING FOR OPPORTUNITIES

The City of Kirkland Transportation Master Plan was developed to set policy and help to prioritize future essential transportation projects in the City through 2035. The Plan contains a set of projects that will improve multi-modal transportation networks, including transit improvements. Metro, through its Spot Improvement program, identified areas where buses experienced congestion through an intersection or a midblock.

Both Metro and the City of Kirkland agreed to form a project partnership at 98th Avenue NE and Forbes Creek Drive. The City planned to implement bike lane improvements along the 98th Avenue corridor. Metro has previously identified the intersection of 98th Avenue NE and Forbes Creek Drive to be a bottleneck location. On 98th Avenue, there are three all-day bus routes operating northbound and southbound through the intersection: Routes 230, 231, 255.

In the morning, the southbound buses experienced delays approaching the intersection and often had to wait for the next signal cycle to pass through the intersection.

Both the City and Metro worked together to develop a short bus lane and transit queue jump signal concept that would accommodate the bike lane and reduce bus delays at the intersection. A queue jump could help buses merge out of the near-side bus stop and help to better manage the interaction between buses and bikes.

Source: King County Metro, Making small changes with big impacts on Forbes Creek Dr. (https://www.youtube.com/watch?app=desktop&v=kgmSRKyOGsA Youtube)

CONNECTING

Metro and the City connected early in the project to ensure that the bike lane could be designed to accommodate the proposed queue jump. After an initial informal agreement to proceed with the proposed partnership project, Metro and the City designated roles and responsibilities for each agency during implementation.

IDENTIFYING THE PROBLEM AND OPPORTUNITY

Due to the near-side stop location for the southbound bus stop, buses had difficulty re-entering the traffic stream. Prior to the project, buses would queue up when approaching the intersection and often missed the traffic light forcing them to wait for the second green light. The City wanted to improve bicycle connections in the area, so a combined bus and bike lane was designed on the southbound approach of the intersection.

DEFINING THE PROJECT AND ITS BENEFITS AND TRADE-OFFS

This partnership project benefits both bus riders and bicyclists. Bus riders on southbound Routes 230, 231, 255 benefit from reduced delay and improved reliability. Bicyclists benefit from having a dedicated/shared bus lane with less traffic, and improved connections to other nearby bikeways. Right-turn access into a small parking lot to the west of the intersection was preserved, since the right-turn traffic volume was small enough to not create interference with buses or cyclists.

98th Avenue NE and Forbes Creek Drive (Before)
Source: Google Maps, 2018

98th Avenue NE and Forbes Creek Drive (After)
Source: Metro, 2020

5.2.2 TOOLS IMPLEMENTED

QUEUE JUMPS AND QUEUE BYPASS LANES

A 950-foot long bus and bike lane was installed approaching the Forbes Creek Drive intersection, and appropriate signage as well as red paint was installed. Through the intersection, green paint was installed to highlight the area where bikes mix with or cross other traffic. A queue jump signal, triggered by video detection, was installed at the traffic signal to give buses an advance green light through the intersection.

FUNDING THE PROJECT

The City of Kirkland funded most of the improvements, including the signage, roadway paint, and traffic signal labor. Metro's contribution to the project was through purchasing traffic signal equipment needed for the queue jump signal.

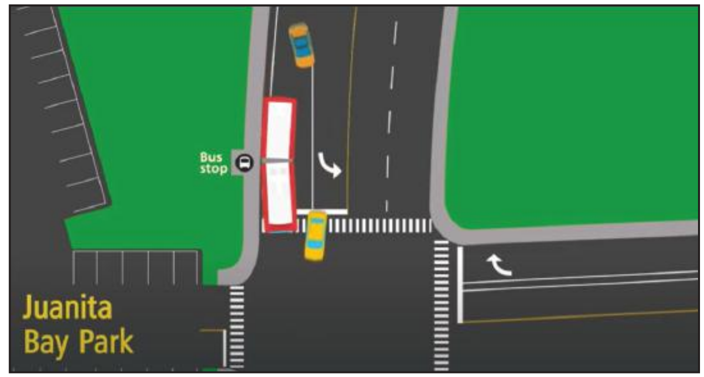
BUILDING THE PROJECT

The improvements were installed by the City of Kirkland in 2019. [A short promotional video] was developed by Metro to highlight this project and its benefits (screen shots below).

5.2.3 LESSONS LEARNED

Lessons learned from the 98th Avenue NE and Forbes Creek Drive Queue Jump included:

- Early coordination allowed the project design to accommodate bus and bike needs from the start; no significant design modifications needed.
- Timing this transit improvement with a City-led project saved considerable cost and effort.



Source: King County Metro, Making small changes with big impacts on Forbes Creek Dr. (https://www.youtube.com/watch?app=desktop&v=kgmSRKyOGsA Youtube)

6. REFERENCE DOCUMENTS

1	**AASHTO'S GUIDE FOR GEOMETRIC DESIGN OF TRANSIT FACILITIES ON HIGHWAYS AND STREETS** *https://trid.trb.org/view/1320922*
2	**KING COUNTY METRO TRANSIT 2019 RIDER AND NON-RIDER SURVEY** *March 2020, https://www.kingcounty.gov/~/media/depts/metro/accountability/reports/2019/2019-rider-non-rider-survey-final.pdf*
3	**KING COUNTY METRO, BUS STOPS ALONG BIKEWAYS GUIDELINES** *prepared by Transit Route Facilities, estimated publish date: August 2021.*
4	**KING COUNTY METRO, METRO CONNECTS: LONG RANGE TRANSIT PLAN** *2017, Update in Summer 2021, http://www.kcmetrovision.org/*
5	**KING COUNTY METRO, MOBILITY FRAMEWORK** *2019, Update in Summer 2021, https://kingcounty.gov/depts/transportation/metro/about/planning/mobility-framework.aspx*
6	**KING COUNTY METRO'S STRATEGIC PLAN** *2017, Update in Summer 2021, https://kingcounty.gov/depts/transportation/metro/about/planning/strategic-plan.aspx*
7	**KING COUNTY METRO TSP POLICY & STRATEGIES** *2021, https://kingcounty.gov/depts/transportation/metro/about/accountability-center/other-reports*
8	**KING COUNTY METRO, TRANSIT ROUTE FACILITIES GUIDELINES** *2018, https://kingcounty.gov/~/media/depts/transportation/metro/about/planning/pdf/2011-21/2018/transit-facilities-guidelines.pdf*
9	**THE CITY OF KIRKLAND TRANSIT IMPLEMENTATION PLAN** *March 2019, https://www.kirklandwa.gov/files/sharedassets/public/public-works/kirkland-transit-implementation-plan-final.pdf*
10	**CITY OF KENT TRANSPORTATION MASTER PLAN** *June 2020, https://www.kentwa.gov/home/showpublisheddocument?id=15900*
11	**NATIONAL ASSOCIATION OF CITY TRANSPORTATION OFFICIALS (NACTO) TRANSIT STREET DESIGN GUIDE** *2013, https://nacto.org/publication/transit-street-design-guide/*
12	**THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD)** *https://mutcd.fhwa.dot.gov/*
12	**TCRP RESEARCH REPORT 215 - MINUTES MATTER: A BUS TRANSIT SERVICE RELIABILITY GUIDEBOOK** *http://www.trb.org/Main/Blurbs/180325.aspx*
13	**TCRP REPORT 183- A GUIDEBOOK ON TRANSIT-SUPPORTIVE ROADWAY STRATEGIES** *http://www.trb.org/Main/Blurbs/173932.aspx*