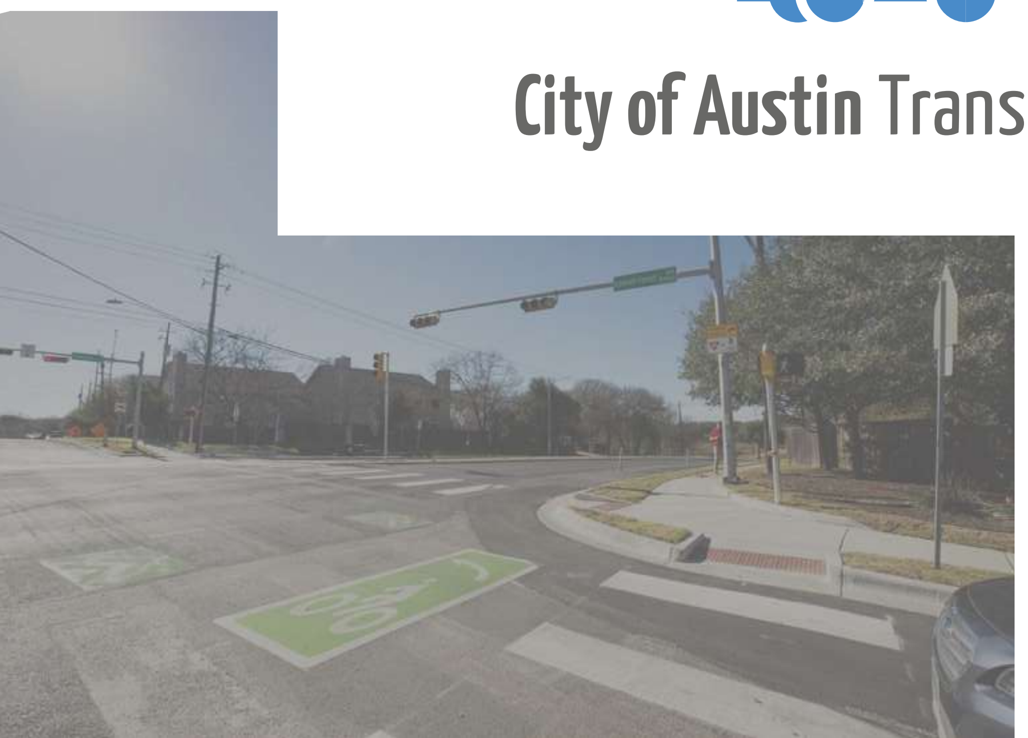
austin MOBILITY BONDS

City of Austin Transit Enhancement Toolbox



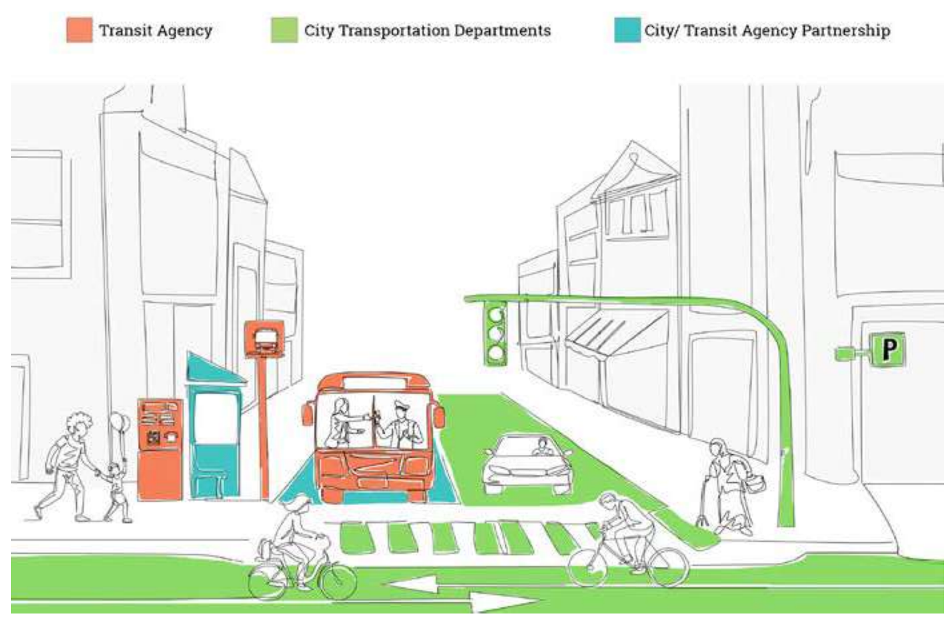
INTRODUCTION

Austin Transportation and Public Works' Transit Enhancement Program works to improve mobility and access to opportunity by enhancing areas of the built environment to support transit riders and transit operations. This Transit Enhancement Toolbox is a collection of potential capital and operational treatments that can be applied in Austin to improve transit speed, reliability and access, and create safer, more predictable interactions between transit and other travel modes.

The toolbox was developed for Transportation and Public Works (TPW) in partnership with CapMetro and Austin Transit Partnership staff and includes 32 tools across four categories ranging from low-cost, minor capital improvements to high-dollar, major infrastructure improvements. The toolbox is intended to serve as a resource for both agency staff and the community, and not only identifies the tools available to improve transit performance, safety and access in Austin, but informs stakeholders about the benefits, trade-offs, and considerations required to implement these tools across the city.

TOOLBOX APPLICATION & STAKEHOLDER COORDINATION

Implementation of the tools outlined in this toolbox requires coordination between agencies and stakeholders, including the City of Austin or the relevant roadway authority, CapMetro or the relevant transit provider, and potential other stakeholders, including area businesses, residents, and elected officials. This coordination is required to get the full benefit of these tools that involve both the roadways and transit service that operates on them. Not all tools will be applicable for all locations, and implementing particular tools may involve trade-offs in the public right-of-way. Before using the toolbox for a project, TPW's Transit Enhancement Program and CapMetro will work together to identify the issues and opportunities at a particular project location, and determine the appropriateness and impact of applying a particular tool at that location, before moving forward with project design.



Source: National Association of City Transportation Officials. Move! That! Bus!

TOOLBOX ORGANIZATION

TOOLS | STREETS AND INTERSECTIONS | STATIONS AND STOPS | ACCESS AND MULTIMODAL INTERACTIONS | TRAFFIC SIGNALS AND OPERATIONS

The 32 tools in the Transit Enhancement Toolbox are grouped into four categories, and each individual tool in that category is covered in a one-pager within the body of this document. More details about the organization of the toolbox, including the summary matrix that provides a snapshot of all 32 tools, can be found below.

SUMMARY MATRIX

A summary matrix of all 32 tools in the toolbox is included on pages 3 and 4. The summary matrix provides an overview of:

- The name of each tool
- The category to which that tool belongs
- The tool's effectiveness at addressing particular challenges
- The tool's cost

This matrix can be used to quickly identify which tools may be most appropriate to improve transit service at a particular location.

TOOL ONE-PAGERS

One-pagers provide an overview of each individual tool, including expected benefits, operational considerations, implementation criteria, related strategies, cost magnitude, and cost considerations.

TOOL CATEGORIES

For ease of navigation, tools are grouped into four categories:

- Streets and Intersections
- Stations and Stops
- Access and Multimodal Interactions
- Traffic Signals and Operations

Each category includes a table of contents, and individual tools within each category are organized in ascending order from least to most capital intensive. Tools may be applied individually or in combination with other tools; see the related strategies section within each tool one-pager for more information.

COST CONSIDERATIONS

The estimated cost ($-$$$$) of each tool includes expenses incurred from project development to construction. Details on the cost magnitudes can be found in the cost considerations section of each tool's one-pager. Actual costs may vary based on the site conditions at each project location.

CHALLENGES	INTERSECTION	CORRIDOR	SIGNAL	RIGHT TURN	LEFT TURN	OTHER TRAFFIC RELATED	INEFFICIENT ROUTE DESIGN	INTERRUPTIONS LEAVING BUS STOP	BUS ZONE DWELL TIME	BUS STOP CAPACITY	PEDESTRIAN CONFLICTS	CYCLIST CONFLICTS	MOTORIST CONFLICTS	
STRATEGY	CONGESTION		TRAFFIC OPERATIONS				TRANSIT OPERATIONS				SAFETY			COST
STREET AND INTERSECTION DESIGN														
Turn Restriction/Exemption	●		●	●●	●●	●	●	●			●	●	●	$-$$
Facilitating Turning Movements				●●	●●	●●					●			$-$$
Roadway Channelization and Turn Pockets	●		●	●●	●●		●				●	●	●	$-$$
Transit Priority Lane (Bus Lane)	●●	●●	●●●	●●		●		●●			●●	●●●	●	$$-$$$$
Queue Jump Lane (Short Bus Lane)	●●●	●●		●●	●●	●●	●●	●●			●	●		$-$$$
Peak-Only Bus Lane	●●	●●	●●					●●		●●		●●	●●	$-$$$
Curbside Bus Lane	●●●	●●●	●●●	●●●				●●		●●		●	●●	$$-$$$$
Offset Bus Lane	●●●	●●●	●●●	●●				●●					●	$$-$$$$
Contraflow Bus Lane	●●●	●●●		●●●	●●●	●●●		●●●				●	●●	$$-$$$$
Reversible / Bidirectional Bus Lane	●●●	●●				●●●		●●●			●●●		●●	$$-$$$$
Median Bus Lane	●	●●●				●●●		●●●		●●	●●●	●●●	●●●	$$-$$$$
STATIONS AND STOPS														
Pull-Out Stop													●	$-$$
Level Boarding									●●●					$-$$
Bus Stop Lengthening							●	●	●	●●●				$-$$
Parking Removal or Alterations		●●						●●		●			●●	$-$$
Bus Stop Consolidation	●						●●●	●	●	●				$-$$
In-Lane Stop								●●●			●●	●●		$$-$$$
Far-Side Bus Stop			●●								●●●		●	$-$$$
Near-Side Stop											●●			$-$$$
Midblock Stop			●●								●●			$-$$$

● Low Benefit
●● Medium Benefit
●●● High Benefit

$: Under $50,000
$$: $50,000-$100,000
$$$: $100,000-$250,000
$$$$: Over $250,000

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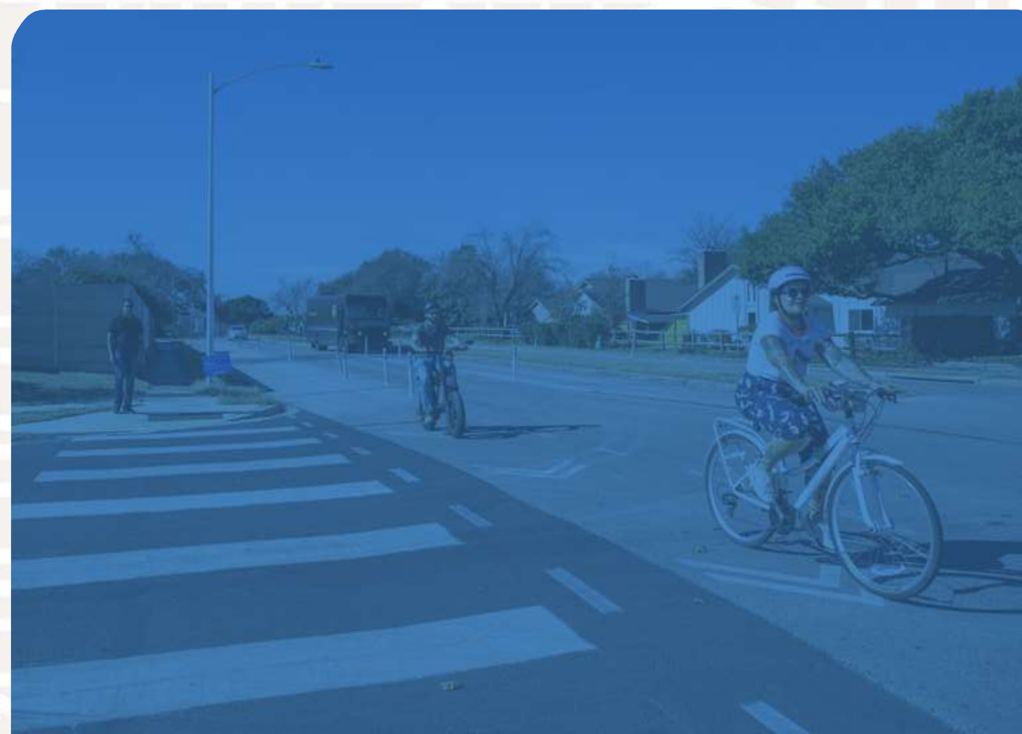
CHALLENGES	INTERSECTION	CORRIDOR	SIGNAL	RIGHT TURN	LEFT TURN	OTHER TRAFFIC RELATED	INEFFICIENT ROUTE DESIGN	INTERRUPTIONS LEAVING BUS STOP	BUS ZONE DWELL TIME	BUS STOP CAPACITY	PEDESTRIAN CONFLICTS	CYCLIST CONFLICTS	MOTORIST CONFLICTS	
STRATEGY	CONGESTION		TRAFFIC OPERATIONS				TRANSIT OPERATIONS				SAFETY			COST
ACCESS AND MULTIMODAL INTEGRATION														
Dedicated Bike Signal	●	●	●	●	●			●●●				●●●		$-$$
Shared Bus-Bike Lane								●●		●		●	●	$-$$
Shared Cycle Track Stop								●●●				●●		$$-$$$
Floating Stop								●●●				●●		$$-$$$
Access Improvements								●●			●●●	●●●		
Bicycle Improvements								●●				●●●		
TRAFFIC SIGNALS AND OPERATIONS														
Traffic Signal Timing Adjustments	●●	●	●●	●	●			●			●	●	●	$-$$
Traffic Signal Phase Modification	●●	●	●	●		●●		●			●	●	●	$-$$
Transit Signal Priority	●●		●●●	●●●	●●●	●●●		●						$-$$$
Bus Signal Phase and Signal Head	●●●		●●●	●●●	●●●			●●			●●●	●●	●●	$-$$$
Reverse Queue Jump	●●	●●			●●			●●					●●	$-$$$
Transit Agency Tools							●●●	●●●	●●●	●●●				

STREET AND INTERSECTION DESIGN



TURN RESTRICTION / EXEMPTION

COST: $ – $$

OVERVIEW:

Turn restriction or turn exemption allows buses to make a movement at an intersection that is prohibited for general purpose traffic.

BENEFITS:

- Allowing buses to make movements that are restricted for other vehicles can allow for more direct bus routing that can save transit travel time

OPERATIONAL CONSIDERATIONS:

- May support contraflow bus transit and/or bicycle lanes
- May be enhanced with dedicated signal phasing and/or transit signal priority
- Design needs to include signing and striping to discourage vehicles from making the restricted movement
- Design may require traffic diversion features (e.g., curbs, median islands) to physically prevent restricted movement.
- Turn restrictions/exemptions can be in effect all day or during certain hours. Exemptions can also be extended to bikes

IMPLEMENTATION CRITERIA:

- A traffic analysis may be needed to understand the impact of the proposed turn restriction/exemption on both transit and general purpose traffic
- If general purpose turns are restricted, identify alternate routing options
- Can be applied to either through lanes or turning lanes

RELATED STRATEGIES:

- Reverse queue jump
- Bus signal phase
- Transit signal priority

COST CONSIDERATIONS:

- Costs depend on location and range from new signage to pavement marking modifications, signal head modifications, and medians

FACILITATING TURNING MOVEMENTS

COST: $ – $$

OVERVIEW:

This treatment involves modifying intersection geometry or roadway markings to facilitate smoother and safer turn movements for buses. Treatments may include the implementation of "smart right" designs, corner radius modifications, mountable aprons, parking modifications, striping changes, and/or pulling back stop bars to making turning movements easier for buses and reduce transit delay.

BENEFITS:

- Improvements that facilitate bus turns can improve transit travel times, and can also improve safety if buses were encroaching into adjacent/oncoming travel lanes or riding over the curb in order to execute a turn

OPERATIONAL CONSIDERATIONS:

- Front-mounted bicycle racks should be considered when analyzing the turn movement to determine the appropriate design
- Signal timing for pedestrian crossing may need to be altered to account for changes to the pedestrian crossing distance
- Design phase should include an auto-turn analysis using the appropriate design vehicle, and a field test may be needed before finalizing recommendations

IMPLEMENTATION CRITERIA:

- The appropriate treatment option will be site specific and could include a minor restriping or parking modification, or a more substantial corner modification
- Mountable aprons should be designed to discourage pedestrian or bicycle refuge. Additionally, on-board bus rider comfort should be considered when developing mountable apron profiles

RELATED STRATEGIES:

- Parking removal/alteration
- Channelization and turn pockets

COST CONSIDERATIONS:

- Costs for pavement markings will be lower while curb and apron construction increases costs, especially if right-of-way acquisition is needed

"Smart right" turn on N Lamar Boulevard at W 29th Street, Austin, TX
Source: Google Street View

ROADWAY CHANNELIZATION AND TURN POCKETS

COST: $ – $$

OVERVIEW:

Roadway channelization is the design of traffic lanes in a way that provides definite paths for vehicles to follow through an intersection. Channelization to support bus operations could include adding left/right turn pockets at intersections with high turn volumes that conflict with bus operations and contribute to transit delay.

BENEFITS:

- Channelization improvements can improve transit travel speeds by clarifying lane operations and reducing delay associated with turning movements
- Adding right or left turn lanes provides roadway space for turning vehicles that would otherwise impede transit

OPERATIONAL CONSIDERATIONS:

- When implemented in coordination with a transit lane, turning vehicles must still cross the transit lane, which can cause delays depending on turn volumes
- May lengthen pedestrian crossing distance
- May require the removal/modification of bicycle lanes, median, parking spaces, or other facilities
- May benefit from the use of raised medians and other vertical elements to direct traffic flow and minimize conflicts

IMPLEMENTATION CRITERIA:

- Identify locations where turning movements cause delay to transit operations and determine if channelization would address the concern
- Implementation may be limited by the availability of roadway space and tradeoffs for other roadway users.

RELATED STRATEGIES:

- Parking removal/alteration
- Facilitating turn movements

COST CONSIDERATIONS:

- Capital costs include new signage and re-striping the roadway, and may include curb modifications
- Adding turn pockets within existing curb lines can sometimes be achieved by relocating bike lanes from in-street to behind-curb facilities, which may require constructing bike lanes or shared-use paths behind curb.

Right turn pocket on 7th Street at I-35 (Austin, TX) separates right turning vehicles from through moving buses

TRANSIT PRIORITY LANE (BUS LANE)

COST: $ – $$$

OVERVIEW:

"Transit priority lane" is the term of art used in Austin for a bus lane. It is a general, catch-all term to describe a roadway lane that is dedicated exclusively or primarily for the use of buses. A transit priority lane can operate full-time or during peak periods only, can be a few hundred feet or multiple miles long, and can be configured in a variety of ways (e.g., directly against the curb, offset from the curb, in the center of the roadway, etc.) depending on transit's needs and the context of the lane within the larger transportation network. Pages 10-16 of this toolbox provide more details regarding the specific types of transit priority lanes (bus lanes) that can be implemented to improve transit operations in Austin.

BENEFITS:

- A transit priority lane can improve bus travel times and service reliability. The magnitude of the improvement will depend on a variety of factors including the level of congestion that existed on the roadway prior to the implementation of the lane, enforcement of illegal parking and other activities in the lane, and whether or not general purpose vehicles are allowed to enter the lane to execute turns
- Traffic analysis may be needed during the design phase to understand the expected transit speed and reliability benefits as well as the anticipated impacts to other roadway users

OPERATIONAL CONSIDERATIONS:

- Operational considerations vary by bus lane type and are discussed in more detail on subsequent pages
- A lane width of 11 feet is generally desired for bus operations. Bus lane widths of less than 11 feet may be warranted depending on the context and following coordination between the City of Austin and the relevant transit provider

IMPLEMENTATION CRITERIA:

- Transit operating characteristics (i.e., bus frequency, bus turn movements, bus stop locations, etc.), the operations of other roadway users (i.e., traffic volumes, turn demand, availability of alternate routes, etc.), and the magnitude, location and source of bus delay should all be considered when determining whether (and what kind of) a bus lane should be implemented

RELATED STRATEGIES:

- Curb management
- Transit signal priority
- Intersection queue jump

COST CONSIDERATIONS:

- Costs can vary widely by bus lane type

Guadalupe Street in Austin, TX

QUEUE JUMP LANE (SHORT BUS LANE)

COST: $ – $$$

OVERVIEW:

Queue jump lanes are relatively short bus lanes that combine dedicated transit facilities with either a leading/lagging bus phase or active signal priority to allow buses to bypass traffic queues and enter traffic flow in a priority position. Queue jump lanes can reduce delay considerably, resulting in transit travel time savings and improved service reliability.

BENEFITS:

- Can significantly improve bus operations by routing buses past traffic congestion approaching an intersection, but the magnitude of the benefit will depend on how much delay, and how consistently that delay, is experienced at a particular bottleneck

OPERATIONAL CONSIDERATIONS:

- Can be implemented in coordination with near-side or far-side bus stops, or in non-stop conditions
- Can be implemented in a shared transit/turn lane if turn volumes are low enough that they don't impede the ability of buses to bypass the queue
- Bus-only phase can be concurrent with pedestrian signal phase to promote safety

RELATED STRATEGIES:

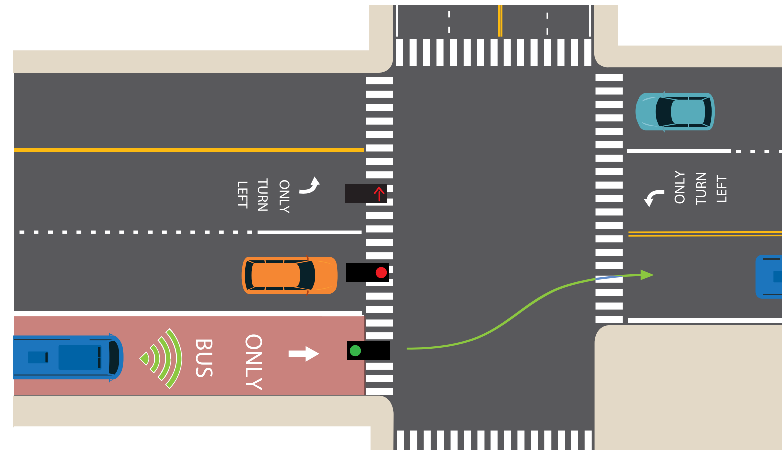
- Parking removal/alterations
- Transit signal priority
- Pre-signals
- Bus signal head

IMPLEMENTATION CRITERIA:

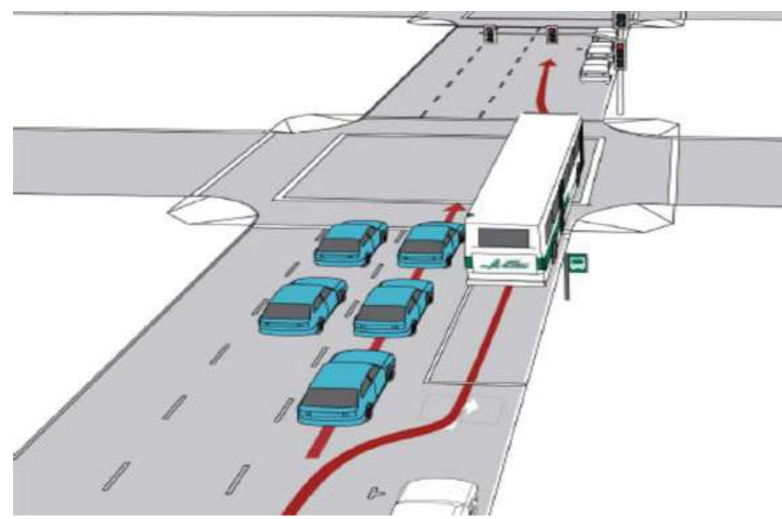
- Separate signal heads must be used to differentiate when transit can proceed from when general traffic can proceed
- Queue jump lane must be long enough that buses can consistently access the lane and reach the front of the queue at the beginning of the signal cycle

COST CONSIDERATIONS:

- Low to moderate cost when using existing right turn lane or removing parking
- Higher cost when curb modifications or ROW acquisition is required to accommodate the lane



Source: Maryland DOT Transit Priority Toolkit



Source: AC Transit

PEAK-ONLY BUS LANE

COST: $ – $$$

OVERVIEW:

A peak-only bus lane operates as a dedicated bus lane during peak travel periods and serves other curbside uses, such as parking or deliveries, at other times of day. This treatment allows transit to take precedence during peak hours when a bus lane is most beneficial to transit operations, while accommodating necessary goods movement and curb access at other times of day.

BENEFITS:

- Provides large boost to transit operations at critical times, substantially improving both service reliability and transit travel times
- Balances competing needs by allowing stationary uses such as parking, freight loading, and street vending during non-peak periods

OPERATIONAL CONSIDERATIONS:

- Generally appropriate on streets with high peak-period bus volumes and high peak-period traffic, plus curbside parking, loading or other flexible uses that can be relocated at certain times of day
- May require additional enforcement to preserve transit operations during peak hours, including towing of vehicles parked in the bus lane during bus-only hours
- May preclude the installation of curb extensions at intersections

IMPLEMENTATION CRITERIA:

- Signage must clearly indicate the lane restriction, the hours of operation, and the times that parking, delivery or vending is prohibited
- Pavement markings must indicate the lane is dedicated to transit

RELATED STRATEGIES:

- Curb management
- Transit signal priority
- Parking removal/alterations

COST CONSIDERATIONS:

- Capital costs include new signage and striping (less expensive), and may include curb modifications (more expensive)

Wilshire Blvd in Los Angeles, CA
Source: NACTO Transit Street Design Guide

CURBSIDE BUS LANE

COST: $$ – $$$$

OVERVIEW:

A curbside bus lane is a travel lane adjacent to the curb that is dedicated exclusively or primarily for the use of buses. Curbside bus lanes can be designed with varying levels of separation from other modes, increasing transit performance and capacity as the level of separation increases.

BENEFITS:

- Can improve bus travel times and service reliability
- Helps raise the visibility of the high-quality transit service

OPERATIONAL CONSIDERATIONS:

- Lanes can be subject to encroachment by deliveries, illegal parking, passenger loading, or other curbside activities; enforcement is needed
- Can be designed to allow general purpose right turn access to driveways and intersections, but transit travel time benefits will degrade as right turn volumes increase beyond 150 vehicles per hour.

IMPLEMENTATION CRITERIA:

- Generally appropriate on streets with relatively high bus volumes where transit vehicles and riders are regularly subject to delay
- Pavement markings (red paint optional) and signage (e.g., "Right Turn Only Except Bus") must indicate the lane is dedicated exclusively or primarily to transit
- Appropriate on streets with no curbside parking or where parking removal is acceptable

RELATED STRATEGIES:

- Parking removal/alterations
- Transit signal priority
- Bus only signal phase

COST CONSIDERATIONS:

- Capital costs include new signage and striping (less expensive), and may include pavement upgrades, curb modifications and/or signal adjustments (more expensive).

East Riverside Drive, Austin, TX

OFFSET BUS LANE

COST: $$ – $$$$

OVERVIEW:

An offset bus lane is a travel lane that is dedicated primarily for the use of buses and is typically located to the left of a curbside travel lane. This type of bus lane is often used to preserve curb space for other uses, such as parking, deliveries, bicycle lanes, or right-turning traffic.

BENEFITS:

- Can improve bus travel times and service reliability while preserving curbside space for other uses like bike lanes, deliveries, parking, or turn lanes

OPERATIONAL CONSIDERATIONS:

- Special consideration must be given to bus stop access and design, and may require restricting curbside uses at bus stops so buses can pull to the curb, or bulbing out the curb so buses can stop in the bus lane
- Turning movements must be carefully managed to minimize conflicts with pedestrians, bicyclists, and other vehicles
- Buses in offset bus lanes may face increased conflicts with vehicles pulling in and out of the curbside lane, or with double-parked or improperly parked vehicles; proper design and enforcement is important for optimal function of offset lanes

IMPLEMENTATION CRITERIA:

- Pavement markings (red paint optional) and signage (e.g., "Right Turn Only Except Bus") must indicate the lane is dedicated primarily for transit
- Generally appropriate on high-activity corridors that have both relatively high bus volumes where transit vehicles and riders are regularly subject to delay, and relatively high demand for curbside uses that cannot be removed

RELATED STRATEGIES:

- Transit signal priority
- Turn restrictions
- In-lane stop
- Floating stop

COST CONSIDERATIONS:

- Offset bus lanes may require higher capital and maintenance costs than curbside bus lanes due to potential need for bus stop reconstruction, overhead signs and more painting/striping to delineate uses

Source: Google Street View
Lavaca St at 10th Street, Austin, TX

CONTRAFLOW BUS LANE

COST: $$ – $$$

OVERVIEW:

A contraflow bus lane is a travel lane for buses that operates in the opposing direction of normal traffic flow on a one-way street. Contraflow bus lanes are typically used to create strategic, efficient connections for buses along a route, but may also be applied to longer roadway segments to take advantage of available capacity in the opposite direction of travel.

BENEFITS:

- Contraflow bus lanes can enable buses to follow a more direct route than would otherwise be possible on a one-way street grid, and can allow buses to avoid traffic congestion in the general traffic lanes

OPERATIONAL CONSIDERATIONS:

- Contraflow bus lane designs require careful consideration of signage and striping so pedestrians, cyclists, and drivers are aware of the potential presence of a bus approaching from an otherwise unexpected direction; dynamic signs at traffic signals may be warranted when extra attention is needed
- Adding additional traffic signal phases to accommodate the contraflow movement may impact the efficiency of the signal system

IMPLEMENTATION CRITERIA:

- Traffic signal infrastructure and signal phasing must be updated to reflect two-way traffic operations
- Pavement markings (red paint recommended) and signage (e.g., “One Way, Do Not Enter Except Buses”) must indicate the lane is dedicated to transit
- A double-yellow centerline marking with optional vertical elements (e.g., delinators) should be applied to separate contraflow bus traffic from opposing traffic

RELATED STRATEGIES:

- Transit signal priority
- Turn restrictions
- Bus signal heads

COST CONSIDERATIONS:

- Contraflow bus lanes may require higher capital and maintenance costs than curbside bus lanes due to the need for additional signal infrastructure and robust signage and striping

Source: Guadalupe Contraflow Fact Sheet, City of Austin

REVERSIBLE / BIDIRECTIONAL BUS LANE

COST: $$ – $$$$

OVERVIEW:

A reversible or bidirectional bus lane is a single travel lane dedicated exclusively to buses that allows transit to travel in either direction through a constrained section of roadway.

BENEFITS:

- Reversible or bidirectional bus lanes can improve bus travel times and service reliability by dedicating a single lane to transit in locations where site constraints prevent the use of separate lanes for each direction of bus travel

OPERATIONAL CONSIDERATIONS:

- A bidirectional, single-lane operation that continuously alternates based on the direction of the approaching bus will accommodate fewer buses per hour than other bus lane types and should only be considered for short segments of roadway, or be implemented where buses operate at low volumes.
- A reversible, single-lane operation that accommodates one direction of bus travel based on the time of day (e.g., northbound in the morning peak, southbound in the evening peak) is most effectively used when there is a significant and distinct difference in traffic volumes by direction and time of day
- Reversible/bidirectional bus lanes are typically more expensive to construct than other types of bus lanes due to the signal system required to control bus access

IMPLEMENTATION CRITERIA:

- Signal system must have block control capabilities that "check-in" and "check-out" buses from the lane to ensure that only buses traveling in the same direction occupy the lane at the same time

RELATED STRATEGIES:

- Transit signal priority
- Turn restrictions
- Bus signal heads

COST CONSIDERATIONS:

- Reversible/bidirectional bus lanes are typically more expensive than other bus lanes due to the signal system required to control bus access1[1]

Emerald Express (EmX) Bus Rapid Transit, Eugene, OR

1 King County Metro Speed Reliability Toolbox

MEDIAN BUS LANE

COST: $$ – $$$

OVERVIEW:

A median bus lane is a travel lane for buses that's located in the center of a multi-lane roadway. This treatment removes conflicts with parking, deliveries, bicycles, right turning vehicles, and other typical curb-side activities.

BENEFITS:

- Median bus lanes can significantly improve bus travel times and service reliability by removing most potential sources of bus delay other than traffic signal-related delays

OPERATIONAL CONSIDERATIONS:

- Should be painted red to distinguish median bus lanes from adjacent general purpose travel lanes; physical separation through the use of barriers (e.g., rumble strips, curbs, etc.) can be considered to reduce encroachment from other vehicles
- Transit performance can be impacted by the signal phasing, especially when vehicle left turn lanes are to the right of the median bus lane and cannot run at the same time due to conflicting paths

RELATED STRATEGIES:

- Transit signal priority
- Turn restrictions

IMPLEMENTATION CRITERIA:

- Typically implemented on major transit corridors with high frequency, heavy delay, and high ridership
- Requires installation of median boarding island bus stops that are fully accessible and connected to a safe, controlled crossing of the roadway
- Installation should be coordinated with land use changes that maximize economic growth potential; setback guidelines and other land use regulations should be tailored to create a more inviting pedestrian environment
- Minimum median bus lane width is 11'

COST CONSIDERATIONS:

- Median bus lanes may require higher capital and maintenance costs than curbside bus lanes due to need for overhead signs, potential roadway reconstruction, and stops in the roadway median

Source: NACTO

Source: NACTO

STATIONS AND STOPS

PULL-OUT BUS STOP

COST: $ – $$

OVERVIEW:

Pull-out bus stops require buses to pull out of the flow of traffic to pick up and drop off passengers from the curb, prioritizing through-moving traffic flow at stop locations

BENEFITS:

- Allows transit to board and deboard passengers in locations where in-lane stops would be problematic, such as high-volume single lane roadways, timepoints or other stop locations with long dwell times
- Can assist operations of rapid or limited stop routes along a roadway shared with local stop transit service

OPERATIONAL CONSIDERATIONS:

- Contingent on available space to accommodate buses pulling fully out of the travel lane and accessing the curb without obstruction before pulling back out
- Buses may have significant difficulty re-entering the traffic stream; a queue jump signal can be considered to facilitate bus merging
- Buses take longer to serve pull-out stops compared to in-lane stops since transit must exit the travel lane completely to access the curb, then merge back into traffic after boarding/deboarding passengers
- Requires careful design consideration along roadways with adjacent bike lanes to ensure potential bus-bike conflicts are minimized

IMPLEMENTATION CRITERIA:

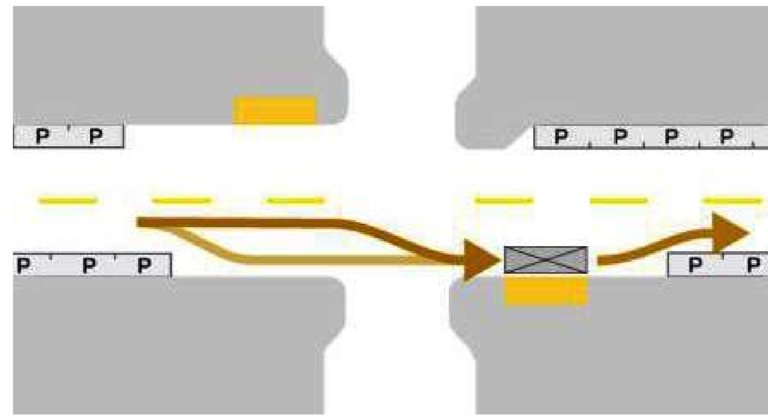
- Removal of parking or other curbside impediments may be required to accommodate bus pull in and pull out maneuvers
- Most effective when used with far side stops and in conjunction with signalization
- May be used as queue jump when designed as near side or far side stop

RELATED STRATEGIES:

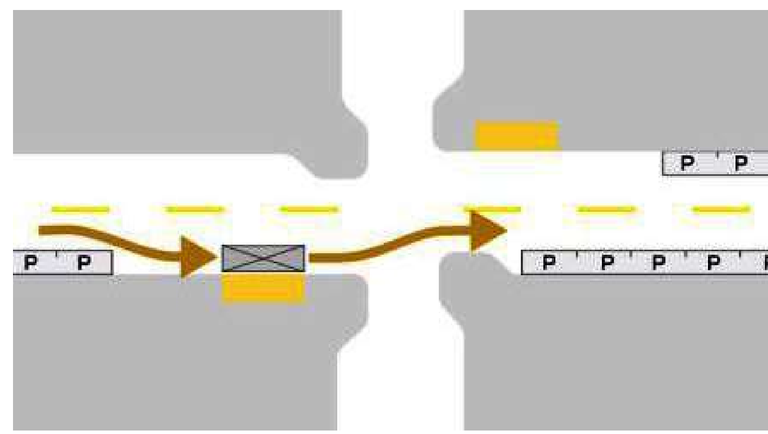
- Level boarding
- Parking removal or alteration
- Bus stop lengthening
- Queue jump

COST CONSIDERATIONS:

- Pull-out stops may be lower cost when implemented on roadways with on-street parking that can be removed for the bus stop, and higher cost when implemented on roadways that require reconstructing the curb line or acquiring right-of-way to accommodate the pull-out



Far-side Pull-out. Source: NACTO



Near-side Pull-out. Source: NACTO

LEVEL BOARDING

COST: $ – $$

OVERVIEW:

Level or near-level boarding at bus stops and stations provides a curb height that minimizes the vertical gap between the curb and the door of the bus, making it easier and faster to board the bus at the bus stop. Near-level boarding places the curb height at 8-11 inches rather than the typical 6-inch curb, while level boarding matches the height of the curb to the floor height of the bus (typically 12-14 inches).

BENEFITS:

- Accommodate seniors and customers with mobility devices or strollers
- Reduce bus dwell time with faster boarding and alighting
- Emphasize bus stop location as separate from pedestrian area

OPERATIONAL CONSIDERATIONS:

- Often requires complete reconstruction of bus boarding area
- Implementation and retrofits can be challenging to integrate with existing sidewalk levels and can result in the need for ramps and railings
- Curb heights can be set to specific fleet specifications and may range from 8-14 inches. Lower curb heights in that range may only provide near-level boarding, but still improve passenger boarding/alighting

IMPLEMENTATION CRITERIA:

- Consider installing at locations that have high numbers of mobility-impaired riders
- Ensure that level boarding stops are compatible with adjacent land uses
- Level boarding stops are commonly implemented with high-capacity transit lines, such as Bus Rapid Transit where there is high ridership and significant stop/station infrastructure
- Level boarding stops must be compatible with bus fleet

RELATED STRATEGIES:

- Curbside bus lanes
- In-lane stop

COST CONSIDERATIONS:

- Cost of this treatment can vary widely depending on if the boarding platform needs to be rebuilt or retrofitted

Source: BaltimoreLink Transit Priority Toolkit

BUS STOP LENGTHENING

COST: $ – $$

OVERVIEW:

Bus stop lengthening allows a stop to serve more (or longer) buses simultaneously.

BENEFITS:

- Increasing the bus stop length to serve more or longer buses can improve travel time reliability; lengthening stops can also provide additional space for bus stop amenities, and can often be accomplished with little to no adverse impact on general traffic flow

OPERATIONAL CONSIDERATIONS:

- Available space and right-of-way may limit opportunities to implement stop lengthening
- Bus stop lengthening may result in a loss of on-street parking or other curb-side activity
- Design platforms to accommodate boarding and alighting from all doors, and consider additional elements to improve passenger comfort
- Agency policy may require that buses stopping in an upstream position still pull up and stop at the front position for accessibility

IMPLEMENTATION CRITERIA:

- Bus stops may need to be lengthened where there are frequent headways and/or multiple bus lines, where the existing stop space is insufficient for the passenger demand, and/or where there is high ridership
- Lengthening must accommodate proper drainage and compliant ADA access

RELATED STRATEGIES:

- Curbside bus lanes
- In-lane stop
- Far side stop

COST CONSIDERATIONS:

- Cost varies based on stop configuration and infrastructure in addition to any parking removal

Lavaca Street and 8th Street, Austin
Source: Google Street View

PARKING REMOVAL OR ALTERATIONS

COST: $

OVERVIEW:

Parking can be altered or removed 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.[1] This tool is a part of curb management, a series of strategies to more efficiently allocate curb space to meet desired needs such as bus stops, loading zones, passenger curbside activity, parking spaces, and more.

BENEFITS:

- Parking removal can facilitate bus turns, improve travel lane widths for transit, or reduce parking encroachment into lanes where transit is operating. This can improve bus travel times, plus reduce sideswipes and other parking-related crashes near the improvement

OPERATIONAL CONSIDERATIONS:

- Parking restrictions can be in effect 24/7 or during peak periods only
- Note that travel lane widths need to be evaluated if parking is being removed for a bus lane, as parking lanes are often 7-8 feet wide and not adequate on their own for bus operations[1]
- Community support for parking removal can be challenging where the public perceives parking to be critical to business or neighborhood access. Extending outreach to impacted constituents prior to removal is important

IMPLEMENTATION CRITERIA:

- Appropriate for streets with curbside loading or parking that can be removed or relocated

RELATED STRATEGIES:

- Peak only bus lane
- Transit priority lane
- Facilitating turn movements

COST CONSIDERATIONS:

- Some costs associated with removal or re-striping of parking. Some new signage may be necessary
- If paid parking is removed, there may be some loss of parking meter revenue unless replacement spots can be secured

1 King County Metro Speed Reliability Toolbox

BUS STOP CONSOLIDATION

COST: $ – $$

OVERVIEW:

Bus stop consolidation, also known as bus stop balancing or bus stop optimization, speeds up bus travel times by relocating or eliminating bus stops in order to increase the distance buses can travel between stops while still maintaining transit access for the area where buses are operating.[1]

BENEFITS:

- Buses spend approximately 20% of their time at bus stops; reducing the overall number of stops can dramatically speed up trips for transit riders.[2]
- Allows better allocation of limited resources to improve accessibility and amenities at the remaining stops

OPERATIONAL CONSIDERATIONS:

- Spacing trade-offs are critical and should be evaluated based on available demographic, socioeconomic, ridership, boarding pattern and bus frequency data
- Creating super-stops at transfer points of connecting routes can include updated rider amenities to improve customer experience[2]

IMPLEMENTATION CRITERIA:

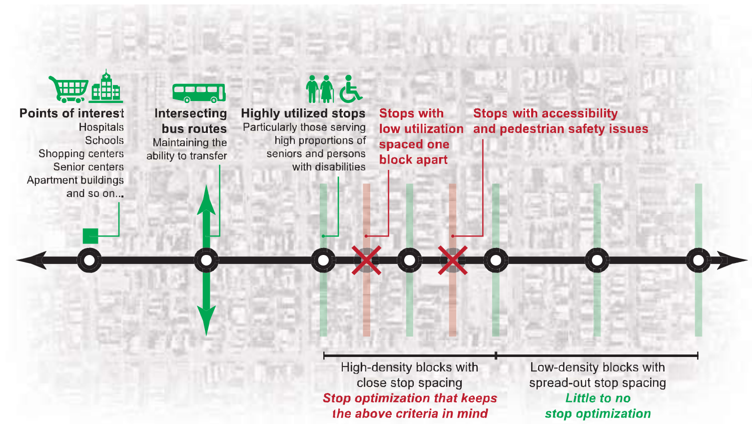
- Consider this treatment where stop spacing is on the lower end of the agency's stop spacing requirements (see table below)
- Consider this on low-performing corridors in terms of ridership and bus travel times

RELATED STRATEGIES:

- Far side stop
- Level boarding
- Route design/alignment

COST CONSIDERATIONS:

- Lower costs include removing bus stop poles and shelter from old site
- Higher costs can include installing new stops, improving ADA access, or new roadway paving



Source: Maryland DOT

CapMetro Recommended Minimum Distance Between Stops

Area Type:	Ideal Stop Spacing Range (Min-Max):
Regular local stops in Downtown or on arterial streets	800-1,600 feet
Suburban and other low-density areas	1,200-2,500 feet

Source: CapMetro Service Standards & Guidelines

1 TCRP Report 183: Transit Capacity and Quality of Service Manual
2 TransitCenter, Bus Stop Balancing: A Companion Guide for Agency Staff

IN-LANE STOP

COST: $$ – $$$

OVERVIEW:

An in-lane stop is a modification of the curb and sidewalk to extend the bus loading/waiting area out to the edge of travel lane, allowing the bus to dwell without having to merge back into traffic, thereby reducing delay.

BENEFITS:

- In-lane stops enable side-running transit vehicles to stop without making large lateral shifts; in-lane stops improve speed and reliability, decreasing the amount of time lost when merging in and out of traffic
- In-lane stops can become a focal point for improved public space along the street, creating space for waiting passengers, furnishings, bike parking, and other pedestrian amenities and community facilities without encroaching on the pedestrian through zone

OPERATIONAL CONSIDERATIONS:

- When placed at intersections, in-lane stops also act as curb extensions to shorten pedestrian crossings
- Can reduce bus and pavement wear and tear, reducing maintenance costs
- In-lane stops often require drainage modifications

IMPLEMENTATION CRITERIA:

- Preferred stop design by City unless safety issue warrants a pull-out stop
- Implement where a bus experiences delay merging into traffic from a pull-out stop
- Consider installing at bus stops where extra sidewalk space or boarding area is needed for high volumes of passengers waiting or for ADA purposes

RELATED STRATEGIES:

- Level boarding
- Floating bus stop

COST CONSIDERATIONS:

- Drainage changes, utility relocations, and relocating a bikeway are the increased cost components of this treatment

Guadalupe St, Austin.
Source: Google Street View

FAR-SIDE BUS STOP

COST: $ – $$$

OVERVIEW:

Far-side bus stops are located downstream of an intersection, allowing the bus to travel through the intersection before stopping to load and unload passengers. Far-side bus stops reduce bus delay and support the use of a broad array of active transit signal priority treatments.

BENEFITS:

- Allows buses to travel through an intersection before stopping, thereby reducing signal delay
- Encourages passengers to cross behind the bus, which increases visibility and improves pedestrian safety

OPERATIONAL CONSIDERATIONS:

- Contingent on available right-of-way on the far side of the intersection
- Most effective when paired with transit signal priority
- Need to consider the proximity to transfer stop locations, transfer ridership demand, and whether a far-side stop results in passengers having to make additional street crossings
- Far-side pull-out stops can benefit from a reverse queue jump to reduce post-dwell merging delay

IMPLEMENTATION CRITERIA:

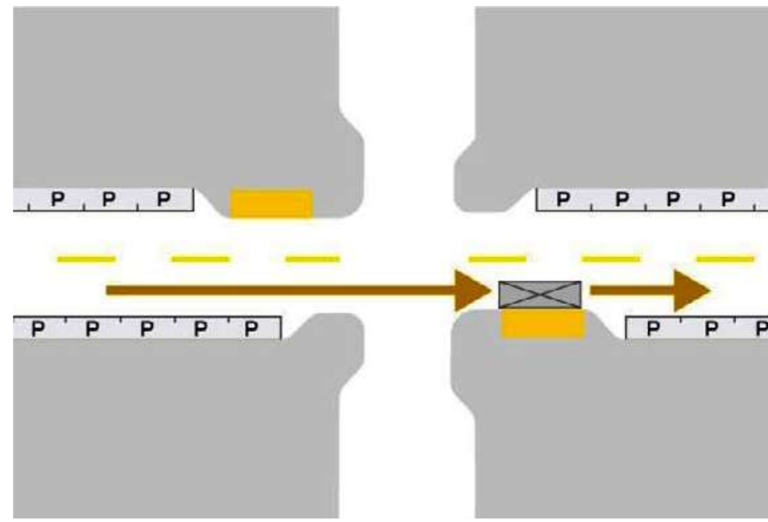
- Preferred stop location by the City unless other criteria warrant near-side stop
- Appropriate at intersections with long traffic signal cycles where a near-side stop may incur significant signal delay
- Consider implementation with bus bulbs to reduce bus merging delay
- Consider adjacent land use and location of trip generators
- Consider proximity to transfer stop locations

RELATED STRATEGIES:

- Curbside bus lanes
- In-lane stop
- Transit signal priority
- Reverse queue jump

COST CONSIDERATIONS:

- Cost varies based on stop configuration and infrastructure



Source: NACTO

NEAR-SIDE BUS STOP

COST: $ – $$

OVERVIEW:

Near-side stops are located at the approach to an intersection and can facilitate in-lane stops in mixed-traffic lanes, ensuring queued vehicles behind transit vehicles do not block the intersection.

BENEFITS:

- Allows passengers to board and alight closer to intersection crosswalks
- Provides opportunity for queue jump at signalized intersection
- Keeps the far side of the intersection clear to receive turns, especially on single-lane roadways

OPERATIONAL CONSIDERATIONS:

- May impact ability of an intersection to process traffic and cause noticeable drops in intersection capacity
- Near-side stops can be used to facilitate transfer between two intersecting routes

IMPLEMENTATION CRITERIA:

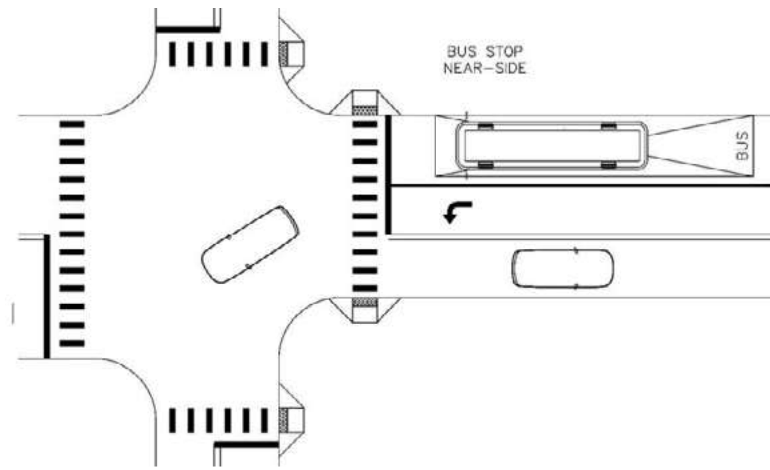
- Near-side stops should be set back at least 10 ft from the edge of the intersection crosswalk, or at the end of the turn radius, whichever is further from the intersection. Stops located just before the crosswalk can block the visibility of pedestrians
- Place near-side stops close enough to the intersection that right-turning vehicles cannot merge in front of the bus

RELATED STRATEGIES:

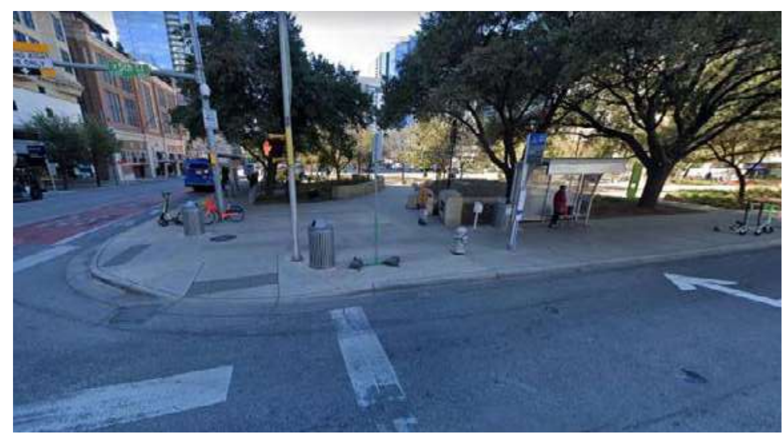
- Queue jump
- In-lane stop
- Level boarding

COST CONSIDERATIONS:

- Cost varies based on stop configuration and infrastructure



Source: City of Austin



Source: Google Street View

MIDBLOCK BUS STOP

COST: $ – $$

OVERVIEW:

Midblock stops occur when the bus stops in between intersections, usually in a well-defined area. Midblock stops should be placed where a midblock pedestrian crossing can be installed in tandem with the transit stop.

BENEFITS:

- Provides transit access to popular destinations on corridors with long distances between signalized intersections

OPERATIONAL CONSIDERATIONS:

- May need to locate bikeway behind stop
- May allow space for multiple route stops or layover space
- May be useful where adding stops at complex or highly constrained intersections would created safety issues for buses or riders

IMPLEMENTATION CRITERIA:

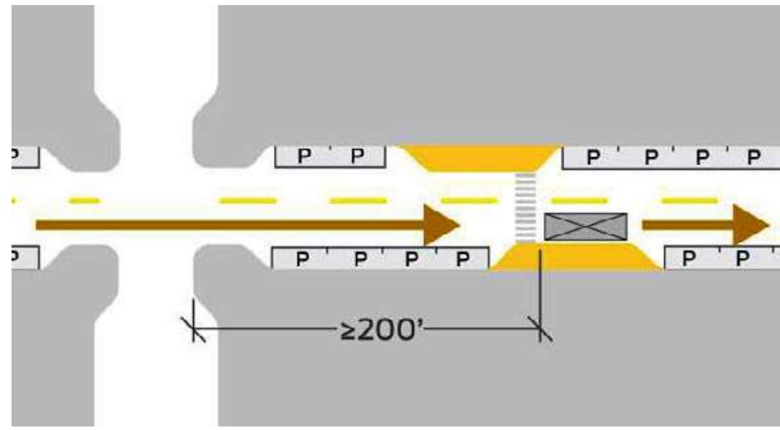
- Use at locations with large destinations midblock
- Consider implementation with bus bulbs for in-lane stops
- Pedestrian crossings should be installed with the transit stop design to facilitate crossings behind the stop, when appropriate

RELATED STRATEGIES:

- In-lane stop
- Floating stop
- Parking removal or alteration

COST CONSIDERATIONS:

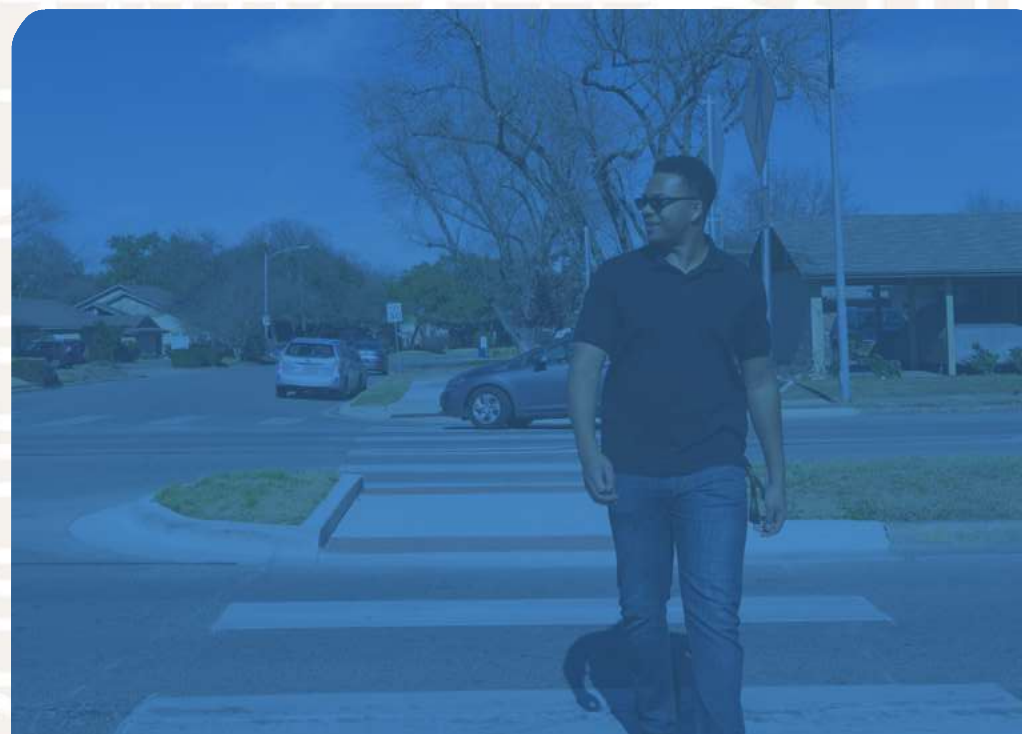
- Midblock stop may require more curb area
- Costs will vary based on stop infrastructure and configuration and may include the cost of adding a midblock pedestrian crossing to support the bus stop



Source: NACTO

Source: Google Street View

ACCESS AND MULTIMODAL INTEGRATION



DEDICATED BIKE SIGNAL

COST: $ – $$

OVERVIEW:

A dedicated bike signal near busy bus stops or intersections where transit vehicles operate can help identify and organize transit, bicyclist, and pedestrian movements.

BENEFITS:

- While the primary purpose is to improve bicycle safety, dedicated bike signals can minimize transit delay by providing reliable and specifically-timed separation of transit and bicycle movements where a bus may otherwise need to yield to many cyclists

OPERATIONAL CONSIDERATIONS:

- The traffic signal cabinet and controller software needs to be able to accommodate the additional phase(s) and input(s)
- Bicycle phases that require additional or exclusive time within the signal cycle length may increase transit delay
- The design should consider any bicycle queue storage needs
- Signing and striping needs to provide clear wayfinding for cyclists and communicate awareness of the bicycle facility to drivers

IMPLEMENTATION CRITERIA:

- Consider locations where buses experience frequent delay as a result of yielding to cyclists
- Existing dedicated bike phases where conflicting right turns are held to create a protected bike interval pose challenges when converting that right turn lane into a bus lane or queue jump lane as the protected bike movement will delay the bus; this situation can be mitigated by using transit signal priority to call a lagging protected bike phase

RELATED STRATEGIES:

- Separated bike and bus facilities
- Turn restrictions
- Signal timing modifications

COST CONSIDERATIONS:

- Costs include new signal heads, signal timing updates, and could include new bike-specific signing and striping

Source: Google Street View

SHARED BUS-BIKE LANE

COST: $ – $$

OVERVIEW:

A shared bus-bike lane is a roadway lane that is dedicated exclusively or primarily for the shared use of buses and bicycles. A shared bus-bike lane is not a high-comfort bike facility and the preferred option for incorporating bicycle lanes into transit infrastructure is a separate bikeway, but a shared bus-bike lane may be an option on streets where dedicated bus and separate bike facilities cannot be provided.

BENEFITS:

- Shared bus-bike lanes can provide increased space and visibility for cyclists while improving transit service reliability on corridors with consistent delay and lower bus volumes
- Shared bus-bike lanes can accommodate both modes at low speeds and moderate bus headways, where buses are discouraged from passing, and bicyclists pass buses only at stops

OPERATIONAL CONSIDERATIONS:

- Not recommended for areas where buses are traveling at speeds greater than 20 mph, or could be expected through design to operate at greater than 20 mph
- Preferred configuration separates bikes from buses at stops
- Bus-bike lanes are not high-comfort bicycle facilities, and are not a substitute for dedicated bikeways

IMPLEMENTATION CRITERIA:

- Applications should generally be limited to bus lanes with operating speeds of 20 mph or less and transit headways of four minutes or longer (max. 15 buses per hour)
- Recommended where dedicated or reasonable parallel bicycle facilities are not feasible

RELATED STRATEGIES:

- Far side stop
- Dedicated bicycle signal
- Traffic signal timing adjustments

COST CONSIDERATIONS:

- Ranges from basic striping and signing to resurfacing pavement, red paint markings, installing overhead signage, or changing roadway cross-section

West 5th Street at Pressler St, Austin, TX
Source: City of Austin

SHARED CYCLE TRACK STOP

COST: $$ – $$$

OVERVIEW:

At shared cycle track stops, a bike lane rises and runs along the boarding area, rather than wrapping behind the back of the bus stop. Bicyclists can ride through the boarding area when no transit vehicles are present but must yield the space to passengers when a bus stops for boarding and alighting.

BENEFITS:

- Avoids potential bike-bus conflict from sharing the travelway, increases bicyclist comfort and safety
- Improves bicyclist visibility and increases predictability of bicyclist positioning on the travelway
- Provides space for transit passengers and amenities while maintaining a clear pedestrian path on the sidewalk

OPERATIONAL CONSIDERATIONS:

- Measures must be taken to ensure bicyclists yield to boarding and alighting transit passengers; compliance is critical to providing safe and comfortable conditions
- Pedestrians must have sufficient space to wait behind the cycle track so they are not trapped between the cycle track and the vehicle lane while waiting
- Bike facilities may be buffered or protected

IMPLEMENTATION CRITERIA:

- Shared cycle track stops require comprehensive multi-sense information to guide blind or visually impaired riders. Appropriate use of detectable warning surfaces is required to meet accessibility standards.
- Used where limited right-of-way or other constraints preclude floating stops with bikes behind the bus stop
- Generally occurs in curbside conditions

RELATED STRATEGIES:

- Dedicated bicycle signal
- Turn restrictions

COST CONSIDERATIONS:

- Costs include restriping and resigning existing curbside station at a minimum and also may include station construction costs

Example of Shared Cycle Track Stop
Source: TriMet

FLOATING STOP

COST: $$ – $$$

OVERVIEW:

Floating bus stops, also known as boarding islands or multimodal bus stops, reduce conflicts between buses, bikes and transit riders by the wrapping the bike lane behind the bus stop. This separation improves safety for bicyclists and pedestrians, and clarifies interactions among all modes.

BENEFITS:

- Routing bikes behind a bus stop improves safety by minimizing conflicts between buses, passengers, and bicycles within the same space; this type of stop layout typically keeps the bus in-lane, reducing delay and friction associated with merging into and out of traffic and enabling faster and more reliable transit operations

OPERATIONAL CONSIDERATIONS:

- A platform is constructed along the right side of the roadway, typically within a current parking area, travel lane, or bike lane, where the bike facility is then routed behind the stop/station area
- Need pavement markings and signage directing bicyclists behind the boarding area and crosswalks directing pedestrians from platform to sidewalk
- When possible, include raised crosswalk to channelize pedestrians and alert bicycle riders to yield to pedestrians

IMPLEMENTATION CRITERIA:

- Streets with heavily-used transit routes and protected bikeways where adequate right-of-way permits the “island” or “floating” configuration
- This treatment is most appropriate for roadways with a high level of interaction among bicycles, pedestrians, and transit
- This treatment requires more right-of-way than similar treatments such as shared cycle track stops. Available right-of-way should be considered when assessing this tool.

RELATED STRATEGIES:

- In-lane stop
- Far side stop
- Shared cycle track stop

COST CONSIDERATIONS:

- Pedestrian fencing, bollards, and object markers may be required
- Costs can be significantly reduced when incorporated into a larger corridor project

Stassney Lane Project at South 1st Street, Austin, TX
Source: City of Austin

ACCESS IMPROVEMENTS

OVERVIEW:

This page describes several access improvements that have been grouped onto one page as a part of Access and Multimodal integration. They don't need a full-page explanation but should be considered when implementing other tools in this Toolbox.

LEADING PEDESTRIAN INVERVAL (LPI):

This tool involves adding a phase where the pedestrian walk indication is displayed 5-15 seconds before the associated vehicle movement receives a green indication on the signal head. This allows pedestrians to get a head start crossing the intersection, minimizing turning vehicle conflicts by increasing visibility of pedestrians.

MEDIAN REFUGE ISLAND:

A concrete refuge island constructed in the median between vehicle lanes gives pedestrians and bicyclists refuge part-way through crossing the roadway. This increases crossing opportunities and make crossing at wide roadway locations safer.

PEDESTRIAN CROSSING TREATMENTS:

These include the following in order of level of effort and level of traffic control required:

- **Raised Crossing:** The crosswalk is physically raised to increase visibility and awareness of pedestrians to drivers. It also has the added benefit of slowing vehicles approaching the crossing.
- **Rectangular Rapid Flashing Beacon (RRFB):** This is a form of advanced warning, and is triggered when pedestrian pushes a button on the beacon before crossing. Flashing lights signal to drivers that a pedestrian is actively crossing at that location.
- **Pedestrian Hybrid Beacon (PHB):** unlike the flashing lights of the RRFB, a pedestrian hybrid beacon will show a red indication after an initial flashing indication to stop vehicles before a pedestrian begins crossing. Vehicles must stay stopped until the beacon flashes and exits the solid red indication.
- **Traffic Signal:** When previous active and enhanced crossing indicators do not suffice, a traffic signal may be installed to support safe pedestrian crossings if it passes signal warrants.

Median Refuge Island, Source: NACTO

Pedestrian Hybrid Beacon
Source: Google Streetview

BICYCLE IMPROVEMENTS

OVERVIEW:

This page describes several bicycle improvements that have been grouped onto one page as a part of Access and Multimodal integration. They don't need a full-page explanation but should be considered when implementing other tools in this Toolbox.

BICYCLE PARKING:

This tool involves providing secure bicycle parking at park and rides and other high-activity transit stops to encourage and facilitate bicycling access to transit.

BIKE SHARE PROGRAM:

This tool involves implementing or expanding a City or agency-wide bike share program to facilitate the use of bicycles for first and last mile trips, especially those that connect to transit. Bike share programs allow people to use bicycles on one leg of their trip, not requiring round trips. They also remove bicycle parking concerns for the individual user. There are many types of bike share programs that can be implemented ranging from docked to dockless options.

SEPARATE BUS AND BIKE FACILITIES:

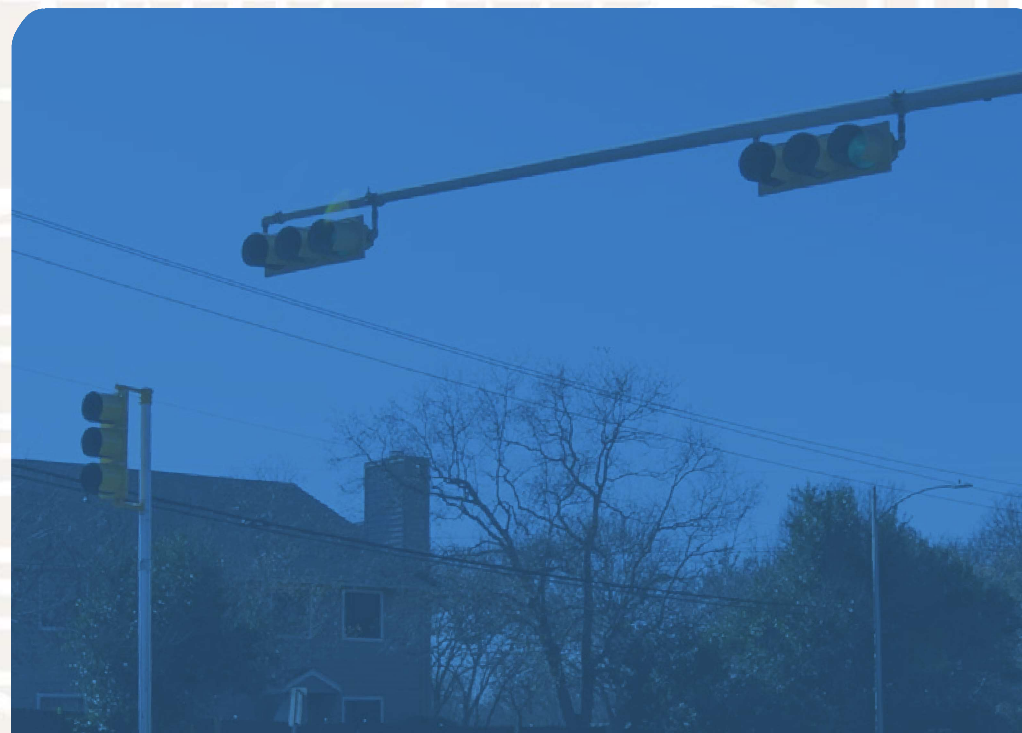
Separated bus and bike facilities generally involve a combination of the following options:

- **Right Side Bike Lanes:** Typically separated bike lanes are on the right-side of the travel way, increasing bicyclist comfort and safety and reducing potential bike-bus conflict in the roadway
- **Left Side Bike Lanes:** This tool involves conventional bike lanes placed on the left-side of one-way streets or two-way median divided streets. The advantage of left side bike lanes is they have fewer bus conflicts along the curb as most bus stops and operations are on the right side of the street.
- **Protected Bike Lane:** This is a bike lane protected by physical barriers such as delineators, curbs, or parking
- **Buffered Bike Lane:** This is a bike lane separated from an adjacent travel lane by a buffer of space, ranging from 2-6 feet, often delineated by striping. Physical barriers are not required for a buffered bike lane but may be used where space is available to provide additional protection for bicyclists.

Buffered bike lane
Source: NACTO

Left side bike lane
ource: NACTO

TRAFFIC SIGNALS AND OPERATIONS



TRAFFIC SIGNAL TIMING ADJUSTMENTS

COST: $ – $$

OVERVIEW:

Traffic signal timing adjustments can be optimized to reduce overall delay for motor vehicles on the intersection approaches used by transit. Since the signal timing is the same whether or not a bus is present, the improvements are considered to be passive.

BENEFITS:

- Can reduce bus stopping and travel time through the corridor by up to 12 percent[1]
- Adjusting signal timing specifically for bus progression will help reduce delay experienced by buses at an intersection[2]

OPERATIONAL CONSIDERATIONS:

- The amount of signal time reallocated to approaches served by buses is constrained by the amount of time required in terms of traffic volumes, lane configuration, and pedestrian volumes to serve vehicles on other approaches[2]
- Changing signal timing for one intersection on a coordinated corridor may require changing timing of the whole corridor except if double or half cycling is employed on the candidate intersection
- Signal timing changes that benefit buses (such as shorter cycle lengths or more green time for the approaches used by buses) may also improve operations for other roadway users

IMPLEMENTATION CRITERIA:

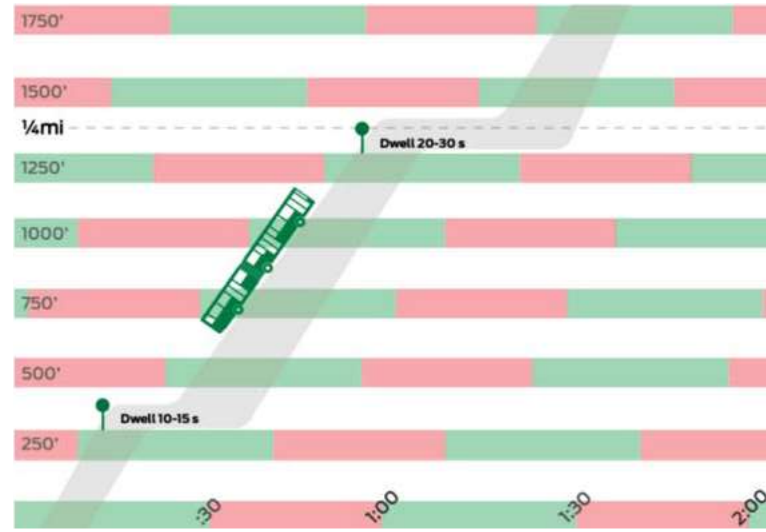
- Can be implemented on corridors with pre-timed signals or coordinated signals
- Most beneficial on coordinated corridors or corridors without isolated traffic signals
- Most beneficial on corridors that experience poor progression or have congestion but are not fully saturated

RELATED STRATEGIES:

- Transit signal priority
- Phase modification
- Bus only signal

COST CONSIDERATIONS:

- Potential for no capital costs if existing equipment is supported, otherwise controller and/or detection upgrades may be necessary
- Timing adjustments would require some staff time



Source: NACTO Transit Street Design Guide

1 Translink Transit Priority Toolkit
2 TCRP Report 183: Transit Capacity and Quality of Service Manual

TRAFFIC SIGNAL PHASE MODIFICATION

COST: $ – $$

OVERVIEW:

Traffic signal phase modification consists of modifying signal phasing for improved safety and transit operations. An example modification may include conversion from permissive left turn phasing to protected-only phasing for increased safety of left turn operations. Conversely, a protected-only left turn phase can be modified to a permitted/protected operation when conditions allow to serve left turn demand during the permissive phase and reduce the amount of protected green time needed, thereby increasing the through movement green time to benefit mainline transit operations. Other phase modifications may include adding right-turn overlap phasing or a left turn reservice phase to provide a left turning bus the opportunity to be served before or after the through phase.

BENEFITS:

- Reduces bus delay and improves travel time reliability by accommodating varying bus arrival times at a traffic signal
- Additional green time for buses will also benefit the motorists sharing the intersection approach

OPERATIONAL CONSIDERATIONS:

- Right-turn overlaps benefit right turning buses, but can also be used to flush right turning traffic from a queue jump lane when used in conjunction with transit signal priority and a transit signalhead
- Need sufficient cycle length at the intersection for phase reservice to effectively function
- Controller upgrades may be needed to provide phase modifications[1]
- Phase reservice can be conditional, i.e., if a bus or two to three cars occupy the left lane, then the left turn signal activates

IMPLEMENTATION CRITERIA:

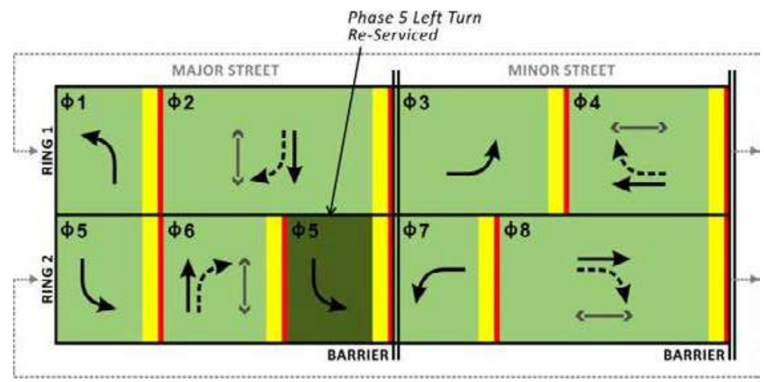
- In a transit context, this strategy has the greatest potential at signalized intersections where buses turn left
- Can be used in combination with transit signal priority to change the phase rotation to faster serve the bus (i.e., dynamic lead/lag left turn phasing)

RELATED STRATEGIES:

- Transit signal priority
- Bus only signal
- Facilitating turn movements
- Queue jump lane

COST CONSIDERATIONS:

- No capitol costs if locations includes required equipment; however changes to wiring, detection, signage, signalheads, controller or firmware may be necessary
- Any new equipment added to a mast arm may warrant installation of a new mast arm to accommodate additional loading



Source: Phase Reservice, TCRP Report 183

Source: NACTO Transit Street Design Guide

1 TCRP Report 183: Transit Capacity and Quality of Service Manual

TRANSIT SIGNAL PRIORITY

COST: $ – $$$

OVERVIEW:

Transit Signal Priority (TSP) is a tool that aids in giving a bus some level of priority moving through intersections so that the bus experiences reduced delay. It is implemented by modifying or altering traffic signal timing or phase allocation using communication technology between a traffic signal and an approaching bus. This strategy may include:

EXTENDING GREEN TIME OR PROVIDING EARLY GREEN TIME	CALLING BUS-ONLY PHASES (E.G., QUEUE JUMP)	DYNAMIC PHASE ROTATION (E.G., DYNAMIC LEAD/LAG LEFT TURN)

BENEFITS:

- Can reduce transit delay by approximately 10-50 percent at a target intersection
- Improves travel time reliability
- Improves overall transit corridor operations and improves reliability of the transit system

OPERATIONAL CONSIDERATIONS:

- Effective at intersections with long queues or high delays
- Limited effectiveness when mainline and cross-street traffic are near or over capacity
- Needs high degree of coordination between agencies responsible for signal and transit operations

IMPLEMENTATION CRITERIA:

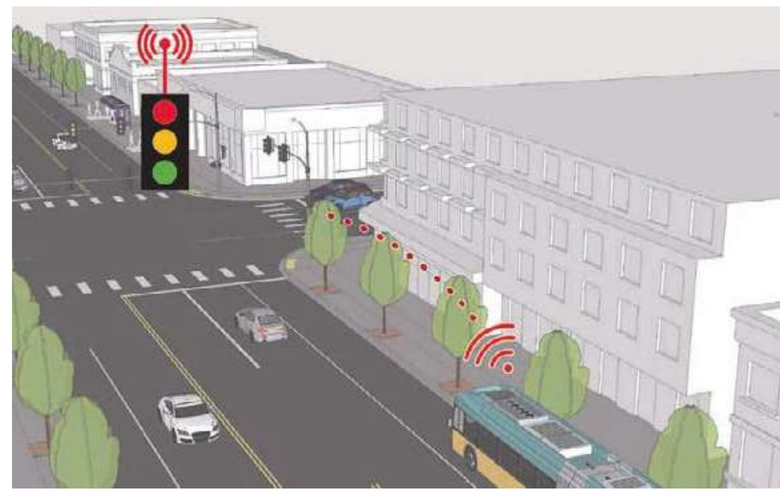
- Works best for signals with longer cycle lengths and for signal spacing greater than a half-mile
- Effective at locations with far-side stop or no stop, allowing buses to clear intersections without waiting; near-side stops have reduced effectiveness

RELATED STRATEGIES:

- Other signal timing strategies
- Queue jump lane
- Far side stop

COST CONSIDERATIONS:

- Upgrading signal controller, detection system, communication, and signal timings are key cost variables



Source: King County Metro Speed Reliability Toolbox

BUS SIGNAL PHASE AND SIGNAL HEAD

COST: $ – $$

OVERVIEW:

A bus signal phase is 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 allow buses to make nonstandard movements at an intersection like making a left turn from a right-side bus lane or movements to and from a median bus lane.[1] Bus-only signal phases are often implemented with separate bus signal heads.

BENEFITS:

- Supports the feasible implementation of other transit-supportive roadway strategies, such as queue jump lanes and bus lanes
- Can help reduce transit travel time and improve service reliability when used to solve issues associated with turning movements[1]

OPERATIONAL CONSIDERATIONS:

- The signal controller needs to have an unused phase available to serve the bus-only phase
- Geometric design considerations like bus turning radii will need to be checked, to ensure sufficient space for a bus to make a turn or merge
- Signing and striping need to clearly communicate operations for motorists
- Separate bus signal head may be added to clearly distinguish the bus-only phase

IMPLEMENTATION CRITERIA:

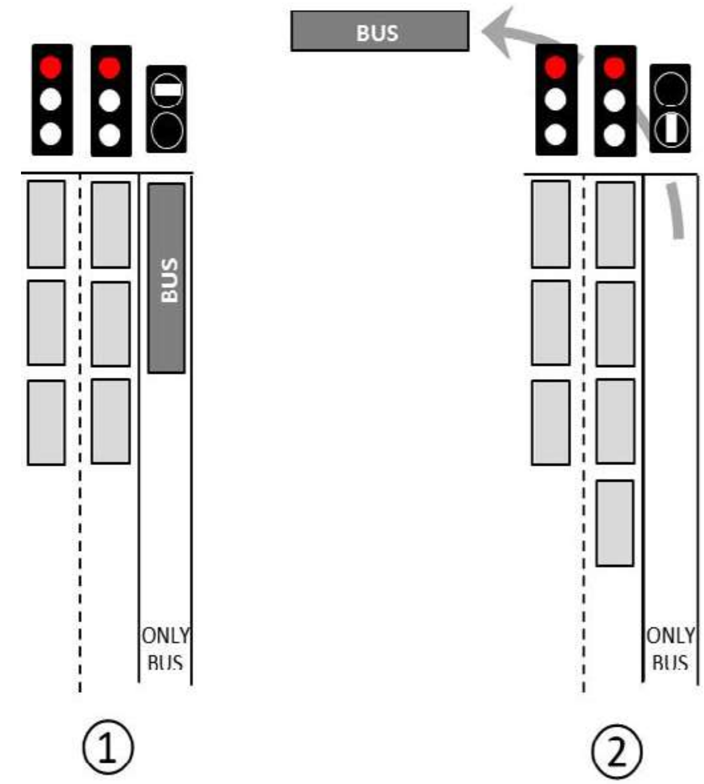
- Can be used whenever a transit vehicle needs to be served through a traffic signal from a dedicated lane. Common examples may include:
  - » Queue jump
  - » Left turn from right lane
  - » Right turn from median/left lane
  - » Entry or exit from a transit lane (median or side)

RELATED STRATEGIES:

- Phase modification
- Intersection queue jump lane
- Facilitating turn movements

COST CONSIDERATIONS:

- Cost depends on whether detection infrastructure, new signal head, or new controller needs to be installed



Example of bus-only signal phase
Source: TCRP Report 183

1 TCRP Report 183: Transit Capacity and Quality of Service Manual

REVERSE QUEUE JUMP

COST: $ – $$

OVERVIEW:

This tool includes communication between nearby traffic signals and the bus to create gaps in traffic to expedite a difficult transit movement. For example, a bus stopped at a far-side pull-out bus stop would trigger a call for a red phase at a downstream intersection to create a gap in traffic that the bus can use to merge back into traffic.[1]

BENEFITS:

- Reduces transit delays at intersections and merge areas where a lack of gaps in traffic otherwise make the bus movement difficult

OPERATIONAL CONSIDERATIONS:

- Signal must 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[1]

IMPLEMENTATION CRITERIA:

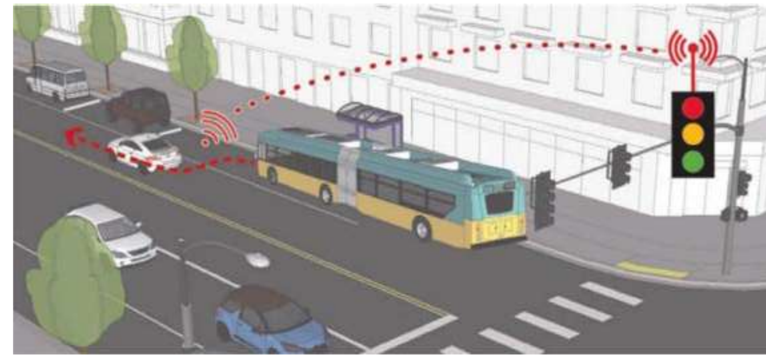
- Appropriate where other signal phasing or timing modifications are not sufficient
- Requires adjacent traffic signal where a phase change can benefit a downstream bus

RELATED STRATEGIES:

- Turn restriction
- Transit signal priority
- Far side stop

COST CONSIDERATIONS:

- Includes controller updates, detection, communication between bus and signal
- May need a planning study to determine appropriateness of strategy



Source: King County Metro Speed Reliability Toolbox

1 King County Metro Speed Reliability Toolbox

TRANSIT AGENCY TOOLS

OVERVIEW:

This page describes several transit enhancements that are outside of the City's jurisdiction but should also be considered as possible treatments to improve transit travel time and reliability.

YIELD-TO-BUS:

Some states (Oregon, Florida, New York and Washington) have passed laws requiring motorists to yield to buses when signaling to re-enter the travel lane from a bus stop.[1] In other states, private vehicles can be encouraged to yield to buses merging into traffic from a bus stop by using a bus-mounted yield sign or illuminated yield-to-bus light.

Yield-to-Bus electronic sign
Source: TCRP

ALL-DOOR BOARDING:

All-door boarding is an operational treatment that allows patrons to board and alight from a transit vehicle from any open door to minimize passenger queues and dwell time associated delay at transit stops. This concept requires fare reading equipment at all doors of the fleet, thus requiring an initial capital expense.

All-door Boarding,
Source: StreetsBlog LA

ROUTE DESIGN/ALIGNMENT:

Route design is a patron-centric treatment of adjusting or changing the alignment of a existing transit route to provide faster service and improve trip reliability to accommodate changing ridership, traffic patterns, and land use.[1]

OFF-BOARD FARE PAYMENT:

This tool involves patrons paying their fares outside buses, thereby reducing bus dwell times. Payment options include off-board vending machines and websites or apps that provide patrons with proof-of-payment.This tool is especially helpful on high-ridership routes where on-board payments would increase transit delay.

1 TCRP Report 183: Transit Capacity and Quality of Service Manual

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