National Capital Region Transportation Planning Board
Metropolitan Washington Council of Governments

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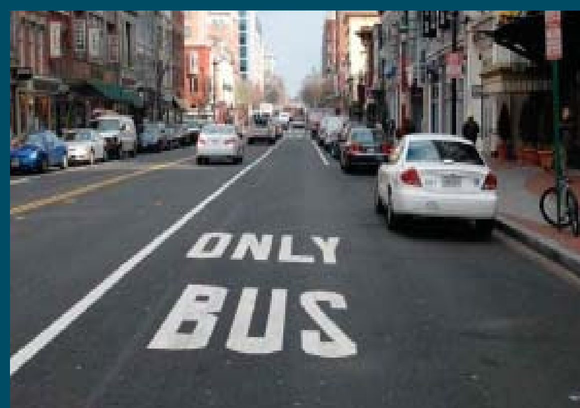
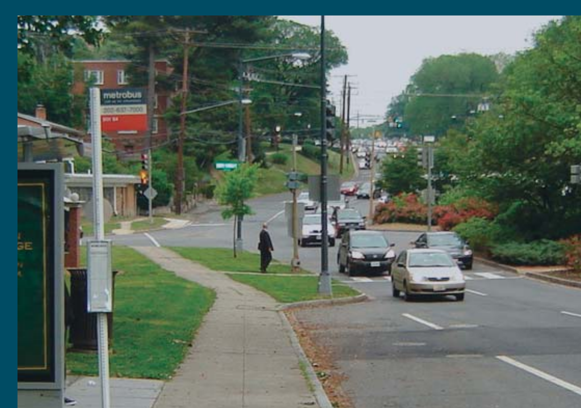
Bus Priority Treatment Guidelines

April 2011





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> *Foursquare Integrated Transportation Planning*

> *National Bus Rapid Transit Institute*

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INTRODUCTION

BACKGROUND

Metropolitan Washington has an extensive, modern transit system comprised of multiple coordinated services featuring rail transit, commuter rail and bus. These services success has attracted more and more riders, pushing many of them to the limits of their operating capacities. Metropolitan Washington also has some of the most congested roadways in the nation, often operating at far below their intended design speeds. The daily congestion commuters experience is projected to increase with the continued decline in the level of service the roadways will be able to provide.

Transportation planning at the regional level is coordinated in the Washington area by the National Capital Region Transportation Planning Board (TPB). Recognizing that there are limited resources to address the current and projected levels of congestion of both the roadway and transit systems, the TPB concluded that improvements in the capacity of the region's transit systems must be planned to maximize their performance, including enhancing the operations of the bus systems.

Buses carry about half of the transit ridership of the Washington Metropolitan region. This is not unusual for cities with rail transit systems, as buses can operate where rail systems would be impractical, too expensive, or would entail unacceptable impacts to the fabric of the community.

Increasing the capacity and level of service possible with the transit system requires improving the operational characteristics of the bus systems. Creating corridors where buses can operate at higher speeds with fewer delays is one key to creating this improved level of service and reliability.

In 2008, the Washington Metropolitan Area Transit Authority (WMATA) approved a plan to implement 23 priority bus corridors in its service area. The 23 corridors chosen serve half of WMATA's bus system ridership. These priority corridors would apply some or all of the available strategies to improve bus operations to varying degrees.

In 2009, TPB, in conjunction with WMATA, conducted an evaluation of the priority bus concept. The study concluded that the corridors chosen would attract more riders, increase access to jobs for the region, improve travel times within the corridors, and could result in operational cost savings. While the study verified the potential benefits of priority treatments, it recognized that a balance must be maintained between transit and traffic systems. The study recommended further analysis at the corridor, segment and intersection level to determine how such a balance could be maintained while increasing transit system performance.

On February 17, 2010, the United States Department of Transportation (USDOT) announced the award of the Transportation Investments Generating Economic Recovery (TIGER) program. In September, the TPB applied for $204 million for a variety of transit projects throughout the region. USDOT subsequently awarded the TPB $58 million in TIGER funding. Fifteen of the corridors proposed for priority treatments for transit received preliminary funding approval.

Improvements to the operations of bus systems involve changes to operations, equipment or the operating environment. There is always overlap among these factors and to achieve significant improvements all three must be in tune. The challenges in improving operations and upgrading equipment can be significant, but are largely under the purview of the transit operator. However, buses operate largely on public roadways using the existing street signal system. Throughout the United States and particularly in the Washington D.C. Metropolitan Area, the roadway, signal systems and sidewalks used by transit riders to access the bus system are not under the control of the operator. In fact, with two states and the District of Columbia as well as multiple municipalities, the operating environment for transit services in this region is among the most complex if not the single most complex of any major metropolitan area.

Audience for Guidelines

This guidebook focuses on the portion of transit systems not under the control of transit operators, the operating environment. It is intended to describe the range of improvements available in the operating environment and to provide a general guide for the implementation of priority bus treatments within the Metropolitan Washington region. It does this by describing the treatments that have proven effective in other cities as well as the Washington region, by answering questions regarding the implementation of priority bus treatments and by providing examples where these treatments have been effective.

Priority transit includes physical and operational treatments applied along corridors to improve transit operations through decreasing travel times and improving reliability for the passenger. These treatments can result in faster travel times for the vehicle, more efficient boarding and alighting operations, and a reduction in the time the bus is stopped in traffic. Treatments considered in this guidebook include:

- Exclusive bus lanes
- Bus Stop location
- Bus bulbs
- Queue jumpers
- Transit signal priority
- Bus Stop design
- Bus shelters

The guidebook is intended for professionals who oversee traffic operations or are involved in the management of roadways because the strategies needed to improve bus operations can have implications for traffic. It is intended to answer questions that state and local agencies may have about the use of a specific priority treatment being considered and the potential impacts on traffic operations of that treatment.

In the early years of the profession, traffic engineering focused on maximizing vehicle throughput on streets. A key tool to achieve that goal was optimized traffic signal timing to insure a high level of service (LOS) and low volume to capacity (V/C) ratio on arterial street segments and at intersections. The profession now takes a more holistic view of "the street" that includes cyclists, pedestrians, and transit in addition to cars and trucks. In this view, maximizing person throughput rather than vehicle throughput constitutes the new paradigm. Tools such as TSP and pedestrian signals help achieve these updated goals.

Organization of Guidebook

The guidebook is organized based on the way a traffic engineer views the roadway: Segments, Intersections, and Sidewalks. Treatments have been placed in a chapter based on their impact to the street. Chapter 1 describes treatments that could be applied to street segments. Treatments that would play a role in intersection operations, such as traffic signals, are included in Chapter 2. Finally, those treatments that would impact pedestrian flows and activity along the sidewalk are included in Chapter 3. Some treatments may appear in multiple chapters because they have an impact on more than one part of the street. While some treatments appear linked to others based on the way a transit professional views them, they may not be in this guidebook based on the impact they have on the street network.

For each treatment described there is an explanation about the treatment itself, followed by a series of questions relating to the typical concerns associated with the implementation of the treatment. An answer that addresses the strategy follows each question. Included with each answer is an example of how the treatment has been applied in an existing transit system. Each example includes how the treatment was applied, implementation steps, impacts, and any key lessons learned.

The appendix of this guidebook provides additional information about the characteristics of a number of projects and services that have been applied both in the Washington Region and in other communities.

The methods available to increase bus speeds, reduce delays and improve the ridership experience range from changes in operating practices to changes in the bus operating environment. This document focuses only on those measures that would require modifications to the operating environment of the bus system, omitting such operating practices as off-board fare collection because those are actions under the control of the transit operator. This report discusses the following tools:

- **Running Way**
  - On Street Exclusive Bus Lane Operations
  - Lane Vehicle Restrictions
  - Lane Markings
  - Mixed Traffic Bus Lane
- **Bus Stops**
  - Stop Location
  - Stop Design
  - Bus Bays
  - Bus Bulbs/Nubs
- **Intersections**
  - Crosswalks
  - Transit Signal Priority
  - Passive Signal Priority
  - Active Signal Priority
  - Queue Jumps
- **Sidewalks**
  - Width
  - Length
  - Height
- **Shelters**

Development of Guidelines

As part of the guidebook development, the study team met with state and local traffic engineers around the Washington metropolitan region. Those agencies are listed below. The authors also would like to acknowledge the contributions of the project's technical advisory committee, which consisted of individuals from transportation agencies and offices in the District of Columbia, Maryland, and Virginia. The committee roster is listed below (project managers in **bold type**), and the authors thank both groups for their time and expertise in developing the final document.

Contributing State and Local Traffic Engineers

- Arlington County
- City of Alexandria
- City of Falls Church
- City of Fairfax
- City of Manassas
- City of Rockville
- District of Columbia
- Fairfax County
- Maryland State Highway Administration District 3
- Montgomery County
- Prince George's County
- Prince William County
- Virginia Department of Transportation Northern Operations Region / Northern Virginia District

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Chapter 1: Priority Bus Treatments Overview

Why Implement Priority Bus Treatments?

Typically, a bus spends 50-60% of its run time in motion, 20% serving bus stops and 20-30% held up in traffic signal or congestion delay. While there are a number of elements to improve the bus customer experience in general, two specific types of improvements are needed to improve travel time. First, a range of service types must be layered upon each other in these corridors to create a "family of services" package focused on meeting numerous market segments within each corridor. These services may include local buses making all stops, limited stop, skip-stop, and express bus service. Second, improvements along the bus running way (street operations) must be made to reduce time spent at traffic signals and in congestion and give the bus priority in travel.

The benefits of implementing priority bus treatments can include reduced bus travel times, increased schedule reliability, a higher public profile, better integration with pedestrian paths, operating cost savings, reduced equipment requirements, and increased transit ridership. Ideally, the total number of persons able to travel in a corridor will be higher with priority bus operations than without as more people can travel by riding a bus than could use the same lane by riding in cars.

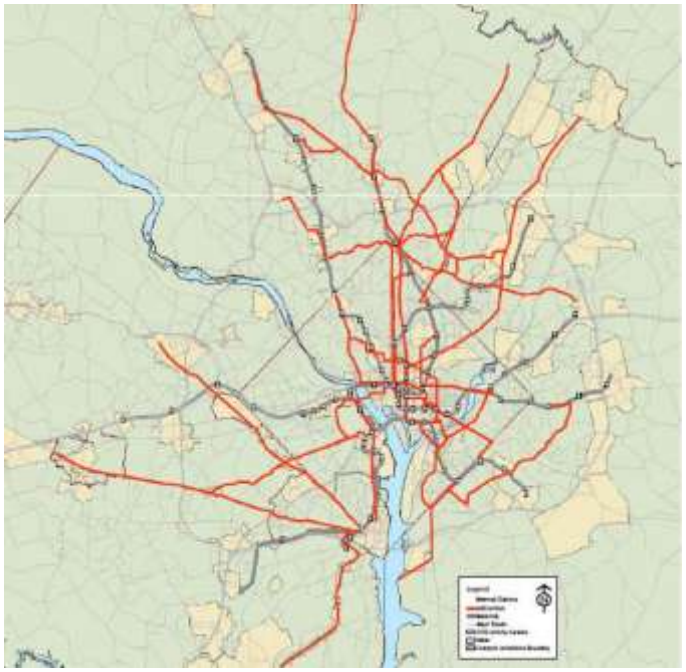
These benefits can range from the marginal to the significant depending on the specifics of the application. In general, the more completely buses can operate in reserved rights-of-way, the better the signal system responds to the needs of the buses, the fewer intermediate stops (e.g. less than ½ mile), and the more quickly buses can be boarded or alighted, the greater the benefits. The longer the corridor in which these characteristics can be achieved, the greater the total benefits that can be achieved.

If all of these benefits could be achieved without impinging on other users of the roadways, priority bus treatments would be the norm across all transit systems. However, the roadways buses use are, with few exceptions, public streets that must also serve adjacent land uses, moving and parked private vehicles, freight carriers, emergency vehicles, bicyclists and pedestrians.

So the implementation of bus priority treatments involves arriving at an acceptable allocation of that scarce resource, the capacity of the roadways to transport people and goods.

In 2009, TPB and WMATA conducted an analysis of the effectiveness of the planned Priority Corridor Network (PCN) for metropolitan Washington. The PCN network consists of 23 existing arterial bus corridors over approximately 235 miles of roadway. Figure 1 shows the PCN network. Nine corridors are in the District of Columbia, nine in Maryland and five in Virginia. Together, bus routes on these corridors carry more than half of Metrobus daily ridership (approximately 250,000 trips per day).

Figure 1: PCN Network



Analysis of the PCN bus priority needs was completed using the COG cooperative land use forecast 7.1 and the regional travel demand model version 2.2. The 2030 baseline run was based on 2030 travel demand, and included all projects in the 2008 CLRP to account for previously planned transit infrastructure projects.

The evaluation compared three scenarios against the 2030 Baseline:

- 2030 Service Only Improvements
- 2030 Full Build Priority Improvements
- 2030 Modified Priority Improvements

The Full Build scenario assumed that all of the segments in the 235-mile PCN took a lane from general traffic for transit-only use in 2030. In order to simulate the service enhancements in the modeled environment, the team assumed 10-minute headway overlay service on all of the PCN corridors while keeping the base, local route headways the same as baseline model conditions.

Results from each segment were then analyzed to determine if a bus-only lane was "warranted" based on two auto related and two transit related criteria:

- 2030 Bus Ridership
- Change in bus ridership 2030 no build vs. 2030 full build
- Adjacent lane volume/capacity ratio
- Reduction in auto trips

Reviewing the quantitative results of these criteria for each segment created a basic "warrant" check and helped determine the segments where transit-only travel lanes were and were not justified. For the segments where a transit-only lane was not justified, it was assumed that small intersection- level running-way improvements would still be made in order to support the PCN system such as transit signal priority or queue jump implementation.

The resulting network was called the "Modified" network. Approximately 90 miles of the total 235-mile PCN system "warranted" a bus only lane, while the rest of the system only warranted spot level improvements.

Table 1: PCN Evaluation Results

PCN Scenario	Operational Cost (over 20 years, in $millions)	Capital Cost ($millions)	New Transit Riders	Transit Riders Diverted from Rail
Full Build	$0	$1,175	>115,000	>100,000
Modified	$840	$500	>100,000	>90,000
Service Only	$1,200	$0	Similar to Modified	0

Table 1 shows the modified network attracted over 100,000 new daily transit riders to the regional system. Additionally, the modified network diverted over 90,000 daily riders from the Metrorail system, relieving some of the capacity concerns for the system and possibly deferring major capital expansion of the heavy rail system by years. The transit ridership in the PCN corridors themselves increased 25% over the baseline 2030 analysis.

The conclusion from this evaluation was that the priority bus measures evaluated demonstrated a clear potential benefit that warrants further development, but that the location of such measures requires case specific analyses to create optimal results. WMATA has begun to prioritize sections of the PCN network that would be most beneficial. These guidelines are one element of that program, but have applicability beyond the PCN program for any bus priority improvements in the Washington D.C. region.

What Are Priority Bus Treatments?

Priority bus treatments are modifications of either the operations or the environment in which buses operate that improve speeds, reduce delays or otherwise benefit bus operations by improving reliability or attractiveness to patrons.

Operating Environment

Changes to the operating environment include:

1. Transit Signal Priority (TSP) gives some or all buses an advantage at signals by extending or advancing green light time for them to allow buses to avoid having to stop.
2. Exclusive bus lanes can be as simple as designating a traffic lane for buses only, or can be as involved as building an exclusive bus guideway apart from the street.
3. Bus stop bulbs add a reserved platform area in parking lanes, extending the bus stop and sidewalk into the parking lane at stop locations.
4. Queue jumps and bottleneck bypasses include short bus-only lanes near congested intersections that allow a bus to pass through a signal in advance of competing traffic. They

can include adding a “bus only” green light in advance of the general traffic green light. The objective of these options is to allow buses to go to the front of the line at intersections when waiting for a signal to change.

5. Bus stations are a top end version of a bus stop that includes more passenger amenities, potentially real-time bus information or off-board fare equipment.
6. Level boarding is the ability of patrons to enter or exit a bus without stepping up or down from the vehicle. Decreasing entry and exit times affects stop dwell times, and, in turn, overall travel times.
7. Crosswalks are important to bus operations because transit users must access or egress bus stops on foot.

These treatments are summarized in the following pages of this section.

Transit Signal Priority

Transit Signal Priority (TSP) is the process by which an advantage is given to transit vehicles operating along a roadway using traffic signals. The advantage can be received through the extension of green time for buses approaching an intersection or advancing green time for buses waiting at an intersection. The use of TSP can be an all day benefit, a peak hour benefit, or some other defined time period of the day. Signal priority can be implemented at single intersections or throughout an entire corridor or system. Conditional signal priority systems can be tied to the bus schedule, only giving priority when a bus is behind schedule. Unconditional systems provide the benefit to the bus every time it approaches an intersection regardless of schedule. The latter ensure that buses not only remain on schedule, but also improve travel times overall. This increases transit’s appeal to potential riders. Advantages can also be gained through the coordination or retiming of signals to accommodate bus travel patterns. This more closely matches signal timing with bus speeds, reducing delays for buses and reducing travel times for the passengers.

TSP can improve the person throughput of an intersection. Traditional level-of-service (LOS) measures do not recognize this aspect because they only account for individual vehicles passing through an intersection. Comparing the number of people moving through a given intersection versus the number of vehicles would produce different results as a measure of LOS. It should also be noted that general traffic can benefit from transit signal priority. When the “mainline” is given an extended green phase not only does the bus benefit, but so do all the vehicles traveling through the intersection around the bus. In this instance, TSP does not just benefit transit. Where there have been negative impacts to traffic, in general those impacts have been shown to be minor. In Los Angeles, the cross street traffic saw an increase in delay of one second per vehicle associated with a decrease in transit running time of almost 8 percent. Delays caused by signals decreased by about 30 percent.

Signal priority can be accomplished through passive means where the signals are retimed to account for transit travel speeds, or active means whereby the bus “announces” its approach to a signal and the signal adjusts the timing based on predetermined parameters. Transit signal priority is different from signal preemption where the signal progression is interrupted.

> "Transit signal priority modifies the normal signal operation process to better accommodate transit vehicles, while preemption interrupts the normal process for special events such as an approaching train or responding fire engine" (Baker, et al. 2004).

Pre-implementation analysis associated with TSP will vary depending on the system chosen. A passive approach would only require an analysis of existing bus operations as part of a signal timing study. Signals would then be retimed based on the results.

An active approach to signal priority would require the purchase of equipment to be installed on the bus that would "announce" when the bus is approaching a TSP equipped intersection. There are a variety of systems available for this including radio frequency or infrared technology. The signal would require a device that could detect the signal coming from the bus and then communicate to the signal controller that a bus is approaching. Most signal controllers today have the capability to process this request and provide the priority. A signal study would determine the necessary equipment upgrades and changes that would be made to provide TSP.

The more complicated system of providing priority only when the bus is behind schedule would require automotive vehicle locator (AVL) equipment and software. AVL allows for real-time tracking of the bus. The ability to know where the bus is at all times provides an added benefit of knowing when the bus is behind schedule. This software and the TSP software would need to interface and make a determination when the priority should be given to the bus.

Exclusive/Restricted Lanes

The most significant element of a bus priority system is often the running way. Significant in this case means in terms of benefits, appearance, cost and difficulty of securing. When the trolleys that occupied the center of many American cities' major streets (e.g. Florida Avenue, Connecticut Avenue, Wisconsin Avenue, Rhode Island Avenue, and Pennsylvania Avenue in the DC area) were discontinued, control of the entire roadway for the benefit of the automobile was the result. To take back some portion of some of those roadways for exclusive public transit use would impact current road users. In fact, there is recent history pointing to a rethinking of how best to use public rights-of-way with consideration of other uses (pedestrians and bicyclists) commonly referred to as "complete streets." As the uses to which public thoroughfares will be put are under reconsideration, it is imperative that public transit be among the multiple uses considered and accommodated.

There is a hierarchy of lane exclusivity, with fully exclusive bus lanes and restricted lanes most appropriate where streets operate at level of service A, B, or C. Where traffic is operating at level of service D the question of exclusive or restricted lanes must be decided on a case-by-case basis. Where traffic is operating at level of service E or worse, it is unlikely exclusive lanes are acceptable.

Priority transit does not require an exclusive transit lane; however, where there are sufficient buses already in operation or planned, formal designation of the outside lane as a bus lane may be justified, since a curb lane heavily used by buses may be a *de facto* bus lane, albeit without some of the benefits.

Designation of a lane for buses can be full time, only during rush hours or even only during non-rush hours. Each has its benefits and costs. Designating a bus lane for only operations during the dead of night would have the fewest implications for traffic but would generally have virtually no benefit for transit either. Designating a lane throughout the day would have the greatest implications for traffic and the greatest benefit for transit operations. This guidebook explores some of the considerations for making a determination of whether and for what times a traffic lane could be designated a bus lane.

Another alternative form of exclusive lane is restricted to buses and high occupancy vehicles (HOVs), or buses, HOVs and bicycles. Such a restricted lane can garner many of the benefits of a bus only lane, yet accommodate other commuters at the same time. The issues introduced by permitting HOV or bikes to use a bus lane are enforcement and capacity. The District of Columbia Department of Transportation (DDOT) has operated combined bus and bike lanes on 7th and 9th Streets NW with mixed success in terms of enforcement. At some point the number of bikes and HOVs affects the speeds of the buses, and in the worst case so reduces the benefits of an exclusive lane as to make it of little value for transit users. Ultimately, a toolbox of differently restricted lanes is available to planners and engineers depending on the solution needed.

Bus Stop Bulbs

Bus bulbs (Figure 2) extend the sidewalk at a bus stop into a parking lane, allowing buses to stop within a few inches of the relocated curb. They are useful where there is a permanent parking lane, but are not appropriate where the curb lane is not for parking but is a moving traffic lane. As such, bus bulbs overcome the problem of accessing buses across a parking lane. The amount of space required is typically about one parking space in length but for high capacity stops a bus bulb should match the door spacing of the longest buses using the stop.

If the curb lane has moving traffic during rush hours but parking otherwise, a bus bulb is not a practical solution. Bus bulbs are often integrated into bulb-outs that improve pedestrian crossings at intersections, shortening the length of the crosswalks and eliminating the problem of pedestrians being less visible behind a row of parked cars. Bus bulb design should also consider cyclist traffic along the route and integrate bike cut-throughs if necessary.

Figure 2: Example of a Bus Bulb

Source: MTA NYC Transit

Queue Jumps and Bottleneck Bypasses

Where an exclusive bus lane is not available, queue jumpers (Figure 3) may provide a benefit at selected intersections. A queue jumper allows a bus to cross an intersection before the rest of the traffic may proceed – getting "a jump" on the next segment. A queue jumper may be constructed in two forms: as a stand-alone pull-in area at an intersection approach with a near-side bus stop, or with the pull in area and a receiving lane in the departure leg of the intersection with a far-side bus stop (Figure 16 for a diagram of bus stop locations). The benefit of a queue jumper is the other vehicles that are often quicker accelerating and tend to squeeze into the lane the bus is using are held back. If all the traffic past the intersection is doing is sitting this does not amount to much of an advantage, but if traffic is moving it can enhance the bus's ability to keep up with traffic.

Figure 3: Example of a Queue Jump

Source: National Bus Rapid Transit Institute

A bottleneck bypass is usually a lane created for a bus to edge around a line of stopped vehicles. It can take the form of a "jug handle" or hook turn where left turning vehicles approach the intersection in the outside lane and are directed through a short exclusive lane that then allows them to enter the crossing roadway away from the intersection, relieving the original intersection of the need to accommodate left turns.

Bus Stations

The simplest bus stop has only a pole or sign designating it is where buses stop. The grandest stops are stations with benches, weather protection, possibly fare equipment and even passenger information systems. To make it easier for users to identify express stops it is recommended that they be distinctive from other stops and include shelters with seating and passenger information (at least posted schedules and maps if not real time information). They should be well lit, easily accessed and attractive. They must appear safe. The level of amenity and refinement that is appropriate is a matter of judgment and financial capability. Full stations can include the same level of facilities as would a rail transit station up to and including parking for commuters. One of the typical issues with bus stations is being able to provide sufficient space for them and their potential effect on sidewalk space since they can consume substantial curb length and depth. Whatever level of station or stop is planned, they must meet ADA requirement including adequate clearances to buses and shelters.

Level Boarding

Being able to enter and leave a vehicle without negotiating steps significantly reduces dwell times for buses at stops. Level boarding also dramatically improves access for the mobility impaired and elderly. To achieve level boarding the curb height and bus floor heights must be at about the same level. In the WMATA system low floor buses have a 7 inch floor height. Curbs significantly taller than that obstruct the doors (if the bus is close enough to the curb for convenient boarding). Level boarding requires the buses be able to parallel the curb. A bus stopping more than a few inches from the curb cannot achieve level boarding, which is one reason for bus bulbs.

Crosswalks

The need for transit riders to be able to safely cross an intersection is paramount. Very rarely does the bus pick someone up at their home or drop them off exactly at their destination. This makes pedestrian access to transit stops a key consideration in planning service. Safety and convenience are factors that should be considered when designing crosswalks.

The goal of priority transit is to attract more riders. Bus stop accessibility can impact transit ridership. If a rider has a well defined, easy to use, and safe way to access the bus stop, there is a greater likelihood they will chose transit. The inclusion of crosswalks in a discussion of priority transit and consideration of pedestrian crossing times versus traffic signal cycles weights the benefits to the users of the transit system and also all pedestrians.

Crosswalks should be clearly defined, directing the pedestrian where to cross the street. At a minimum, this should include a striped crosswalk. Additional treatments could include colored/textured pavement, vertical deflection (e.g. Raised crosswalks), grade-separation, and/or pedestrian signals. Consideration for pedestrian sight lines should also be made. The location of the bus stop should be a consideration too. Choosing a location that would place the pedestrian in a potentially hazardous situation when crossing the street would not be ideal.

Large intersections may be ideal locations for improvements such as bus bulbs. While these improvements are designed to provide a convenient way for the bus to access passengers, they can also provide a safer pedestrian environment. The bus bulb shortens the distance across an intersection. This reduces the distance a pedestrian needs to cross in addition to providing a design element that can passively slow traffic. It also improves safety and accessibility for mobility impaired individuals.

This guidebook makes frequent references to highway level of service (LOS). It is useful for readers to understand what is generally meant by level of service A, B, C, etc. in the context of where certain priority transit strategies may be applicable. Table 2 provides an overview of the LOS letter categories for urban streets. Readers interested in more detailed information are encouraged to reference the *2000 Highway Capacity Manual (HCM2000)* from the Transportation Research Board (or the soon to be released 2010 HCM).

Table 2: Overview of Level of Service for Urban Streets[1]

Level of Service Category	Description of Traffic
A	Primarily free-flow operations at average travel speeds. Vehicles are completely unimpeded in their ability to maneuver within the traffic stream. Control delay at signalized intersections is minimal.
B	Reasonably unimpeded operations at average travel speeds. The ability to maneuver within the traffic stream is only slightly restricted, and control delays at signalized intersections are not significant.
C	Stable operations; however, ability to maneuver and change lanes in midblock locations may be more restricted than at LOS B.
D	Borders on a range in which small increases in flow may cause substantial increase in delays and decreases in travel speed.
E	Characterized by significant delays on the street segment and at signalized intersections.
F	Characterized by urban street flow at extremely low speeds. Intersection congestion is likely at critical signalized locations, with high delays, high volumes, and extensive queuing.

[1] Adapted from Transportation Research Board (2000)

Chapter 2: Street Segments

Running Way

Enhancing the running way for transit vehicles can have dramatic results on transit users' travel time. Improvements in travel time have been shown to increase ridership while lowering operating costs. There are basically three types of lane treatments:

- Exclusive: A lane is reserved solely for use by buses or solely by buses and other government vehicles such as emergency vehicles.
- Restricted: A lane is reserved for buses (with or without emergency vehicles) and High Occupancy Vehicles (HOVs) such as car pools. Depending on the restrictions, general traffic may also use the lane upon approaching an intersection to make turning movements.
- Unrestricted: Buses operate in mixed traffic with no special provisions to improve operations.

There are a number of considerations to be addressed before a lane is restricted or made exclusive. Those considerations can be categorized by applicability, potential benefits, potential impacts and other considerations.

Table 3 summarizes those considerations for each treatment.

Table 3: Lane Treatment Considerations

Exclusive Lanes
Applicability
High volume streets operating at levels of service A, B or C.
Potential Benefits
Improved bus schedule reliability, higher bus speeds
Potential Impacts
Reduction of private vehicle capacity or increased congestion of remaining mixed traffic lanes, elimination of curb parking spaces.
Considerations
Traffic impacts, reduction of parking capacity, turning movements
Restricted Lanes
Applicability
High volume streets operating at levels of service A, B or C.
Potential Benefits
Improved bus schedule reliability, slightly higher bus speeds, HOV capacity
Potential Impacts
Less reduction of private vehicle capacity but risk of bus delays by HOV's, elimination of curb lane parking
Considerations
Untrained drivers use of lane, signage, enforcement, safety and turning movements
Unrestricted Lanes
Applicability
High volume streets operating at levels of service E or F
Potential Benefits
Designated stop space, potential to provide a bus shelter and paved landing pad
Potential Impacts
Little or no improvement in bus operations
Considerations
Unchanged operational environment for buses

The following options are treatments that could be considered for the bus running way.

On-Street Exclusive Bus Lane

On-street exclusive bus lanes provide separation of the transit vehicle from other traffic. This separation allows the bus to avoid congestion, which ultimately improves travel times, capacity, and schedule reliability. These three factors correlate directly with improvements in ridership. Bus lanes have restrictions that prohibit other vehicles from parking or stopping within them, but can allow vehicles to enter near intersections to allow for turning movements. On-street bus lanes typically do not have physical barriers that separate the lane from mixed traffic, nor are they grade separated. Several different characteristics may distinguish a bus lane:

- Markings
- Signage
- Barriers
- Location of the lane within the road
- Flow of the lane
- Operational characteristics of the lane
- Vehicle restrictions (H. S. Levinson, et al. 2003)

The following frequently asked questions relate to the creation of an exclusive bus use.

(Q) How can it be determined whether an exclusive bus lane should be considered?

(A) There are some general guidelines that can be used. The Transportation Research Board states that bus lanes may be warranted when peak hour bus volumes are between 30-40 buses per hour and passenger volumes are 1,200 or higher per hour in a corridor[2]. The second guideline considered is when the buses currently or are expected to carry as many people as the automobiles traveling in the remaining lanes (Vuchic 2007). These guidelines may also be considered with respect to anticipated or forecast future ridership in a corridor or segment.

(Q) What will the impact on traffic be when a lane is used for buses only?

(A) Each situation is different and requires analysis to determine the benefits of implementation. Formulas are available that can determine the impact of dedicating a lane to buses based on known traffic volumes. Important considerations are the existing surrounding street network and the opportunities for drivers to choose alternative paths to their destination. Also, the ability for drivers to opt for a shift in travel mode should be factored. A significant improvement in bus service should prompt some drivers to switch to taking the bus (Kittleson & Associates, Inc. 2007).

[2] Exhibit 4-37 – General Planning Guidelines for Bus Preferential Treatments: Urban Streets; TCRP Report 100 Transit Capacity and Quality of Service Manual – 2nd Edition Part 4 Bus Transit Capacity; Transportation Research Board, 2003.

The 2010 edition of the Highway Capacity Manual will reflect a more multimodal perspective than formerly. It will include sections on the measurement of levels of service for transit, bicycles and autos. In this way it will be possible to assess the relative level of service impacts of reserving a lane for transit on all users. This more comprehensive perspective to measuring impacts included in the HCM 2010 is becoming more accepted by traffic engineers and is consistent with the concepts explored here in this guidelines document.

(Q) Will the entire transit corridor need to have an exclusive bus lane?

(A) No, Exclusive bus lanes do not need to span the entire length of a given transit corridor to achieve the desired benefits of the treatment. Sections of a corridor where it makes sense from a financial and operational standpoint should be considered for exclusive bus lanes (H. S. Levinson, et al. 2003).

(Q) Will parking need to be removed from the street?

(A) Not necessarily. Segments where it has been determined that on-street parking is a critical need can use a middle or median lane for a bus lane. The use of a middle lane often requires construction of a bus bulb or island stop. These stops enable buses to remain in the bus lane when stationing. This avoids the need for buses to weave in and out of traffic, ensures access for people with disabilities, and speeds bus service. Other considerations could be parking restrictions that allow for parking during off-peak hours or some other specified time frame. It is important to consider that removing parking to provide a bus lane does not impact existing traffic capacities. The removal of parking also allows the bus easy and safer access to customers on the sidewalk without additional construction and removes the conflicts between traveling buses and vehicles parking.

Streets where parking has been removed to accommodate a bus lane have shown a reduction in collisions (15%-20%) and an overall increase in travel speeds. Parking should not be in place on heavily congested streets, especially during peak travel times. Parking should be removed from a street where an exclusive bus lane is being considered for the curb lane during the following conditions - traffic volumes are between 500-600 vehicles per lane per hour, Level of Service (LOS) for the street is "E" or "F", and travel speeds fall below 20 MPH (H. S. Levinson, et al. 2003).

(Q) Does a bus lane need to be a specific width?

(A) It is desirable to have at least an 11 foot lane. This allows for the accommodation of an 8.5 foot wide bus. If possible, 12-13 foot wide lanes should be used

(H. S. Levinson, et al. 2003). WMATA recommends a minimum of 12' for a bus lane consistent with TCRP Report 19: Guidelines for the Location and Design of Bus Stops.

Lane Location

The location of an exclusive bus lane within the roadway can determine the impact of many of the other factors associated with an exclusive lane. There are four locations considered for the purposes of this guidebook, shown in Figure 4:

1. Outside lane/curb lane
2. Middle lane
3. Center lane
4. Median lane

Each location has its own pros and cons as well as design features to be considered. There is no definitive rule for determining which location should be used in each case. Careful analysis of the characteristics of the corridor being considered for an exclusive lane should be conducted. This analysis should look at traffic flows, turning movements, roadway design, parking restrictions, and traffic signal design. Table 4 provides some of the pros and cons associated with the four different locations. Following Table 4 are questions related to location of an exclusive lane.

Figure 4: Guidebook Lane Terminology

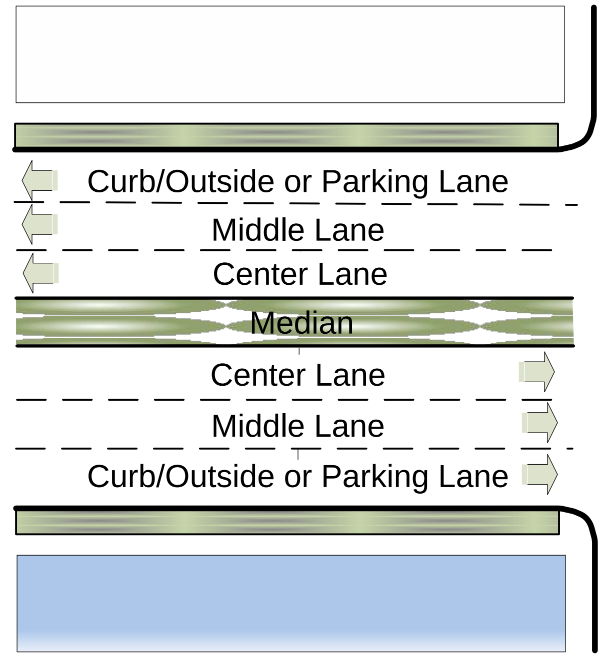


Table 4: Pros & Cons of Different Lane Use for Exclusive Bus Use

Lane Used	Pros	Cons	Application
Outside 	• Lowest cost of installation • Typically occupies less street space • Lower capital costs associated with bus stops • Easier/Safer Pedestrian Access	• Conflicts with on-street deliveries and other curb access needs • Conflicts with right turns • Conflicts with bicycle travel • Lower transit travel times savings • Requires removal of on-street parking • Does not provide strong image to priority service • Can be difficult to enforce	• Restricted lane use; may permit HOVs, must accommodate turning vehicles, often restricted to peak periods only
Middle 	• Allows for on-street parking • Removes conflicts with illegally parked vehicles • Allow bus to avoid delays from turning vehicles	• Conflicts with cars parking • May require bus to pull out of traffic or construction of a bus bulb in order to access passengers • Strict enforcement needed	• Restricted lane use with HOV, turning vehicles, and peak-period only while allowing on-street parking
Center 	• Moves bus operations away from the curb and sidewalk	• Conflicts with left turns • May require medians or islands with ample space to accommodate passengers waiting • May require buses with driver-side doors for passenger boarding	• Restricted lane use; may permit HOVs, must accommodate turning vehicles, often restricted to peak periods only
Median 	• Clearly separates the bus stop from sidewalk activity • Provides a strong sense of identity to the priority bus • Enables contra-flow bus operation • Best option for future conversion to streetcars / LRT	• Pedestrian access more challenging • Requires the most space and greatest street width • Safety considerations involving wayward vehicles • Conflicts with left turns • Restricts flexibility of bus operation in using general traffic lanes or entering and exiting bus lane	• 24/7 dedicated bus-only with physical separation

(Q) What considerations are needed when placing the bus lane in an outside lane?

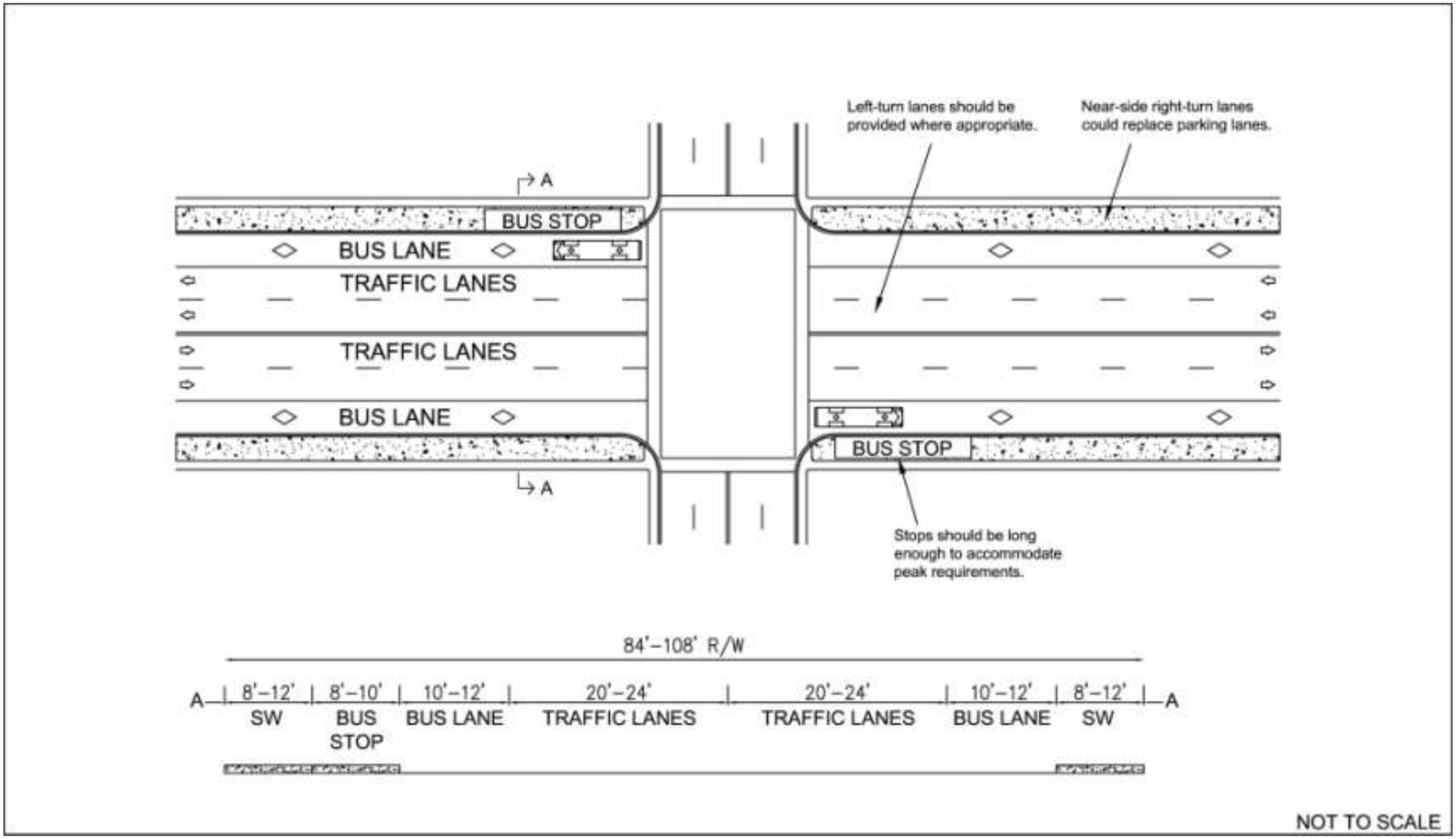
(A) While use of an outside lane as an exclusive bus lane is desired as a full-time restriction to enforce the identity of a priority transit service, often the outside lane is restricted to bus use only during specific time periods (peak travel periods). Typically, parking will be restricted during these time periods that the bus has exclusive use of the lane. Some jurisdictions permit vehicles to use the restricted lane if they are turning right at the next intersection. This provides a low cost solution to improving transit service during peak travel times without impacting traffic by removing a general travel lane or limiting turning movements.

The outside lane should be at least 11 feet wide, preferably 13 feet. Wider lane widths or a second middle lane should be considered in instances where there are heavy volumes of curb-side deliveries or bus volumes approach 100 buses per hour. Lanes should be marked with a wider solid white line to denote the special restriction along with signage along the street and possibly overhead on mast arms showing when the restriction is in effect. Additional design features may involve raised lane delineators as an additional visual and tactile cue that the lane is not a general travel lane (H. S. Levinson, et al. 2003).

The design and physical condition of the outside lane should also be examined. Locations where the road is crowned may produce issues.

Figure 5 provides the configuration of an outside lane bus lane.

FIGURE 5: BUS LANE IN OUTSIDE LANE



BRT Operating in the Outside Lane (Las Vegas, Nevada)

Project Overview: In 2004, MAX began operating 10 buses and serving 22 stops. A major arterial street overlay project completed a few years earlier by the state DOT involved both pavement resurfacing and a new lane configuration, which made available an extra outside lane where there was previously a shoulder. The state DOT, transit operator, and city government agreed to convert this lane into a transit-only lane, which now covers 7.8 miles.

Key Stakeholders: This project was planned and implemented by the Regional Transportation Commission of Southern Nevada which includes the MPO, the transit authority and traffic engineering. To have the main parties involved all housed within one agency was an extraordinary coordination advantage for this project.

Project Cost: The total project cost was $20.3 million.

Impact on Transit: Within the 1st year, travel time along the corridor decreased by 40% and ridership increased by 30%.

Impact on Traffic: There was minimal impact to the traffic due to the bus only lane.

Lessons Learned: The project had a lot of location specific, environmental implementation issues.

Source: Regional Transportation Commission of Southern Nevada; FTA

(Q) Are cars prohibited from making right turn movements from a bus lane using the outside lane?

(A) Not necessarily. Restrictions can be modified to allow vehicles to make a right turn using an outside bus lane. These restrictions do remove potential conflicts that occur between buses traveling through an intersection and vehicles attempting to make a right hand turn from a middle lane.

(Q) What are the benefits of prohibiting right turns by general traffic?

(A) Placing right turn restrictions can improve travel time savings by reducing the delay a bus would encounter at intersections where right turns would otherwise occur. The combination of right turning traffic and heavy pedestrian flows can combine to create significant travel time delays for transit vehicles operating in the outside lane. These time savings can be calculated using HCM or other methods of intersection analysis that include the number of pedestrians crossing an intersection and the number of right turns occurring during a signal cycle. These time savings would need to be weighed against the impact of prohibiting vehicles from turning right.

Another consideration would be to restrict turning movements to specific times of day, which is already done in many cities during the morning and evening rush. When turning is allowed from the bus lane, the solid line should be transitioned into a dotted line showing that general traffic is allowed access to the lane (H. S. Levinson, et al. 2003).

(Q) In what situations would a middle exclusive lane be considered as a bus lane?

(A) Use of the middle lane can be considered when curb-side parking removal is not an option. This option is another lower cost alternative to the median bus lane. Lane should be at minimum 11 feet wide. Special lane markings, colors, or textures should be used to differentiate the exclusive lane from general traffic lanes. Depending on the width of the road segment, it is desirable to create a left turn lane so that a bus needing to make a left turn can exit the exclusive lane and not interfere with through traffic.

Right turn movements can be made from the exclusive lane or removal of parking can be done on the approach will allow for a right turn lane that does not impact bus travel. Construction of bus bulbs on the far-side of the intersection allows the bus to stop and pick up passengers without needing to pull out of

Middle Bus Lane (Boston, Massachusetts)

Project Overview: In 2002, Phase I of the Silver Line began operating along Washington Street. Sixty-foot buses run along dedicated lanes for the majority of the route. Bikes and cars making right hand turns are permitted to use the bus lane. The reconstruction of Washington Street created 2 general traffic lanes, 2 bus lanes and 2 curbside parking lanes.

Key Stakeholders: The project was a joint effort by Massachusetts Bay Transportation Authority (MBTA), Massachusetts Highway Department and the City of Boston.

Impact on Transit: It had a very positive impact on transit, including weekday boardings increasing by 96% between 2001 and 2005 compared to the original bus route. However, increased headways are currently an issue because the buses are operating in small portions of mixed use traffic lanes. PM travel times have dropped as much as 25% compared to surface mixed traffic operations.

Impact to Traffic/Lessons Learned: As a result of the mixed traffic operations, the project partners are working on implementing Transit Signal Priority in the corridor. In addition, MBTA has been much more successful keeping cars out of the bus only lanes in other corridors if they are painted red. Therefore, Washington Street's bus lanes will soon be painted red and have enhanced signage. Finally, it is important to note that this project spurred significant real estate investment along the corridor a few years before implementation which has continued to this day.

Source: MBTA

the travel lane or interfere with turning movements. This design feature also creates a unique location where passengers can wait that does not impact pedestrian flow along the sidewalk. Two considerations for use of the middle lane are the potential for conflicts occurring between buses and vehicles attempting to park or leave a parking spot and the need for strict enforcement of the bus only restriction (H. S. Levinson, et al. 2003).

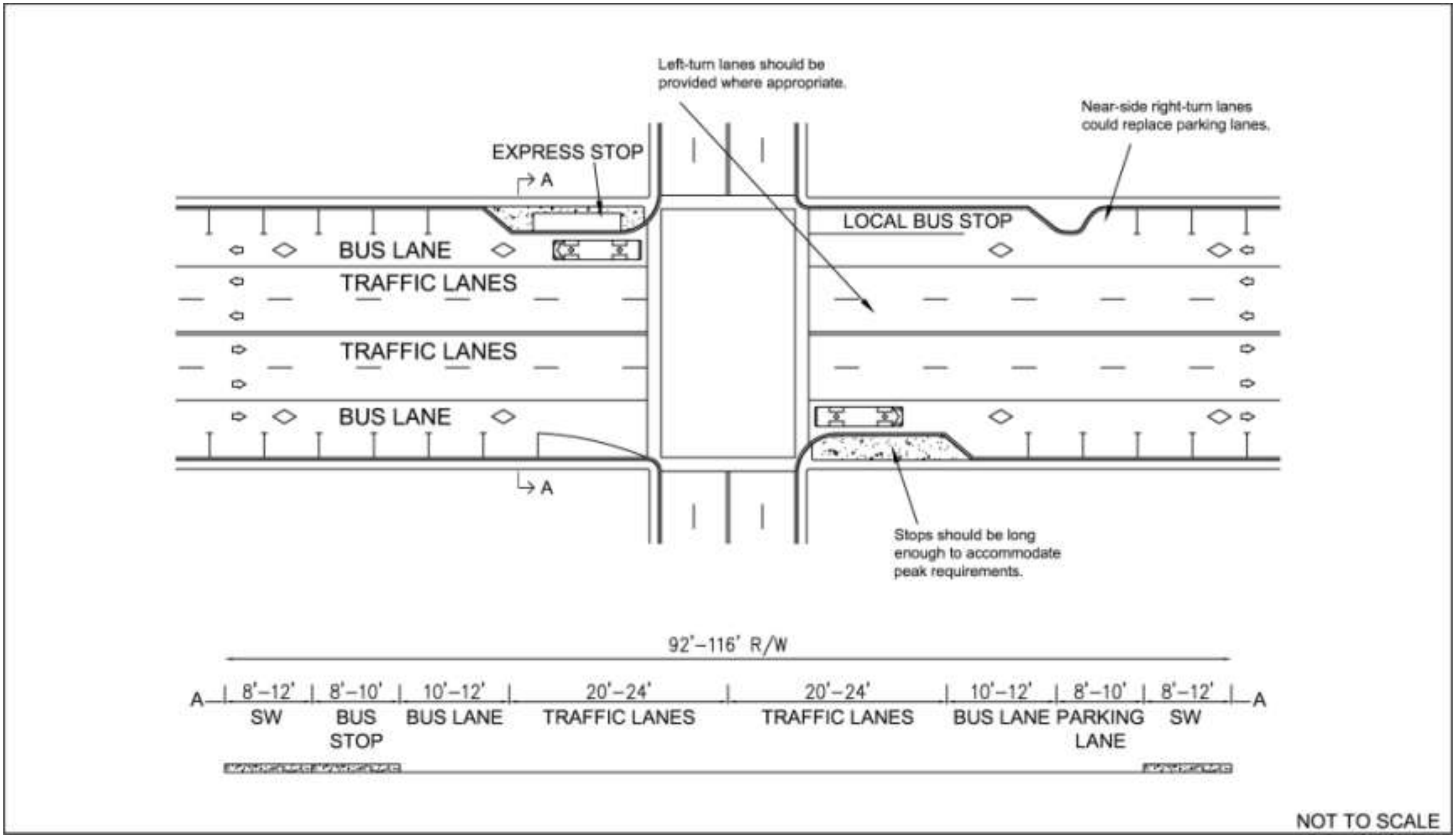
Consideration of a middle bus lane should examine potential conflicts between buses and vehicles accessing adjacent on-street parking, as well as vehicles searching for on-street parking and vehicles leaving parking spaces and weaving (across the bus lane) to access the center lane of the roadway. The severity of these conflicts will depend not only on congestion in the vehicle lane but also on turnover of on-street parking spaces and on bus frequency in the bus lane.

Figure 6 shows a middle lane bus lane with on street parking. Figure 7 is a schematic drawing of a similar application showing typical dimensions.

Figure 6: Middle Bus Lane With On-Street Parking in Cleveland, Ohio

SOURCE: NATIONAL BUS RAPID TRANSIT INSTITUTE

Figure 7: Middle Bus Lane with On-Street Parking



(Q) What considerations are needed when placing the bus lane in a center lane?

(A) When operating buses in a center lane there are a number of considerations. The first needs to be reducing the potential conflicts between priority buses and general traffic. The biggest conflict will occur between buses and vehicles attempting to turn left. It would be ideal to limit or prohibit left turning vehicles, but this would be unrealistic for an entire corridor. It is recommended that where possible, left-turn lanes should be used. This will allow traffic to turn left without blocking the travel lane for the bus. Lane striping should be used to communicate where it is appropriate to cross into the bus lane when accessing a turn lane. In situations where the design constraints won't allow for a left-turn lane, traffic signals should be used to clear the bus lane of turning traffic early in the cycle. This will help reduce the delays that would be associated with vehicles attempting to turn left from the bus lane.

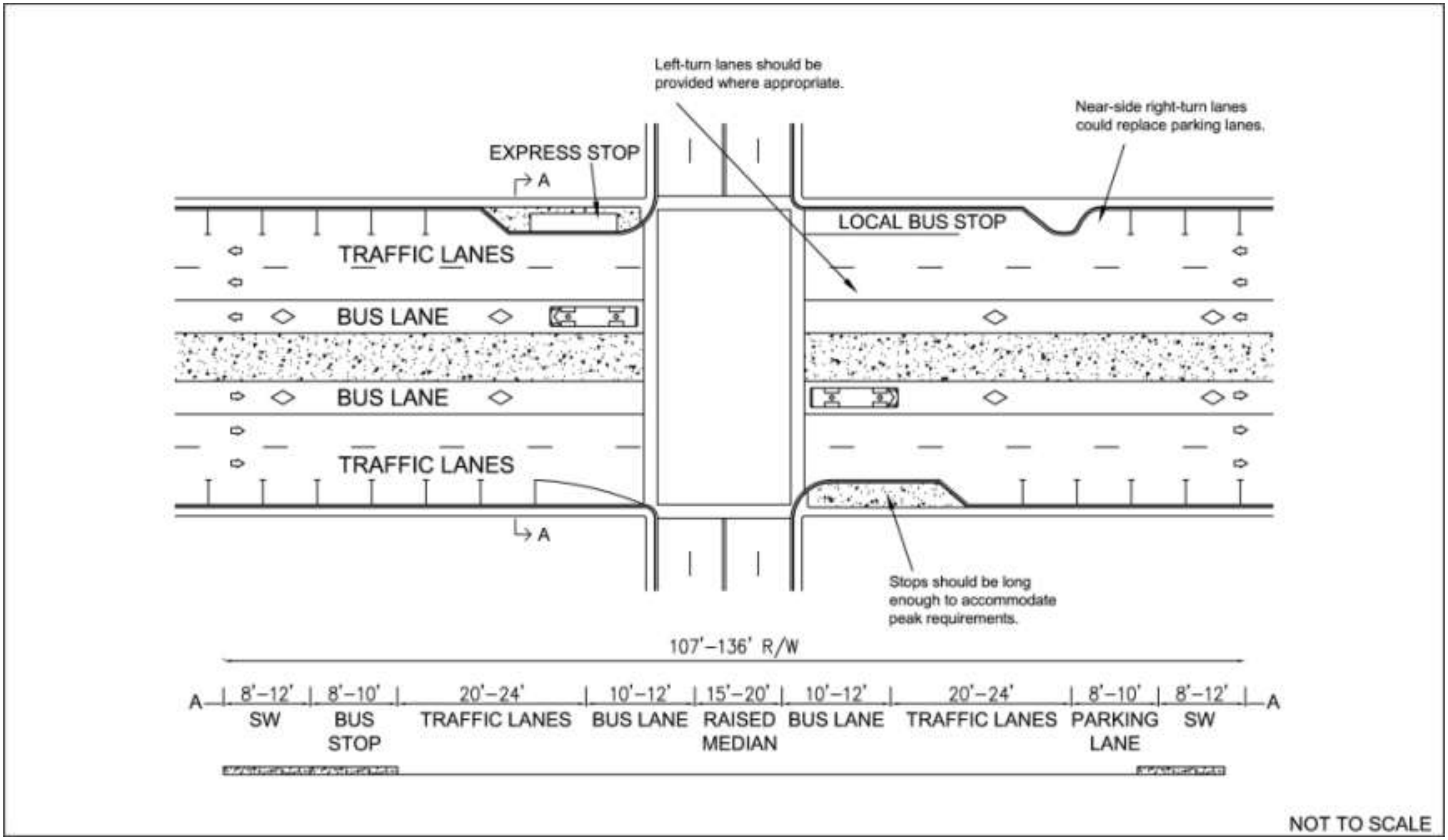
The second consideration relates to placement of the bus stop and station area. Most buses are designed with the doors on the right side of the bus. When using the center lane for bus operations it may be difficult due to space constraints to build an island between the center lane and interior lanes. This type of bus stop would also present issues in routing traffic and pedestrian access. The other option is to place the stop in the median and use buses that have doors on the left side or doors on both sides. These buses would be limited to operating only on routes that have stops located on the left side of the bus. The benefit would be that a single stop could serve both directions of travel (H. S. Levinson, et al. 2003).

(Q) How large should the median be when locating a bus stop?

(A) The median should be approximately 20 feet in width to accommodate waiting passengers and any amenities such as shelters or benches. The median should be sufficiently large to accommodate the shelter being used while also allowing ample clearance on the sides to address ADA Design Guidelines as discussed in the shelters section in Chapter 4. The length of the stop should be sufficiently long to accommodate the size of the vehicle being used as well as the number of vehicles that may stop at any one time (H. S. Levinson, et al. 2003).

Figure 8 shows typical dimensions for a center lane bus lane.

FIGURE 8: CENTER BUS LANE



(Q) Should Local buses use a center lane bus lane?

(A) The center lane should not be used by local buses. Local buses typically stop more frequently due to the higher number of stops used on local service. This would require the construction of more median located bus stops or more bus stop islands, increasing costs. The frequent stopping of local buses would also impact travel times of priority buses. It is preferable and recommended that local buses continue to serve the curb side of the street when operating priority bus in the center lane (H. S. Levinson, et al. 2003).

(Q) What considerations are needed when placing the bus lane in a median lane?

(A) Special considerations when using the median lane for a bus lane primarily relate to safety issues. The first involves pedestrians accessing the median to access the bus stop. Appropriate pedestrian signals, signage, and pavement markings should be in place to ensure safe crossing by pedestrians. Ensuring the location meets all accessibility guidelines for ADA compliance is also essential. A second consideration for median bus lanes is having the necessary space to accommodate waiting passengers and possibly transit shelters, fare collection devices, and other amenities. This will always require a physical median or island station with a raised curb edge and sufficient width. Ensuring that the passenger waiting area is protected from potentially wayward vehicles should also be a key consideration.

Figure 9 shows a median bus lane in Eugene, Oregon.

Median bus lanes can be separated from general traffic with a special marking or signage. Whenever possible, it is desirable to have median bus lanes physically separated from the surrounding traffic. This separation improves operations and safety. When considering median

Figure 9: Example of Median Bus Lane in Eugene, Oregon

SOURCE: NATIONAL BUS RAPID TRANSIT INSTITUTE

bus lanes for a four-lane major arterial, the roadway should be at least 75 feet wide to accommodate the necessary design features. In most instances, the necessary curb to curb distance required will be greater. It is advisable to allow enough space to accommodate two bus lanes, one for each direction, space for a passenger platform, and space for the physical barrier. For a bus-only roadway, between 32 feet and 36 feet should be sufficient for the above features. In situations where space is at a premium to dedicate for an exclusive bus lane, a single lane can be built that would operate in the peak direction only; traveling "inbound" during the morning and "outbound" in the evening (H. S. Levinson, et al. 2003).

(Q) Would left hand turns need to be prohibited when an exclusive bus lane is in the median lane?

(A) It is advisable to prohibit left hand turns along corridors where an exclusive bus lane is located in the median lane. This reduces conflicts and improves safety along the corridor while also decreasing travel times. In many instances, it may be infeasible to remove all left hand turns from a corridor. In these instances, it is advisable to place a protected left turn phase in the traffic signal for the lane next to a median bus lane. A protected left signal phase will reduce the potential for conflicts between buses and vehicles turning left as well as limit the queuing of vehicles attempting to turn left.

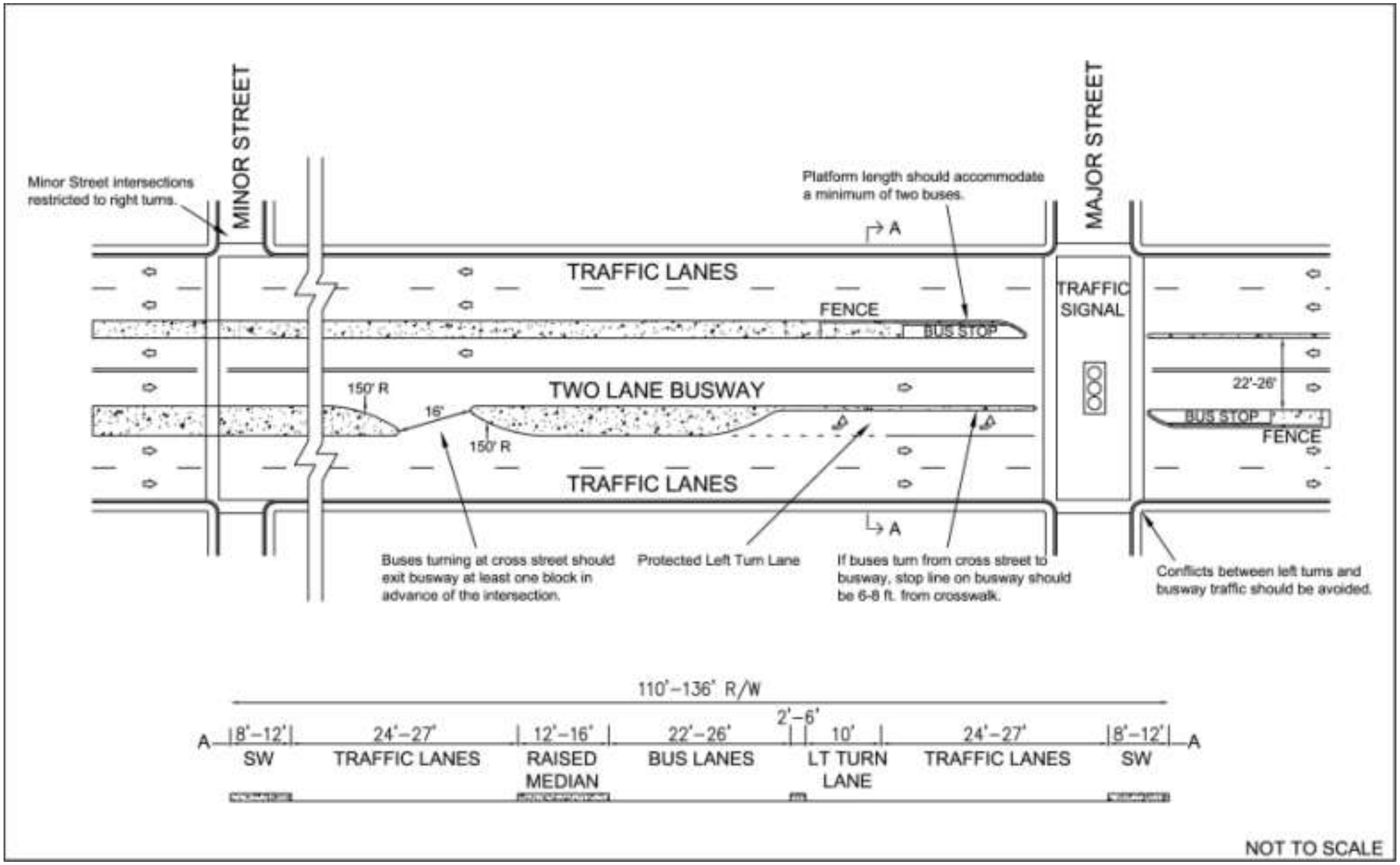
It is also advisable to place bus stops on the far-side of the intersection when considering median bus lanes. This allows the bus to continue traveling after picking up passengers without being held by a left-turn signal and removes the bus from the intersection and potential conflicts with turning vehicles (H. S. Levinson, et al. 2003).

(Q) What is mid-segment entry or egress from the median lane?

(A) Specific issues such as mid-segment egress and stop location would need to be evaluated on a case-specific basis by area traffic engineers and transit planners. Mid-segment entry / egress from a median bus lane may be needed in certain cases where locating a bus stop in the median is not possible and the bus needs to enter the general purpose travel lanes to serve an adjacent bus stop. In general, the impact of mid-segment busway entry or egress on following buses in the busway is dependent on conditions in the general traffic lanes.

Figure 10 shows the typical dimensions for a median bus lane.

Figure 10: Bus Lane in Median



BUSES OPERATING IN THE MEDIAN LANE (THE HEALTHLINE IN CLEVELAND, OHIO)

PROJECT OVERVIEW: The Greater Cleveland Regional Transit Authority (RTA) began operating the HealthLine in October 2008. The HealthLine rapid transit vehicles operate along Euclid Avenue from Downtown to East Cleveland, a length of approximately 7 miles.

PROJECT COST: The total project cost was $200 million including items such as vehicles, construction, design, environmental, art, management and streetscape.

IMPACT ON TRANSIT: The HealthLine had an outstanding effect on transit, a 45% ridership increase in the first 12 months. The first 6 months of year 2 are already tracking at a 50% increase. The project's goal was to reduce riders' travel time by 12 minutes; however, current reductions are about 10 minutes.

IMPACT ON TRAFFIC: Prior to the implementation of the HealthLine, Euclid Avenue was 2 lanes in each direction, 3 lanes in a few places. Lanes were converted to create the median bus lane which had a negligible effect on traffic because cars were diverted to the 2 robust thoroughfares on each side of Euclid Avenue. During model runs, Euclid Avenue was taken out of the network rather than trying to run the model with one lane in each direction. Level of Service C results demonstrated that the HealthLine didn't negatively affect traffic conditions. No intersection improvements were necessary. In addition, a parking lot utilization study was conducted to address the existing on-street parking. The study revealed that many of the lots adjacent to the streets were not at capacity; therefore, more than 100 on-street parking spaces were eliminated. Some on-street parking spaces were added in the downtown area to accommodate higher demand.

LESSONS LEARNED/KEY STAKEHOLDERS: Funding was a major obstacle to the implementation of this project. Once BRT was identified as the best type of transit for the corridor, it still took years to organize the project. The project entered PE in 1997 and received environmental clearance in 2002. A full funding grant was awarded to RTA for $168.4 million in 2004. Ohio Department of Transportation (ODOT) contributed $28 million and the transit agency covered the remaining $4 million. Construction of the HealthLine began in 2004 with operation beginning in 2008. RTA recommends that agencies considering similar type projects have the City as an in-person, not a paper only, partner. In Cleveland's case, it took more than just the Mayor and City Council to be on-board with the project, but also all the local players, i.e. public power. An interagency agreement is a good start but a more active role is required from all parties involved.

SOURCE: GREATER CLEVELAND REGIONAL TRANSIT AUTHORITY

Lane Operations

Service and policy decisions about how an exclusive bus lane will operate are based on a number of factors. These can include existing and future traffic conditions, resources available and demand. Lane operations cover decisions on how long the service will operate, how many lanes are needed, the direction the lane flows, and whether vehicles can pass one another.

(Q) Will an exclusive bus lane need to be in place 24 hours a day?

(A) No, there is no requirement that the bus lane be in place at all times. In fact, many cities provide a bus lane only during peak travel times that reverts back to a mixed traffic lane during off-peak hours. A determination of how long the bus lane should remain in effect will be required for all corridors being considered for an exclusive bus lane (Kittleson & Associates, Inc. 2007).

(Q) When would a contra flow lane be considered?

(A) It is advisable to use contra flow in situations where a one-way street segment occurs. The use of a contra flow travel direction increases the image of any priority transit service and provides a greater level of self enforcement of the exclusive bus only lane restriction.

Another consideration for the use of contra flow lanes would be the creation of an exclusive bus lane in the median that would operate in peak travel directions only. This would only require space for one Lane (H. S. Levinson, et al. 2003).

(Q) What concerns are associated with contra flow transit operations?

(A) There are mixed results on whether the use of contra flow lanes increases collisions. Vehicular collisions actually decrease on roads that were previously two-way prior to being converted to one-way with a contra flow transit lane. The greatest number of collisions tends to involve pedestrians. These result from the conditioning associated with one-way traffic operations and the expectation that traffic will only be traveling in one direction. Signage and in some instances barriers need to be installed to warn pedestrians to scan both directions before crossing the street.

There is also a belief that contra flow operations do not necessarily benefit priority transit that operates in both an inbound and outbound direction simultaneously. Bus operations on two different one-way road segments with contra flow lanes would be required to provide bi-directional transit service and would effectively sever continuous service (i.e., a passenger would need to board or alight the bus on two different streets depending on their direction of travel). These

OPERATIONS ARE FELT TO REDUCE THE VISUAL IMPACT THAT PRIORITY TRANSIT SEEKS (H. S. Levinson, et al. 2003).

(Q) DOES THERE NEED TO BE A BUS LANE TRAVELING IN BOTH DIRECTIONS?

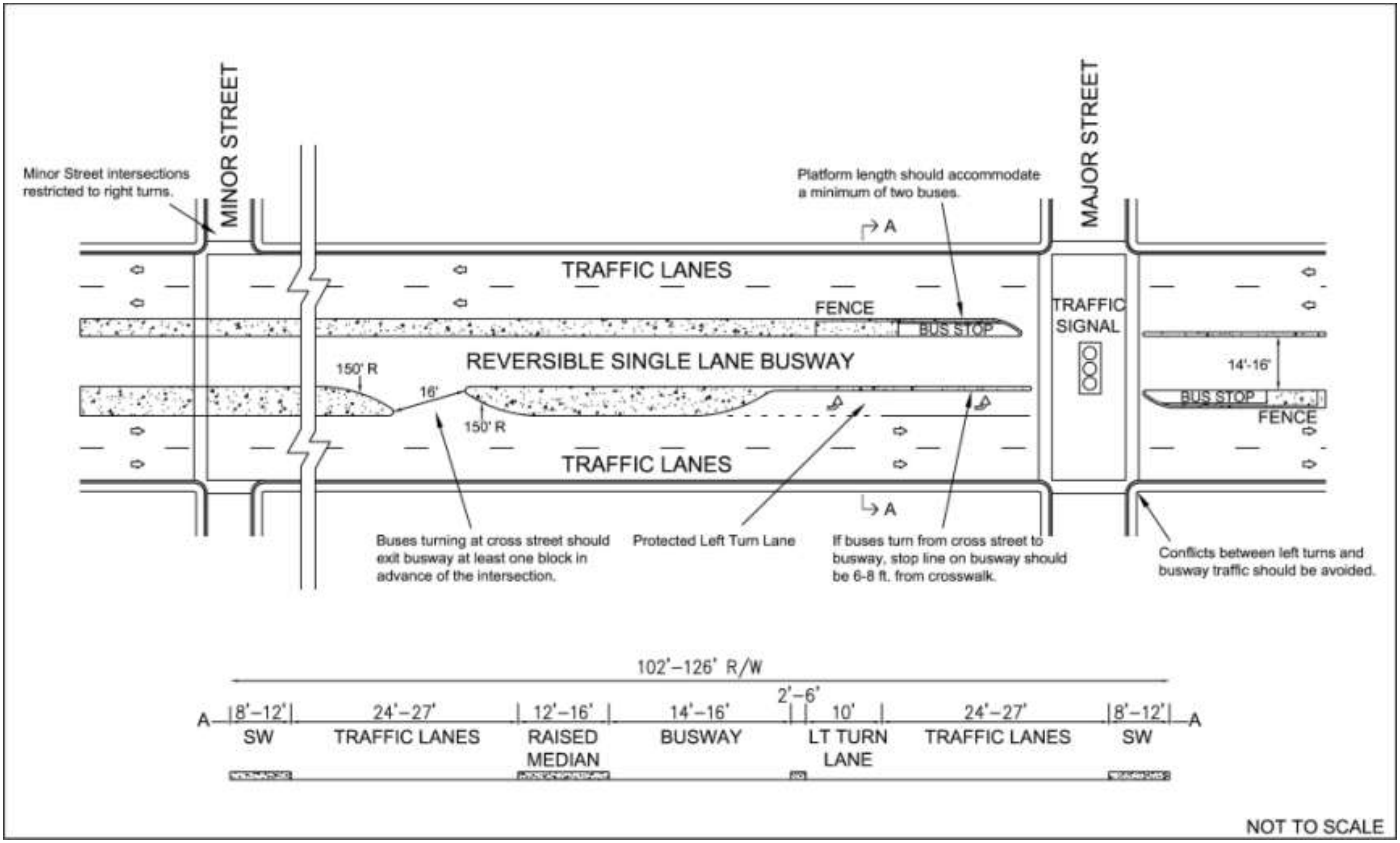
(A) NO, THE BUS LANE COULD BE REVERSIBLE AND RESTRICTED TO THE PEAK TRAVEL DIRECTION ONLY. THIS WOULD ALLOW FOR BUSES TO GET PRIORITY TREATMENT, PROVIDING BETTER SERVICE TO CUSTOMERS, IN THE PEAK TRAVEL DIRECTION. THE MORNING COMMUTE WOULD ALLOW BUSES EXCLUSIVE LANE ACCESS IN ONE DIRECTION AND THEN THE OTHER IN THE EVENING. THIS OPTION WOULD RETAIN A LANE FOR GENERAL TRAFFIC USAGE BECAUSE ONLY ONE IS NEEDED FOR BUS OPERATIONS. DEPENDING ON THE DESIGN OF THE ROADWAY, THE NUMBER OF PEAK DIRECTION LANES COULD INCREASE. THIS WOULD ALLOW THE BUS TO HAVE AN EXCLUSIVE LANE WITHOUT TAKING A PEAK DIRECTION LANE FROM MIXED TRAFFIC. IF A SUFFICIENTLY WIDE MEDIAN IS AVAILABLE, IT CAN BE TAKEN FOR THE BUS LANE WITHOUT IMPACTING THE EXISTING TRAFFIC LANES (H. S. Levinson, et al. 2003).

FIGURE 11 SHOWS A REVERSIBLE MEDIAN BUS LANE. FIGURE 12 PROVIDES TYPICAL DIMENSIONS FOR A MEDIAN BUS LANE.

FIGURE 11: EXAMPLE OF A REVERSIBLE BUS LANE IN EUGENE, OREGON

SOURCE: LANE TRANSIT DISTRICT

FIGURE 12: REVERSIBLE BUS LANE IN MEDIAN



Lane Vehicle Restrictions

Restrictions on which vehicles can use bus-only lanes can be tailored to the individual characteristics of a particular road's or region's needs from a range of options and alternatives. Restrictions could allow for taxis or high occupancy vehicles to share the lane. Some areas allow bicycles to share the bus lane, but would typically require a slightly wider lane to allow the bus to pass cyclists. These restrictions, like priority bus transit, allow for flexibility as the service grows and changes.

(Q) Does the bus lane need to be restricted to buses only? What other vehicles can a restricted bus land accommodate?

(A) Bus lanes can be opened to other specific kinds of traffic to allow for better use of the lane. Examples of this include taxis and/or emergency vehicles.

Consideration should also be given to vehicles that may need to access the outside lane such as delivery vehicles or municipal vehicles. These vehicles can be given time periods during which they may use the outside lane for deliveries if the exclusive lane is only operational during peak times. Pull-in areas or special parking areas can be designed to allow access as well (Diaz and Hinebaugh 2009).

The state of Maryland has a "complete streets" requirement that must be included in considerations when placing a bus lane. Fulfilling this requirement may include loosening lane restrictions, including allowing cyclists to use the bus lane. Engineers and planners in Maryland must conduct further investigation on the specifics of the State's complete streets law as part of their evaluation, particularly if the bus lane is to be installed on a state roadway.

(Q) What are the challenges to enforcing restricted bus lanes?

(A) The challenges associated with enforcement of bus lanes vary depending on the design of the lane. Streets that do not have a physical barrier between the bus lane and mixed traffic typically have more violations. Costs associated with enforcement are another challenge. Determining who should be in charge of enforcement can be difficult, especially where the bus will travel through multiple jurisdictions (H. S. Levinson, et al. 2003).

(Q) What are keys to setting up a successful enforcement program?

(A) It is important to ensure that all parties involved in enforcement are included early in the process. This will allow issues to be addressed sooner. Developing an educational campaign for the public will inform them about the presence of an exclusive

BUS LANE AND THE CONSEQUENCES OF A LANE VIOLATION (H. S. Levinson, et al. 2003).

(Q) WHAT ARE POTENTIAL ENFORCEMENT STRATEGIES THAT CAN BE APPLIED TO AN EXCLUSIVE BUS LANE?

(A) PASSIVE ENFORCEMENT STRATEGIES CAN INVOLVE SIGNAGE AND OTHER TREATMENTS SUCH AS COLORED PAVEMENTS OR RAISED LANE DELINEATORS. THESE DEVICES PROVIDE A VISUAL OR AUDIBLE CUE TO MOTORISTS THAT THE LANE IS NOT INTENDED FOR GENERAL TRAFFIC. THESE DEVICES ARE OFTEN A LOWER COST OPTION THAN MORE ACTIVE TREATMENTS SUCH AS PHYSICAL MONITORING OF THE LANE, BUT DO NOT PROVIDE A "POLICING" FUNCTION FOR ENFORCEMENT OF THE RESTRICTION. IT HAS ALSO BEEN SHOWN THAT POSTING THE POTENTIAL FINES FOR VIOLATING A LANE RESTRICTION ALONG THE CORRIDOR HAS A PASSIVE ENFORCEMENT EFFECT ON VIOLATORS.

ACTIVE ENFORCEMENT OF LANE RESTRICTIONS CAN CONSIST OF PATROLS BY ENFORCEMENT AGENCIES THAT WILL TICKET AND FINE VIOLATORS. THIS FUNCTION CAN BE PROVIDED BY A PHYSICAL POLICE PRESENCE OR THROUGH VIDEO SURVEILLANCE. OTHER ENFORCEMENT PROGRAMS HAVE UTILIZED THE PUBLIC TO REPORT VIOLATORS. THE HERO PROGRAM USED IN WASHINGTON STATE ALLOWS THE PUBLIC TO CALL IN INFORMATION ABOUT VIOLATORS. WHILE FINES ARE NOT ISSUED THROUGH THIS METHOD, THE VIOLATOR DOES RECEIVE INFORMATION ABOUT THE RESTRICTION (H. S. Levinson, et al. 2003).

LANE MARKINGS

Lane markings for exclusive or semi-exclusive bus lanes provide a number of benefits. The visible cues of different lane striping, markings, signs (Figure 13) or paving materials and colors tell pedestrians and other motorists to pay attention. This contributes to the enforcement of vehicle restrictions in exclusive bus lanes and lower travel times. They also increase visibility of the bus, which not only acts as a promotion and identity tool, but also increases safety. Audible cues can be added as well through the use of raised lane delineators, rumble strips, or different paving materials.

FIGURE 13: EXAMPLE OF BUS ONLY SIGNAGE IN LEEDS, ENGLAND

SOURCE: NATIONAL BUS RAPID TRANSIT INSTITUTE

(Q) IS SIGNAGE REQUIRED FOR BUS ONLY LANES?

(A) Yes, to make the lane restriction enforceable from a legal standpoint, signage needs to be posted stating the restriction (H. S. Levinson, et al. 2003).

(Q) What can be done to improve the visibility of bus only signage?

(A) Placement of the signage is an important consideration. Typically, most traffic signage is placed in the ground along the curb edge. Parked vehicles and traffic in general may make it difficult for drivers to see this signage. Adding signage over the lane will increase visibility of the signage in addition to clearly marking which lane the restriction applies. The use of lane markings, different lane striping, or even lane color will increase visibility of not only the restriction but also the bus service. It is important to consider that the use of lane markings, striping, or colors will also increase maintenance costs. These costs will need to be balanced against the benefits of greater visibility (H. S. Levinson, et al. 2003).

(Q) Are there issues with using raised pavement markings?

(A) The benefit of using raised pavement markings is greater visibility and enforcement of the lane restriction. Certain raised pavement markings can create safety issues for those riding motorcycles and bicycles (Diaz and Hinebaugh 2009).

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Figure 14: Example of Raised Lane Delineators for the Lymmo Service in Orlando, Florida

SOURCE: NATIONAL BUS RAPID TRANSIT INSTITUTE

ed lane delineators.

Painted Curbside Bus Lane (New York City Transit in New York, New York)

Project Overview/Key Stakeholders: In 2008, painted curbside bus lanes were implemented by New York City Department of Transportation, in consultation with New York City Transit, along 2 corridors – Fordham Road/207th Street in the Bronx and Manhattan and 34th Street in Manhattan. The lanes are painted red/terra cotta and also have overhead signs.

Project Cost: The cost for the red lane material is approximately $4 per square foot. The bus lanes must have a 10 foot width minimum, but 12 foot is preferred. The City is in the process of evaluating other materials with different implementation costs, but better durability. The current material is very durable on newly paved asphalt streets, but does poorly on old asphalt or concrete roadways. Finally, the cost for the overhead signs is approximately $10,000 each for the cantilever pole.

Impact on Transit: Since the buses have priority when traffic is heaviest and can avoid delays caused by parking activity, the project has a very positive effect on transit speeds. However, buses may not always be able to use the bus lane due to illegally parked cars or legally right-turning vehicles.

Impact on Traffic: The effects on traffic are a bit more complex. Traffic flow is improved when a bus lane replaces a parking lane; however, parking is lost. In order to maintain parking, a traffic lane may be eliminated which would affect General traffic.

Lessons Learned: Community impacts were the biggest obstacle to project implementation. Loss of parking spaces and construction issues – the red material takes a good bit of time to install and is affected by weather, so it can take a while to complete a corridor – heavily impacted the community. A significant amount of public outreach is necessary to successfully implement this type of project.

Source: New York City Transit

(Q) Are there any restrictions on the use of lane color?

(A) The use of colored lanes to reinforce a traffic control must have the restriction in place at all times according to the 2009 Manual on Uniform Traffic Control Devices. Currently, the manual provides little direction or recommendation on the use of lane color as a traffic control device. However, there is no restriction on the use of a different color pavement material such as using a concrete bus lane next to asphalt general traffic lanes (American Association of State Highway and Transportation Officials 2010).

Figure 15 shows a colored pavement lane treatment.

Figure 15: Example of Colored Pavement Bus Lane in Rouen, France

SOURCE: NATIONAL BUS RAPID TRANSIT INSTITUTE

Mixed Traffic Bus Lane

In certain instances, it may be necessary to operate priority buses in mixed traffic. Situations where it is either cost prohibitive or operationally infeasible to provide a lane restricted to bus operations would be instances where the bus would operate within mixed traffic. Issues that may result from operating a bus in mixed traffic are a reduction in schedule adherence/reliability, increased travel times, and a loss of "identity" for a priority bus service. Situations where the bus operates in mixed traffic should occur sparingly. There are other treatments that can be used in conjunction with mixed traffic operations that may improve travel times and reliability. The use of bus bulbs, queue jumps, or special bus restrictions alone or in concert can improve priority bus operations.

(Q) What is the difference between a mixed traffic priority bus lane and existing bus operations?

(A) There is no difference when looking at the restrictions on who can use the lane. The priority bus operates in mixed traffic just like current buses do. The differences would occur when other priority treatments such as transit signal priority or queue jumps are applied to the corridor.

(Q) What are some of the priority treatments that could be considered when trying to improve travel times and service reliability for buses operating in mixed traffic?

(A) The following is a list of treatments that could be considered when looking to improve transit service in a corridor which operates in mixed traffic. This list is not exhaustive, nor does it provide an in-depth discussion of each. Each treatment mentioned will be discussed in greater detail in subsequent sections.

- Traffic signal optimization/coordination
- Transit signal priority
- Queue jumps
- Turning restrictions that exempt buses
- Bus stop relocation
- Bus stop design improvements (bus bulbs)
- Bus stop spacing improvements

Bus Stops

Design features associated with size and location of bus stops can impact traffic operations along street segments. Features such as bus bulbs, pull-ins, or boarding islands can impact road geometries as well as road capacity.

There are three types of bus stop: curb side stops, bus bulbs and bus bays.

Stop Design

The configuration and design of the area where the bus stops and picks up and drops off passengers is dependent on a number of factors. Considerations should include the following questions:

- Is the stop a layover point[3]?
- What is the number of passenger boardings and alightings?
- How many buses will be stopping at one time?
- Does the stop need to allow room for buses to pass stopped vehicles?

Table 5 provides a summary of the considerations to be addressed in selecting the type of bus stop to be provided.

Table 5: Bus Stop Treatment Considerations

Curb Side Bus Stops
Applicability
Moderate or high volume stops where 110’ to 150’ of curb lane space (5 to 8 parking spaces) is acceptable and a 10’ width curb lane exists
Potential Benefits
Low cost, location flexibility
Potential Impacts
Loss of curb lane parking, delays in buses merging into traffic
Considerations
Cost, lane space for buses to stop and traffic impacts
Bus Bulbs
Applicability
Moderate or high volume stops where 80’ of curb lane space (4 spaces) is acceptable and a curb lane width of at least 6’ is available
Potential Benefits
Space for shelter and riders, no delay in buses reentering traffic lane
Potential Impacts
Traffic delays behind stopped buses, cost, loss of some curb lane parking
Considerations
Traffic, curb space availability, cost, adjacent land use compatibility
Bus Bays
Applicability
High volume stops where substantial lineal curb space (over 700’) is acceptable and a curb lane width of 12’ is available
Potential Benefits
Full speed reentry to traffic lane, reduced curb length is needed
Potential Impacts
Substantial cost, substantial loss of curb lane parking
Considerations
Space availability, cost, adjacent land use compatibility

[3] A layover point is the location along a route where the bus can sit and recover time if the route is ahead of schedule or the operator may take a break if the schedule allows time. These locations are typically found at the beginning or end of a route.

Table 6, from the Transit Cooperative Research Program Report 19 *Guidelines for the Location and Design of Bus Stops* by the Texas Transportation Institute (1996), provides an expanded set of pros and cons associated with different stop types

Table 6: Comparison of Stop Types

Type of Stop	Advantages	Disadvantages
Curb-side	• Provides easy access for bus driver and results in minimal delay to bus • Is simple in design and easy and inexpensive for a transit agency to install • Is easy to relocate	• Can cause traffic to queue behind stopped bus, thus causing traffic congestion • May cause drivers to make unsafe maneuvers when changing lanes in order to avoid stopped traffic
Busbay	• Allows patrons to board and alight out of travel lane • Provides a protected area away from moving vehicles for both the stopped bus and bus patrons • Minimizes delay to through traffic	• May present problems to bus drivers when attempting to re-enter traffic, especially during periods of high roadway volumes • Is expensive to install compared with curb-side stops • Is difficult and expensive to relocate • May disrupt the urban fabric in central city areas
Open Bus Bay	• Allows the bus to decelerate as it moves through the intersection • See Bus Bay advantages	• May cause delays to right-turning vehicles when a bus is at the start of the right turn lane • See Bus Bay disadvantages
Queue Jumper Bus Bay	• Allows buses to bypass queues at a signal • See Open Bus Bay advantages	• May cause delays to right-turning vehicles when a bus is at the start of the right turn lane • See Bus Bay disadvantages
Bus Bulb	• Removes fewer parking spaces for the bus stop • Decreases the walking distance (and time) for pedestrians crossing the street • Provides additional sidewalk area for bus patrons to wait • Results in minimal delay for bus • Accentuates the streetscape, providing space for shelters, plantings, and street furniture	• Costs more to install compared with curb-side stops • See Curb-side disadvantages • Depending on site conditions, may result in permanent loss of parking

Source: Transit Cooperative Research Program Report 19: Guidelines for the Location and Design of Bus Stops (1996) (adapted)

The following section will answer questions related to the design of bus stops and their impacts on street segments. Readers are also urged to consult the December 2009 WMATA report *Guidelines for the Design and Placement of Transit Stops* for more regional information on bus stops, including information on stop spacing, sight distance, and pedestrian access.

(Q) When should a bus bay be considered?

(A) Bus bays of all types (curb-side, open, queue jumper) make more sense in suburban environments where speed Limits are typically faster on arterials (40 mph or greater). Consideration should be given to traffic volumes. When Speeds are high and traffic volumes along the outside lane are more than 250 vehicles per hour and bus boardings and alightings are high, a stopped bus can have a serious impact on traffic. It is important to ensure that there is ample right of way available to install a bus bay without impacting the existing sidewalk width. (Texas Transportation Institute 1996)

If an exclusive bus lane is being used and there is no need to remove the bus from a general travel lane, a bus bay could be used for a corridor where local bus service operates with priority bus service. The bus bay would allow the local bus to pull out of the exclusive bus lane and not impede travel times.

(Q) The bus is having difficulty merging back into traffic after pulling into the bus bay. Is there anything to improve operations?

(A) While the advantage of the bus bay is the ability to remove a stopped bus from a travel lane, very high traffic volumes or speeds could make it difficult for the bus to merge back into traffic. Some localities have passed laws that require drivers to yield the right of way to a bus attempting to merge into traffic. The passage of such a law would also require a large promotional campaign to be effective. Some transit systems that operate in areas with similar laws have installed electronic signage on the bus that reminds traffic to yield when the bus is attempting a maneuver with the turn signal activated (King 2003).

(Q) When are bus bulbs an appropriate solution for a bus stop design?

(A) Bus bulbs are more appropriate in urban environments where speed limits are typically lower. Bus bulbs also provide an excellent location for the bus to stop along street segments where parking must be retained. This design allows more parking to be kept and allows the bus easy access to passengers. Since a bus bulb is an extension of the sidewalk, they provide additional room for the installation of passenger amenities such as shelters and fare collection devices. The additional space

ALSO ALLOWS FOR THE CREATION OF A WELL DEFINED BUS STOP THAT DOES NOT IMPACT PEDESTRIAN FLOWS ALONG THE SIDEWALK AND PLACES A SMALL BUFFER BETWEEN BUS STOP ACTIVITY AND BUILDING FRONTS. THE IDEAL SETTING FOR INSTALLING BUS BULBS WOULD BE CORRIDORS WHERE ON-STREET PARKING IS REQUIRED AND THE NEIGHBORING LANE HAS BEEN RESTRICTED FOR BUSES ONLY (Texas Transportation Institute 1996).

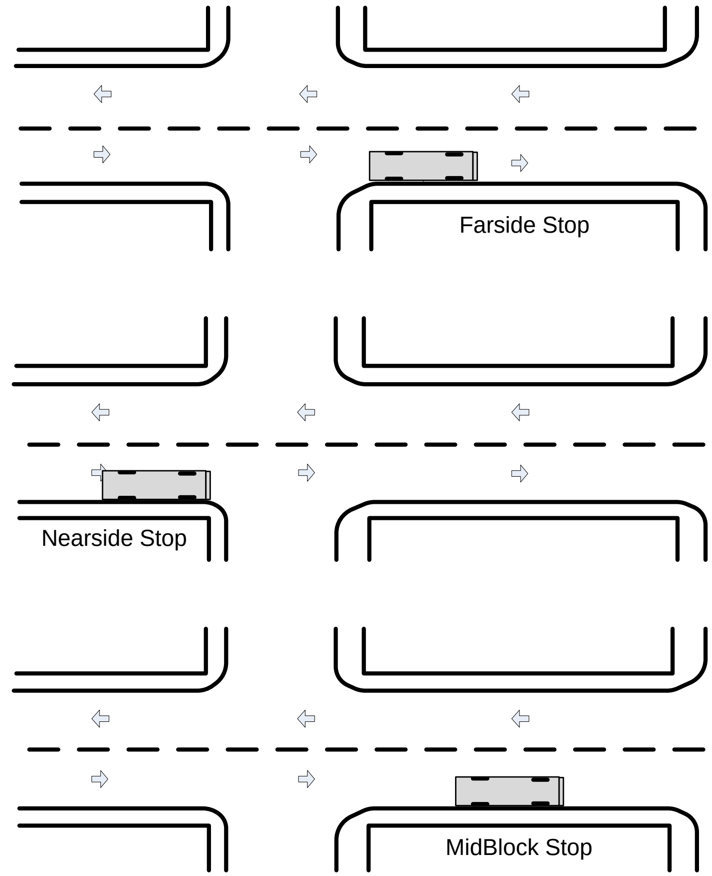
The two pictures to the right show the evolution of a bus bulb in New York City. The initial implementation had a fence separating it from the existing sidewalk. The second photo shows the removal of the fence and the use of a grate to connect it to the sidewalk. These bulbs were implemented with a middle lane bus lane, which maintained parking along both curbs. There were issues with these bulbs, since some models of buses were not able to allow a wheelchair to board because the lift extended too far from the bus.

Source: New York City Transit

Stop Location

The location of the bus stop in relation to the intersection is a decision that can have differing impacts on not only traffic and pedestrian operations but also transit operations as well. There are three choices when determining stop location: far-side, near-side, and mid-block (Figure 16). Mid-block stops are not as common as the other two, and are typically found in areas where there may be a long block face or other unique characteristics that precludes the other locations. Table 7 from the Transit Cooperative Research Program Report 19 *Guidelines for the Location and Design of Bus Stops* by the Texas Transportation Institute (1996) shows the pros and cons associated with each different location. Additional considerations are needed when considering priority treatments that will be discussed below.

Figure 16: Bus Stop Locations



Source: Transit Cooperative Research Program Report 19: Guidelines for the Location and Design of Bus Stops (1996)

Table 7: Comparison of Bus Stop Locations

Location	Advantages	Disadvantages
Far-Side	• Minimizes conflicts between right turning vehicles and buses • Provides additional right turn capacity by making curb (outside) lane available for traffic • Minimizes sight distance problems on approaches to intersection • Encourages pedestrians to cross behind the bus • Curb-side creates shorter deceleration distances for buses since the bus can use the intersection to decelerate • Results in bus drivers being able to take advantage of the gaps in traffic flow that are created at signalized intersections	• May result in the intersections being blocked during peak periods by stopping buses • May obscure sight distance for crossing vehicles • May increase sight distance problems for crossing pedestrians • Can cause double-stopping, with a bus stopping far side after stopping for a red light, which interferes with both bus operations and all other traffic • May increase number of rear-end collisions since drivers do not expect buses to stop again after stopping at a red light • May increase number of side-swipe collisions • Could result in traffic queued into intersection when a bus is stopped in travel lane
Near-Side	• Minimizes interferences when traffic is heavy on the far side of the intersection • Allows passengers to access buses closest to crosswalk • Results in the width of the intersection being available for the driver to pull away from curb • Eliminates the potential of double stopping • Allows passengers to board and alight while the bus is stopped at a red light • Provides driver with the opportunity to look for oncoming traffic, including other buses with potential passengers	• Increases conflicts with right-turning vehicles • May result in stopped buses obscuring curb-side traffic control devices and crossing pedestrians • May cause sight distance to be obscured for cross vehicles stopped to the right of the bus • May block the through lane during peak period with queuing buses • Increases sight distance problems for crossing pedestrians
Mid-Block	• Minimizes sight distance problems for vehicles and pedestrians • May result in passenger waiting areas experiencing less pedestrian congestion	• Requires additional distance for no-parking restrictions • Encourages patrons to cross street at midblock (jaywalking) • Increases walking distances for patrons crossing at intersections

Source: Transit Cooperative Research Program Report 19: Guidelines for the Location and Design of Bus Stops (1996)

(Q) Does the addition of priority corridor treatments alter the decision making when deciding stop location?

(A) Yes, the use of transit signal priority is more difficult with near-side bus stops. Positioning the stop prior to a signalized intersection will impact the signals at that intersection if TSP is being used. Therefore, it is advisable to use far-side bus stops when considering signal priority (Diaz and Hinebaugh 2009). However, far-side stops are less important if the TSP architecture has been designed to recognize "open door" status (i.e., if the bus door is open the TSP call is dropped, and once the bus door is closed, the TSP call is placed again).

(Q) When is a near-side bus stop typically recommended?

(A) Near-side bus stops are preferable when there is a high number of buses and the impacts to traffic are not considered critical. Near-side stops are a better choice when there is on-street parking. The use of a near-side allows the bus to merge back into traffic more easily when there aren't parked cars in front of the bus. Vehicles turning right will be impacted by buses that stop at near-side stops. Depending on the lane configuration, vehicle will become "trapped" behind the bus, or as the bus attempts to merge back into traffic the driver will have to pay particular attention to vehicles going around the bus and then turning right (H. S. Levinson, et al. 2003).

As mentioned above, use of a near-side stop may impact TSP operations. Stop location and the type of TSP application used will need to be considerations when making a decision about TSP.

(Q) When is a mid-block bus stop typically recommended?

(A) Mid-Block stops are not a common location used for a bus stop. This type of location places the stop further from the corners of a block face and creates a longer distance for pedestrians crossing the street to access a bus stop. Mid-block stops are generally only used in situations where the block face is extremely long, the bus stop itself needs to be long to handle a high volume of buses, or some other external factor that precludes the use of a far-side or near-side location (H. S. Levinson, et al. 2003). Mid-block stops are often combined with bus bulbs to minimize impact on curb space and parking.

(Q) When is a far-side bus stop recommended?

(A) Far-side bus stops should be considered when TSP is being considered. If the signal controller has no way of determining if the bus is stopped to pick up or drop off passengers then a far-side bus stop is preferable. This will eliminate the bus requesting priority when it is stopped to load/unload passengers.

Far-side stops are a better choice when the bus has exclusive use of the curb lane. This eliminates conflicts with right turning vehicles. It is not advisable to place a stop on the far-side when on-street parking is allowed, especially during peak travel times. Parked vehicles make it difficult for the bus to merge back into traffic without extending the "no Parking" zone. This reduces the parking capacity of the street.

Similar to conflicts with right-turning vehicles when the bus operates in the curb lane, far-side stops should be used when the bus operates in the center lane. This reduces conflicts with left-turning vehicles (H. S. Levinson, et al. 2003).

(Q) What other conditions should be considered when deciding stop location?

(A) Placement of a stop on the near-side of the intersection should be avoided where there are a high number of right turn movements. A near-side stop would produce a queue of vehicles waiting to make a right turn. These vehicles would be forced to wait, creating longer queues. Vehicles may also attempt to go around the bus, creating unsafe conditions with vehicles changing lanes, passing the bus and then attempting to move right again.

Stop location for bus lanes using the center lane should also be examined. The use of a near-side bus stop at an intersection with a high number of left turn movements should be cognizant of whether the signal has a protected left phase and whether vehicles can use the bus lane to turn left. Allowing vehicles to turn left in front of an approaching bus presents safety concerns (H. S. Levinson, et al. 2003).

CHAPTER 3: INTERSECTIONS

Intersections and the control of vehicles and persons passing through them form a critical component of roadway operations, and so examining the role of intersection control (traffic and pedestrian signals) in priority bus treatment is crucial: everything happens at intersections.

Transit signal priority (TSP) is a key component of priority transit. Traffic signals provide control for intersections, coordinating vehicle through and turning movements as well as when pedestrians should cross. In concert with TSP, queue jumps can be used to improve transit travel through an intersection. This type of treatment may require intersection redesign and changes in signal design.

Intersections can be impacted by a number of the priority treatments being considered in the Washington region. Since the majority of bus riders walk to their bus stop, it is also important to address crosswalks and pedestrian access.

TRANSIT SIGNAL PRIORITY

Transit Signal Priority (TSP) is the process by which an advantage is given to transit vehicles operating along a roadway through the modification of traffic signal timing. The advantage can be received through the extension of green time for buses arriving late at an intersection or advancing green time for buses waiting at an intersection. Signal priority can be tied to bus schedule (conditional), only giving priority when a bus is behind schedule, or it can occur at all times (unconditional). The latter ensures that buses not only remain on schedule, but also improves travel times overall. This increases transit's appeal to potential riders. Advantages can also be gained through the coordination or retiming of signals to accommodate bus travel patterns. This gives the bus a priority over general traffic and reduces delays for the bus, improving travel time for the passenger.

TSP can improve the person throughput of an intersection by weighing passenger in buses versus passengers in cars. Traditional LOS measures do not recognize this aspect because they only account for individual vehicles passing through an intersection. Comparing the number of people moving through a given intersection where TSP is applied versus the number of vehicles would produce different results as a measure of LOS. The 2010 update to the Highway Capacity Manual provides some direction on accounting for the benefits of transit when computing LOS for a segment or intersection to provide a picture of how the intersection performs. It should also be noted that general traffic can benefit from transit signal priority. When the "mainline" is given an extended green phase not only does the bus benefit, but so do all the vehicles traveling through the intersection. In this instance, TSP doesn't just benefit transit.

Signal priority can be accomplished through passive means where the signals are retimed to account for transit travel speeds or to minimize person delay rather than vehicle delay, or active means where the bus "announces" its approach to a signal and the signal adjusts the timing based on predetermined parameters. Active priority can employ different strategies, such as green extension, early green, and actuated transit phase (where the vehicle is detected at the intersection rather than while approaching the intersection; actuated phases can be used with queue jumpers), phase insertion, or phase rotation. (Smith, Hemily and Ivanovic 2005).

TSP can be applied on an intersection-by-intersection basis or via a network or corridor approach. A corridor or network approach requires the transit vehicles to be equipped with a GPS/AVL system and the traffic signals to be part of an adaptive signal control system. In total, this approach is sometimes called real-time TSP (*ibid.).*

Transit signal priority is different from signal preemption where the signal progression is interrupted (Kittleson & Associates, Inc. 2007). "Transit signal priority modifies the normal signal operation process to better accommodate transit vehicles, while preemption interrupts the normal process for special events such as an approaching train or responding fire engine" (Baker, et al. 2004). Table 8 presents an overview comparison of signal preemption and signal priority and common applications.

(Q) When should transit signal priority be considered?

(A) TSP should be considered in corridors that have heavy traffic congestion resulting in bus delays. Prior studies have shown that TSP is most effective at intersections that operate at a LOS of 'D' or 'E' and have a volume to capacity ratio between 0.80 and 1.00. Long traffic queues associated with V/C ratios above 1.00 have shown that TSP can be ineffective in allowing buses to reach the signal in an allowable timeframe to take advantage of the green. Simulation modeling can provide a means to compare current conditions along a corridor against conditions available using TSP. Modeling will allow for a more quantitative examination of the costs versus the benefits and is recommended prior to implementation as part of a thorough engineering study. Ultimately, the goal of TSP is to reduce total person delay for the corridor in question. While this may result in an additional short delay for some vehicles, overall the corridor will move more people with fewer delays (Kittleson & Associates, Inc. 2007).

The guidance above relates to a general "rule of thumb" when considering TSP. TSP should be

CONSIDERED WHEN THE GOAL OF THE CORRIDOR IS TO IMPROVE TRANSIT TRAVEL TIMES. SIGNAL PRIORITY CAN BE USED IN SITUATIONS WHERE THE BUS OPERATES IN AN EXCLUSIVE LANE OR IN MIXED TRAFFIC. SIGNAL PRIORITY CAN ALSO BE USED TO GIVE A BUS AN ADVANTAGE OVER TRAFFIC STOPPED AT AN INTERSECTION WHEN USED IN CONCERT WITH A QUEUE JUMPER. TSP CAN BE UTILIZED DURING PEAK TRAVEL TIMES OR THROUGHOUT THE DAY. WHEN PLANNING FOR TSP, IT SHOULD BE DETERMINED WHAT TSP IS DESIGNED TO ACCOMPLISH. IF TSP IS ONLY DESIGNED TO IMPROVE BUS OPERATIONS DURING PEAK TRAVEL TIMES IT WOULD BE LIMITED IN USE AND POSSIBLY DIRECTION. IF THE GOAL IS TO IMPROVE TRANSIT PERFORMANCE FOR ALL TRAVELERS IT SHOULD BE CONSIDERED AS AN OPTION THROUGHOUT THE SERVICE SPAN OF THE TRANSIT SYSTEM.

Table 8: Overview of Signal Coordination, Signal Preemption and Signal Priority

	Passive		Active		
Traffic Signal System Operational Strategy	Signal coordination set for Bus Transit travel speeds	Bus Transit Passive Signal Priority	Bus Transit Active Signal Priority	Transit Signal Preemption	Conventional Traffic Signal Preemption (Not used in bus operations)
Typical Target Vehicle	Buses	Buses who are behind schedule	Buses who are behind schedule	Light Rail Vehicles	Police vehicles, emergency vehicles, fire trucks, ambulances
Typical Application Location	Specific bus corridor(s)	On conventional intersection approaches	On intersection approaches with bus only lanes or queue jumpers	On routes with railways in or adjacent to the street	Near fire stations and routes leading from fire stations
Description of System Operation	Network / corridor approach	Buses with strobe on vehicle approach	Buses with GPS on vehicle approach if behind schedule	LRT with GPS on vehicle approach	Emergency Vehicles with infrared and white light strobe An Emergency Vehicle is detected on the approach, the signal pre-empts the existing phase in service and "times out" the minimum pedestrian walk, clearance and yellow and all-red intervals of the signal phase in service and then calls into service the programmed pre-empt phase. The pre-empt signal phase is held in service for a minimum time and then is released to the next programmed signal phase.
Pedestrian Crossing Provisions	Minimum clearance time provided	Minimum clearance time provided	Minimum clearance time provided	None?	None
Relative Implementation Cost		Low	High	Low	Moderate
Adaptability	Moderate	Moderate	High	Moderate	Moderate
Potential Obstacles to Implementation	Coordination for bus travel speeds may negatively impact other vehicles, particularly those travelling faster than the bus			Same as conventional preemption	Pre-emption kicks signal out of coordination and it takes 3 – 5 cycles, which can be as much as 15 minutes, to get back into coordination. It can take even more time after that for the traffic queued to be "cleared" and the operation to return to a steady state of platoons progressing through coordinated signals. However, preemption is required for emergency response.
Known Applications in the DC Area			Georgia Ave NW, US 1/Richmond Hwy in VA along REX	Baltimore Central LRT (Howard Street)	Region-wide

Note: there are other preemption cases such as a loop placed at a location (e.g., on a freeway off-ramp such that if the queue backs up to that point, the pre-emption phase is called into service to allow the standing queue to clear so the queue does not back up and block the freeway). Pre-emption is also applied at intersections near railroad-highway grade crossings. If a train is coming, then the signal phases in service are pre-empted to call into service the signal phase that is needed when the train passes thru the hwy grade crossing. This prevents drivers from seeing green indications when just downstream is a RR-Hwy Grade crossing.

(Q) DOES TSP NEED TO BE USED IN CONCERT WITH TREATMENTS LIKE EXCLUSIVE BUS LANES IN ORDER TO BE EFFECTIVE?

(A) NO, SOME TRANSIT SYSTEMS HAVE UTILIZED TSP IN MIXED TRAFFIC OPERATIONS WITH POSITIVE RESULTS. THE USE OF TSP ALLOWS THE TRANSIT VEHICLE TO REALIZE TIME SAVINGS WHILE TRAVELING WITHIN MIXED TRAFFIC. THE TRAFFIC TRAVELING WITH THE BUS WILL ALSO REALIZE THESE TIME SAVINGS AS WELL (H. S. Levinson, et al. 2003).

(Q) DOES TSP NEED TO BE USED AT INTERSECTIONS THROUGHOUT THE LENGTH OF AN ENTIRE TRANSIT CORRIDOR?

(A) WHILE THERE ARE BENEFITS IN A CORRIDOR-LONG IMPLEMENTATION, TSP MAY PROVIDE BENEFITS EVEN AT SPECIFIC INTERSECTIONS. TSP SHOULD AT LEAST BE CONSIDERED FOR INTERSECTIONS EXHIBITING SIGNIFICANT DELAYS FOR TRANSIT. THIS MAY BE ISOLATED TO A SINGLE INTERSECTION THAT HAS HEAVY CONGESTION OR A SERIES OF INTERSECTIONS THAT PRESENT DELAYS FOR TRANSIT. ULTIMATELY, THE GOAL OF TSP WOULD DETERMINE THE APPLICATION ALONG A CORRIDOR. IF THE GOAL IS TO REDUCE THE DELAY TRANSIT INCURS THEN IT WOULD BE APPLIED AT INTERSECTIONS WHERE BUSES HAVE DELAYS. IF THE GOAL IS TO IMPROVE OVERALL TRANSIT TRAVEL TIMES THEN IT MAKES SENSE TO APPLY TSP THROUGHOUT THE CORRIDOR AND NOT JUST FOCUS ON INTERSECTIONS WHERE DELAY OCCURS.

(Q) DOES TSP NEED COMPLEMENTARY PHYSICAL INFRASTRUCTURE SUCH AS QUEUE JUMP LANES?

(A) A SECOND CONSIDERATION IS THE USE OF QUEUE JUMPS OR BYPASS LANES WITH A PRIORITY SIGNAL. THIS TREATMENT INVOLVES ALLOWING BUSES TO USE A RIGHT TURN ONLY LANE TO BYPASS TRAFFIC IN THE MAINLINE. TRAFFIC IN THE RIGHT TURN LANE WOULD RECEIVE A PROTECTED RIGHT TURN PHASE, BUT THE BUS WOULD BE ALLOWED TO PROCEED THROUGH THE INTERSECTION TO A FAR-SIDE BUS STOP. THIS TREATMENT COULD UTILIZE THE EXISTING SIGNAL PHASING OR RECEIVE A SPECIAL PHASE WHEN THE BUS REACHES THE TURN LANE (Kittleson & Associates, Inc. 2007).

(Q) CAN SIGNAL PREEMPTION BE USED FOR APPLICATIONS INVOLVING PRIORITY TRANSIT?

(A) YES, SIGNAL PREEMPTION CAN BE USED FOR PRIORITY TRANSIT SERVICE. CAREFUL CONSIDERATION SHOULD BE USED WHEN WEIGHING THE USE OF SIGNAL PREEMPTION FOR PRIORITY TRANSIT. SIGNAL PREEMPTION WILL ALTER THE NORMAL SIGNAL OPERATION BY INTERRUPTING SIGNAL OPERATIONS AND GIVING PRIORITY TO THE TRANSIT VEHICLE. FOR THESE REASONS IT IS TYPICALLY USED AT RAILROAD CROSSINGS AND INTERSECTIONS FOR EMERGENCY VEHICLES. THE DESIGNED PURPOSE IS TO IMPROVE SAFETY AT CROSSINGS OR INTERSECTIONS AND IMPROVE RESPONSE TIMES. THE IMPACTS OF SIGNAL PREEMPTION ON OVERALL SIGNAL OPERATIONS AND TRAFFIC COULD BE GREATER THAN THE USE OF TSP (Baker, et al. 2004).

Passive Signal Priority

Passive signal priority provides an advantage to transit vehicles traveling along a corridor without the vehicle communicating with the signal to acquire priority. This is typically done through changes in signal timing that account for the differences in travel speeds between cars and buses, progressing the signals for buses as opposed to cars. Passive timing changes can be done on an intersection-by-intersection basis or to an entire system of signals depending upon the extent of priority needed. Some common methods used are reducing cycle times, priority movement repetition, green priority weighting, and signal linking for bus progression (Johnstone 2004).

(Q) When should signal coordination occur along a corridor?

(A) Traffic signals along a priority corridor should be coordinated when the signals are a mile or less apart. It is also beneficial if the signals are spaced at regular intervals (H. S. Levinson, et al. 2003).Situations where transit operations are predictable are also ideal for application of passive signal priority. A passive signal priority system does not require vehicle detection equipment and is solely based on timing of the signal progression. A bus that doesn't operate on a regular schedule could not take full advantage of a signal retiming as part of passive signal priority (Baker, et al. 2004).

(Q) What are the benefits of using passive signal priority for transit?

(A) Passive signal priority does not require as much additional equipment and in most cases may not require any additional equipment. This type of improvement requires a retiming and coordination of the traffic signals along a corridor. Pierce County, Washington saw a 5-30% reduction in signal delay for transit from signal coordination (Baker, et al. 2004).

(Q) Will the retiming of traffic signals to the benefit of transit present huge problems for the remainder of traffic?

(A) Not necessarily. Obviously each corridor will present its own unique set of circumstances that need to be addressed. The ability to model existing and future conditions for comparison will provide a wealth of information prior to implementation. When Los Angeles was in the process of considering signal timing changes for their Metro Rapid service, they discovered that small timing changes (≤ 10 seconds) provided fewer delays to transit without a major impact on traffic. They also determined as a part of their analysis that headways had to be greater than 3 minutes and the bus stops needed to be located far-side (H. Levinson, et al. 2003). Typically, the traffic traveling with the transit route that is receiving passive signal priority will also realize the benefits of signal coordination and retiming. In Pierce County, Washington, general traffic traveling with a transit route receiving passive signal priority saw a reduction in signal delay of 18-70% for general traffic (Baker, et al. 2004). However, Side streets and pedestrians have experienced small impacts as a result of passive signal priority.

(Q) How many phases should the signal provide?

(A) As few as possible to accommodate existing traffic conditions. Ideally, a two phase signal operation would be used. This allows for shorter time between phases because there are fewer phases that need to occur, resulting in a reduced travel time for passengers on the bus. Additional phases may be necessary when the median lane is used for transit operations. The additional phases would be needed to handle conflicting turning movements (H. S. Levinson, et al. 2003).

(Q) How long should the signal's cycle length be?

(A) Cycle lengths along a priority corridor should be as short as possible to accommodate traffic flows as well as transit. Cycle lengths approaching 120 seconds should be limited to complex intersections, bridge approaches, or during peak travel times. Another important consideration when determining cycle length is the impact the cycle length may have on transit scheduling. Cycle lengths that allow for an "even" number of cycles during an hour would result in transit schedules that use the same time day to day (i.e., "clockface" scheduling, arrivals at :15, :30, :45, etc.) (H. Levinson, et al. 2003).

(Q) Will additional equipment need to be purchased to implement TSP?

(A) Passive signal priority should not require additional equipment. The signal controller just needs to have the ability to be "retimed" with different phase and cycle time adjustments.

Active Signal Priority

Active signal priority enables a transit vehicle approaching a signalized intersection to "request" priority through the intersection. There are a number of technologies available to allow the signal controller to detect an approaching transit vehicle. Once detected, the signal controller can either extend the green phase in order to allow the bus to proceed through the intersection, shorten the red phase (giving the bus an early green), or insert a special phase for the waiting transit vehicle. More complex systems can determine whether the bus is on schedule and will only grant a priority green signal to a bus that is behind schedule.

(Q) When should active signal priority be considered?

(A) Active signal priority provides more flexibility in the use of TSP because it detects the transit vehicle prior to determining whether to activate priority. Passive signal priority does not grant this level of flexibility. Active signal priority allows for fluctuations in transit operations and scheduling that may occur, generally due to traffic or other conditions are unpredictable or variable. For example, while boardings and alightings are often consistent at each stop, there may be instances where the ridership increases or decreases for an unforeseen reason. This change would impact travel time versus schedule and make active signal priority a better choice because of the adaptability of the application.

Ultimately, it is important to consider the travel time savings realized by the transit passengers and traffic traveling with the priority transit route. If the time savings realized is greater than the time lost for cross-street traffic and pedestrians then the application would be an overall benefit (Smith, Hemily and Ivanovic 2005)

(Q) When using active signal priority, what should the triggers be?

(A) There are no definitive rules on what the trigger should be for active signal priority. Some systems allow for unconditional activation of signal priority. This means every vehicle with the ability to request priority receives priority at the appropriate sequence in the phasing. Active signal priority may also use distance based triggers (e.g., detection within 500 feet of an intersection) or time-based triggers as discussed below.

Some systems only give the vehicle priority if it is behind schedule. This level of signal priority requires additional equipment that can monitor the bus in relation to the schedule. This is typically accomplished through the use of automatic vehicle location (AVL) equipment. This would add to the cost of implementation if not already in place. The rule for how far behind schedule the bus needs to be before receiving the priority would depend on the situation (i.e.,2 mins, 5 mins). That determination would need to be made between the traffic engineer and the transit provider. An engineering study should aid in this determination. The engineering study can also determine how often the signal priority can be given in a specified time interval. Los Angeles Metro limits the use of TSP to every other signal cycle. Ultimately, the overall person delay for both buses and general traffic should decrease with only a small increase in general traffic delay (Kittleson & Associates, Inc. 2007).

(Q) What is the impact on pedestrians when Active TSP is utilized?

(A) The impacts on pedestrians are minimal. Cross street signals will always retain a sufficiently long minimum green phase time to allow pedestrians adequate time to cross the street. This is regardless of the signal head used (flashing hand or countdown). Even if a bus has approached and been recognized by the signal, it will not receive a green phase until the minimum time set for the cross street green phase is met. accordingly, intersections that have heavy pedestrian activity can impact the benefits realized by TSP (H. S. Levinson, et al. 2003).

(Q) Will new equipment be needed for an active signal priority system?

(A) This will depend on the existing equipment in place. The existing controller must be able to implement TSP. If it cannot, then a new signal controller will need to be installed. If the system is designed to provide conditional priority in situations where the bus is behind schedule, an Advance Transportation Controller (ATC) will be needed.

In addition to signal controls, detection equipment will be needed at both the intersection and on all buses. The technologies available to accomplish this task will vary depending on whether the bus is operating in an exclusive lane or in mixed traffic. Table 9 shows the available technologies for each scenario. It is important to note that if a preemption device is in place for emergency vehicles, this device may be used to provide detection capability for a signal priority system for transit.

The detection equipment will in many cases also require equipment be installed on the bus as well. More complex systems that monitor transit schedules will require an Automatic Vehicle Location (AVL) system be installed on the transit vehicles (Baker, et al. 2004).

Table 9 summarizes the range of detection equipment available.

Table 9: Detection Equipment for Different Lane Types

Exclusive Lane	Mixed Traffic
Induction loop detector	RF tag
Video detector	Optical emitter
GPS/AVL	GPS/AVL
Optical emitter	Infrared
Radar detector	
RF tag	

Source: An Overview of Transit Signal Priority, ITS America, 2004

Table 10 provides advantages and disadvantages associated with a number of technologies used to communicate between the bus and signal.

Table 10: Comparison of TSP Communication Technologies

Technology	Advantages	Disadvantages
Inductive Loops	• Devices placed in guideway rather than vehicle	• Only appropriate for exclusive busways • Devices damaged in road construction
Low Frequency RF (100-150 KHz)	• Transmitters inexpensive and are easily removed or replaced	• Message transmitted may be hindered by accumulated dirt or snow on tag
900-1000 MHz RF	• Transmitters inexpensive and are easily removed or replaced • Can transmit much information	• Message transmitted may be hindered by accumulated dirt or snow on tag
Spread Spectrum Radio	• Can transmit much information	• Not as accurate in locating buses as other radio frequency technologies • Can be affected by weather • May be more expensive
Infrared	• Well proven in Europe	• Limited ability to provide precise vehicle information • Limited amount can be transmitted from vehicle • Requires line of sight
Video		• Requires line of sight
Optical	• Cost savings if already in place for emergency vehicle preemption	• Limited ability to provide precise vehicle information and transmit from vehicle • Requires line of sight
GPS/AVL Vehicle Tracking		• Buildings may block signal • May not provide precise location information for signal priority treatment

Source: TCRP Report 90 Bus Rapid Transit volume 2: Implementation Guidelines (2003)

Transit Signal Priority (Pioneer Valley Transit Authority in Springfield, Massachusetts)

Project Overview: In 2001, the Pioneer Valley Transit Authority (PVTA), the Pioneer Valley Planning Commission (PVPC) and the City of Springfield teamed up to implement TSP on one of the busiest city routes. In 2005, the system was implemented and consists of optical-based transmitters (located on the buses) and receivers (located on the traffic signals). Visible and infrared light are emitted from the transmitters. If the bus is within 400 feet of an intersection, the optical transmission is detected by the receiver. Depending on the status of the signal sequence, the green light on the cross street is shortened or the green light along the bus route is extended. The project includes TSP at 9 signalized intersections. The distance from the first TSP intersection to the last TSP intersection is approximately 3.5 miles, while the total length of the express route which utilizes TSP is approximately 6.5 miles.

Project Cost: Congestion Mitigation Air Quality (CMAQ) funds were granted to PVTA; therefore, the transit agency was able to reimburse the City for a portion of the signal improvement expenses. The total project cost was approximately $300,000.

Impact on Transit: Implementation of TSP, along with limited stops, I-91 express operations and more efficient routing, reduced the travel time of the bus route by 15 minutes. In addition, ridership increased by 8% during the first year.

Lessons Learned/Key Stakeholders: Key participants from this project – City of Springfield Department of Public Works, Pioneer Valley Transit Authority, Pioneer Valley Transportation Commission, a traffic signal representative from NAZTEC, and a transit priority system representative from GTT – credit this project's success to team work during all phases, including field work programming, testing and fine tuning.


Source: Pioneer Valley Transit Authority

Queue Jumps

Queue jumps can be integrated with bus stop design and used with both near-side and far-side stops. Using a queue with a far-side stop usually requires the addition of a bus bay (receiving lane) on the opposite side of the intersection. The bus bay allows the bus to proceed straight through the intersection, bypassing traffic at the intersection to access a far-side bus stop. The downside of this type of application as a means to bypass traffic and gain a travel time advantage is that upon entering the bus bay, the bus must merge back into traffic.

The use of a pull-in queue jump and signal priority treatments can provide a means for transit to gain an advantage over general traffic when used in conjunction with a near-side bus stop and does not require a bus bay on the opposite side of the intersection (Figure 17). If a far side bus stop is used, a bus bay on the opposite side of the intersection should be included (Figure 18).

Queue jumps and signal priority can also be an effective way to provide time savings to buses in corridors in which it is not feasible to dedicate a full lane as an exclusive bus lane. The bus would travel in mixed traffic until it reaches the queue jump and TSP would allow it to bypass traffic at the intersection upon proceeding. While not providing the level of priority an exclusive bus lane does, the queue jump provides a certain level of time savings the bus would not otherwise receive.

Figure 17: Example of Queue Jumper with TSP

(Q) When is it advisable to consider a queue jump?

(A) Queue jumps are most beneficial when the bus is approaching an intersection that has heavy congestion or an area where a bottleneck occurs. TCRP Report 19 mentions that a level-of-service of "D" or worse should be observed prior to considering this as a solution. The queue jump will allow the bus to bypass the traffic queue and proceed through the intersection (Texas Transportation Institute 1996).

Figure 18: Example of Queue Jumper with Far-Side Bus Bay with TSP

(Q) Does the queue jump require its own exclusive lane for transit only?

(A) No, the queue jump can use a right turn lane to bypass through traffic. One important consideration is giving the queue jump lane a protected right turn phase in the signal at the same time the bus is getting a priority signal to proceed through the intersection.

This will allow the traffic in the queue jump to make the right turn and not impede the bus from being able to proceed through the intersection. It is also necessary to ensure that the right turn lane is sufficiently long to allow the bus to access it prior to reaching queued vehicles (Kittleson & Associates, Inc. 2007).

(Q) Does the traffic signal need to be activated by the transit vehicle in order to be beneficial?

(A) No, while active signal priority is preferred for queue jumps, the bus can use a combination of a right-turn only lane and a right-turn only signal to gain an advantage over traffic proceeding through the intersection. This means the right turn lane will clear traffic and allow the bus to continue through the intersection prior to the mainline traffic. Proper signage notifying drivers that only the bus can use the right-turn only lane to proceed through the intersection would be required. Intersections where this is allowed would also not have protected left phasing for cross-street traffic concurrent with the protected right phase. Ultimately, a signal optimization study should be conducted when considering this type of application to determine the proper timing and phasing. Utilizing an active signal priority may provide the bus some travel time savings, but the cost would need to be balanced with the benefits (Kittleson & Associates, Inc. 2007).

Crosswalks

The need for transit riders to be able to safely cross an intersection is paramount. Very rarely does the bus pick someone up at their home or drop them off exactly at their destination. This makes pedestrian access to transit stops a key consideration in planning service. Safety and convenience are factors that should be considered when designing crosswalks.

The goal of priority transit is to attract more riders. Bus stop accessibility can impact transit ridership. If a rider has a well defined, easy to use, and safe way to access the bus stop, there is a greater likelihood they will chose transit. The inclusion of crosswalks in a discussion of priority transit not only benefits the users of the transit system but also all pedestrians. The impact on an intersection cannot be neglected. The following is a discussion of issues that may arise when addressing pedestrian needs.

(Q) Should every intersection near a transit stop have a crosswalk?

(A) It is important to provide a clearly defined path where the pedestrian should cross. At a minimum, this should include a striped crosswalk. Additional treatments could include colored/textured pavement, vertical deflection (e.g. raised crosswalks), grade-separation, and/or pedestrian signals. Consideration for pedestrian sight lines should also be made. Discussions earlier about far-side and near-side stops presented some of the issues related to providing the pedestrian with a clear view of oncoming traffic.

(Q) What if the road is wide and it takes a long time for pedestrians to cross?

(A) A large intersection may be an ideal location for improvements like bus bulbs. While these improvements are designed to provide a convenient way for the bus to access passengers, they can also provide a safer pedestrian environment. The bus bulb shortens the distance across an intersection. This reduces the distance a pedestrian needs to cross in addition to providing a design element that can passively slow traffic. This improvement would also improve safety and accessibility for mobility impaired individuals (Nabors, et al. 2008). Bus bulb design should also take into account cyclist traffic along the route and provide bicycle cut-throughs as necessary.

Figure 19 shows a pedestrian crossing of a roadway with a median bus lane.

Figure 20 shows a single bus bulb and crosswalk. A bus bulb does not itself reduce crossing times; rather, reducing the crosswalk distance reduces crossing times. Bus bulbs are likely to reduce crosswalk distance. By reducing crosswalk distance by the depth of the bus bulb, crossing time is reduced accordingly: about 3 seconds (at a walking speed of 3 feet per second) for a single bus bulb and double for paired bus bulbs.

Figure 19: Example of a Crosswalk in Val de Marne, France

Source: National Bus Rapid Transit Institute

Figure 20: Example of a Bus Bulb in Chicago, Illinois

Source: Streetsblog.org

(Q) What are additional treatments that could be applied to an intersection to improve pedestrian safety?

(A) The addition of pedestrian signals is an important feature to any busy intersection. They provide the pedestrian with information about when it is safe to cross. The signals are typically part of the intersection signal timing, but in some instances a "walk" signal can be requested by the pedestrian waiting. Other features that should be considered at locations where heavy pedestrian traffic is observed are signal heads with a countdown feature. These allow the pedestrian to know how long they have remaining to cross the street prior to the signal changing (Nabors, et al. 2008). Ensuring that intersections have accessible pedestrian signals and pedestrian ramps is important as part of ADA requirements.

Figure 21 shows a pedestrian crossing actuator.

Figure 21: Example of a Pedestrian Crosswalk Signal in Leeds, England

Source: National Bus Rapid Transit Institute

(Q) How do pedestrian signals interact with Transit Signal Priority?

(A) When TSP is implemented at an intersection, there are mandatory minimum allowances for cross traffic and clearance times of the intersection and those must include allowances for pedestrians to safely cross the street and clear the crosswalk.

Chapter 4: Sidewalks

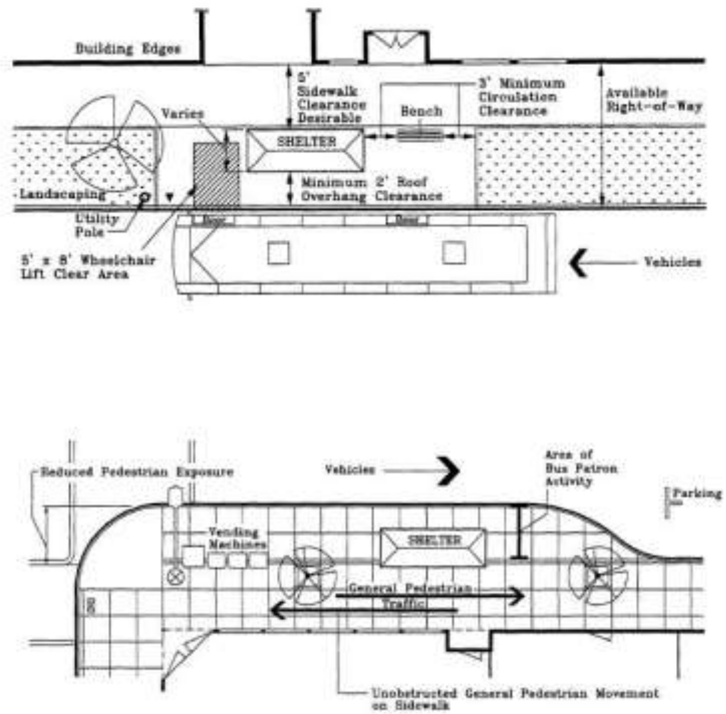
Sidewalk Design

Priority transit will typically have more transit amenities than a traditional bus stop. The amenities will typically include unique shelters designed to accommodate higher passenger volumes and system information in the form of electronic boards or large system maps. These stations may also include off-board fare collection (Figure 22). All these factors combine to require more space than a traditional bus stop and should be considered when planning station locations. Other considerations should include how many buses will be stopping at each location at one time. This will determine the length of each station. Determine whether the curb edge will be level with the bus floor to ensure level boarding and other accessibility issues.

Width

Sidewalk width will vary from location to location. Width should take into account the expected pedestrian levels for a particular area to allow reasonable flow of pedestrian volumes. Width should also vary dependent on the amount of types of street furniture. Features such as bus shelters, benches, or trash cans should not be placed without regard to pedestrian flows. Appropriate clear zones need to be maintained in order for a sidewalk to conform to ADA design guidelines.

Figure 22: Example of Bus Stop & Shelter Design



Source: TCRP Report 90: Bus Rapid Transit Volume 2 - Implementation Guidelines

(Q) Will the addition of station amenities impact the required width of the sidewalk?

(A) The width of each sidewalk will vary based on average pedestrian flows and other design factors. When considering the placement of amenities such as shelters, it is important to maintain an adequate clear zone that will allow the sidewalk to continue to function with the existing pedestrian flows. In order to ensure compliance with ADA guidelines, it is also important to locate shelters or other street furniture such that it allows a person in a wheelchair sufficient clearance as well as access to the shelter. This may require the extension of a sidewalk. As mentioned earlier, bus bulbs are an excellent treatment that can provide adequate space for a transit station without impacting the existing sidewalk. It is recommended that station platforms provide 10-12 feet for the passenger waiting area. This width should double when using the median as the passenger waiting area (H. S. Levinson, et al. 2003).

Length

The length of a sidewalk typically corresponds to the length of the block face. With regard to transit, the length of the sidewalk pertains to the area that needs to be available for transit activity. This area is based on the number of buses that will be serving a particular stop at one time. A typical city bus is approximately 40 feet long, which would mean a stop should allow a minimum of 50-60 feet for the bus to access the sidewalk and waiting passengers. If more buses are expected to serve the bus stop or the bus is going to be longer because it's articulated, the length of the bus stop should increase accordingly. This is important to consider when designing the sidewalk because a sidewalk may need to be wider where the bus stops are in order to accommodate existing pedestrian traffic and stop activity. This would not mean that the entire sidewalk needs to be widened, just the area impacted. The length would also need to be determined if a bus bulb was installed.

(Q) How long should the station area be?

(A) Station platform length will vary based on the surrounding environment and the number of buses expected to arrive within a given time frame. At the least, station platforms should provide approximately 50-60 feet to accommodate a standard 40 foot bus. When using articulated buses or expecting to accommodate more than one bus, additional space will be required (Diaz and Hinebaugh 2009). Typical articulated buses are 60-62 feet in length. This would require a station area of at least 65 to 70 feet in length (Kittleson & Associates, Inc. 2007)

Curb Height

The height of the curb at a transit station is important to consider from an accessibility and travel time savings standpoint. Standard curb height is six inches which is well below the floor level of a low floor bus, let alone a standard bus. This results in passengers having to step up or down in order to board or alight from the bus, and makes it difficult for individuals with a mobility limitation to access the bus without additional assistance. This assistance is typically provided by deploying a ramp from the transit vehicle or kneeling the bus in order to bring the bus closer to the station platform height. This action increases the amount of time that a bus dwells at the bus stop ultimately impacting the travel time of the transit vehicle. Increasing the height of the curb to the level of the bus floor would allow passengers to board or alight from the vehicle without having to step up or down and reduces the need for deploying the bus ramp.

(Q) Does the Americans with Disabilities Act Accessibility Guidelines (ADAAG) require taller curbs for priority bus service?

(A) No, The requirement for taller curbs is only associated with new rail transit and not new bus transit. However, priority bus service often attempts to provide many of the benefits of rail transit at a reduced cost. It would therefore be beneficial to consider increasing curb heights to reduce the vertical clearance issues between the bus floor and the curb edge. ADAAG mandates a difference of not more than +/- 5/8 of an inch between the rail car floor and station platform height. A similar standard should be used when considering level platforms for bus stations. This would result in a curb height of approximately 14 inches (H. S. Levinson, et al. 2003).

(Q) What are some of the challenges associated with increasing the height of the sidewalk?

(A) Raised curbs will only work in road segments that provide a straight approach for the bus. If the curb edge curves it may not allow for the bus to pull close enough to the curb, resulting in gaps between the curb edge and doors.

Increasing the sidewalk height to 14 inches would more than double the height from the standard curb edge. This increase in height could present design issues in transition from the standard sidewalk and curb height as well as safety issues associated with the increased height between the curb edge and the street. It is recommended that the curb edge be marked with tactile treatments and painted a different color to alert the waiting passenger of the difference in height.

Concerns with buses damaging tires as they attempt to "dock" close to the curb to eliminate gaps between the curb edge and bus door can be alleviated by using a sloped curb edge or Kassel Curb. This curb design provides a shorter curb face against the street edge that drivers can pull up against without damaging the body of the bus or the face of the wheel. The curb then slopes up to the full height, which will align with the bus floor when properly "docked" (H. S. Levinson, et al. 2003).

Shelters (Swift BRT in Snohomish County, Washington)

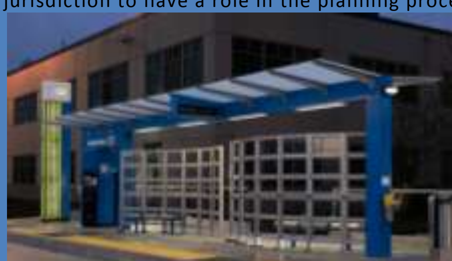
Project Overview: In 2009, Swift BRT began operating along 16.7 miles of arterial and Business Access or Transit (BAT) lanes. The BRT overlaps along 6.5 miles of a BAT lane, 10.5 miles of TSP, and the remainder in mixed flow traffic. TSP will be fully implemented by the beginning of 2011. Swift operates using 15 vehicles and serves 24 stations. Swift features 3 doors that simultaneously allow passengers to board and alight, off board fare collections and a 10 second dwell time.

Project Cost: The total project cost was approximately $25 million; however, half of this cost was for the vehicles. The station kits cost approximately $112,000 each and were built behind the sidewalks on 60 X 10 pads. Costs varied by location depending on land acquisition and underground utilities.

Impact on Transit: In less than 2 months, Swift ridership was 2500 per day and 3200 per day after 4 months. The riders' travel time along this corridor decreased from 73 minutes to 54 minutes.

Impact on Traffic: This project had very little impact on traffic since the BAT lane was already in place and TSP effects were minimal.

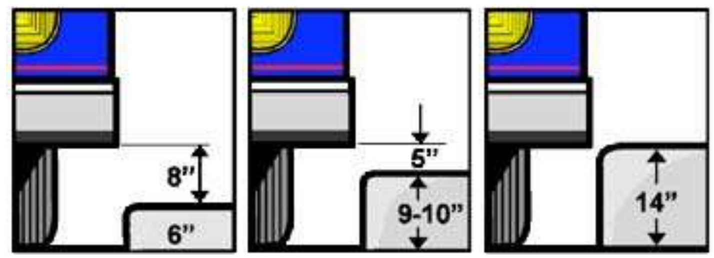
Lessons Learned/Key Stakeholders: The biggest implementation obstacle was coordinating the requirements of 5 different jurisdictions and the state DOT. Lessons learned included starting a technical committee as early as possible and allowing each jurisdiction to have a role in the planning process.



Source: Community Transit

Another consideration should be the design of the vehicles being used along the corridor. There is no standard for the height of low-floor buses in the industry. Therefore, some buses may present issues when using certain curb heights. If the curb height is higher than the floor of the vehicle it will present conflicts with the doors opening (**Figure 23**). Currently, WMATA low-floor buses cannot access stops where the curb height is greater than seven inches. It is not advisable to exceed this height when designing curbs that would improve platform to bus access.

Figure 23: Example of Curb Edge Heights



Source: Characteristics of Bus Rapid Transit (pp. 2-25), NBRTI (2009)

Shelters

Shelter design can be a major component of priority transit service. Fewer stop locations and the addition of amenities such as more substantial system information and off-board fare collection result in the need for more space and a larger shelter than a traditional stop. Priority transit stops typically have higher ridership figures per stop because of the fewer number of stops, a result of increasing the distance between stops, and the attractiveness of the service, again resulting in a need for more space. Station designs that are unique to the service and provide greater amenities are seen as an added feature to priority transit that makes it more attractive to riders and sets its identity apart from the local service. At a minimum, shelters that are served by priority transit should include special signage that informs customers to difference. These differences result in unique requirements that must be addressed.

(Q) Where should shelters be located along a priority transit corridor?

(A) Shelters should be located near major activity centers along the corridor. These locations could be major job centers, hospitals, universities, government facilities, or recreation and shopping centers. Other considerations should involve the existing sidewalk design and whether it can accommodate the shelter or allow for expansion to provide space for a shelter. Locations should provide good access by all modes of travel and should be near intersections where other transit converges, allowing for transfers (Kittleson & Associates, Inc. 2007). As with any stop location, lighting and safety should be considered. Locations with adequate lighting that provides an environment that is safe for passengers to wait is ideal.

(Q) What design features should the shelter include?

(A) Shelters should be designed with regard to the surrounding built environment. Shelters should not detract from the character of the area in which they are located. Shelters should provide protection from the weather; taking into consideration the extremes (i.e., extreme heat or cold). Shelters should be comfortable to the user and also provide a safe location for waiting passengers. Shelters need to comply with all ADA Guidelines to ensure accessibility for all users. It may be necessary to consider multiple shelter designs and configurations based on the different locations (suburban vs. urban), size restrictions, as well as ridership levels (H. S. Levinson, et al. 2003).

(Q) Will the shelter impact the design of the surrounding sidewalk?

(A) Placement of a shelter may require a redesign of the surrounding sidewalk. Placement of the shelter should ensure that no part of the structure is closer than 2 feet to the curb edge to reduce the potential of bus striking the shelter. In addition, the shelter should be sited to allow for at minimum 4 foot clear zone behind or in front of the shelter to allow wheelchairs to navigate around the shelter and to ensure a comfortable distance for waiting passengers from the road edge. (Texas Transportation Institute 1996). Sidewalk design and shelter design should also accommodate wheelchair access to the shelter itself.

Figure 24 provides examples of shelters.

Shelters (The HealthLine in Cleveland, Ohio)

PROJECT OVERVIEW: The Greater Cleveland Regional Transit Authority (RTA) began operating the HealthLine in October, 2008. The HealthLine serves 62 stops at 36 stations. Three unique station designs are illustrated in the photos. The shelters have a modular base design, as well as A316 stainless steel and glass. Station features include:

- Attractive
- Easily Accessible Fast-Loading
- Near Level Boarding
- ADA Compliant
- Conveniently Located
- Integrated into the Community
- Fare Vending Machines
- Emergency Phones
- CCTV
- Real-Time Passenger Information
- Passenger-Friendly Waiting environment
- Benches and Lean Bars

SHELTER COST: The Downtown shelters cost $210,000 per unit. The Midtown shelters cost $206,000 per unit. The Curbside shelters cost $71,000 per unit. These prices are for the structure only and do not include any of the amenities listed above. In addition, the platforms cost approximately $70,000 per unit. (Refer to the Cleveland case study in chapter 1 for additional project information). **(SOURCE: RTA)**

Source: RTA

FIGURE 24: EXAMPLES OF PRIORITY TRANSIT SHELTERS

Upper left – Silverline in Boston, MA. Lower left – Shelter along the South Miami-Dade Busway in Miami, FL. Upper right – Lymmo in Orlando, FL. Lower right – MAX in Kansas City, MO.

SOURCE: NATIONAL BUS RAPID TRANSIT INSTITUTE

Appendix A: Summary of Findings and Local Examples of Priority Treatments

A study of local express services was conducted to determine what priority treatments are currently being used and how they benefit the service when compared against local routes. Six routes were observed: Richmond Highway Express (REX), Metrobus 79 Extra Line, Metrobus 37 Express, Metrobus 39 Express, Metrobus 28X, and Metrobus S9. Observations about the operating environment, bus operations, on-time performance, traffic, and ridership were made. Observations were done without notifying the drivers. Comparisons of these routes to local routes that operate along the same routing were done using posted schedules. The analysis provides an insight in what priority treatments are currently being used and how successful they are.

Table 11 provides a summary of the case studies used throughout the guidebook as well as the local examples of express routes using select priority treatments described in this appendix. Table 11 shows the routes and the treatments that each route uses. This allows for a comparison of treatments across a variety of examples.

Table 11: Case Study Summary

Route Agency	Bus Priority Treatment: Lane of Travel				Vehicle Restrictions			Operations			Lane Markings			Stop Location				Stop Design				Transit Signal Priority			Sidewalk Design		Shelters	
	Outside	Middle	Center	Median	Bus Only	Bus & Select	Mixed-traffic	Full-time	Part-time Peak	Limited Stop	Striping & Marking	Colored Lane	Lane Delineators	Near-side	Mid-block	Far-side	Driver-side	Curb-side	Bus bay	Bus bulb (nub)	Median	Active	Passive	Queue Jump	Standard	Level	All Stops	Unique Design
HealthLine: Greater Cleveland Regional Transit Authority				●	●			●			●					●					●	●				●	●	●
MAX: Regional Transportation Commission of Southern Nevada	●				●			●			●							●										
Silver Line: Massachusetts Bay Transportation Authority		●			●			●			●																	
Bx12: New York City Transit	●				●			●				●				●		●					●	●	●			●
Pioneer Valley Transit Authority	●							●														●						
Swift: Community Transit	●					●		●			●					●		●				●			●			●
REX: Washington Metropolitan Area Transit Authority	●						●			●								●							●			
Metrobus 79: Washington Metropolitan Area Transit Authority	●						●			●								●							●			
Metrobus 37: Washington Metropolitan Area Transit Authority							●			●																		
Metrobus 28X: Washington Metropolitan Area Transit Authority										●																		

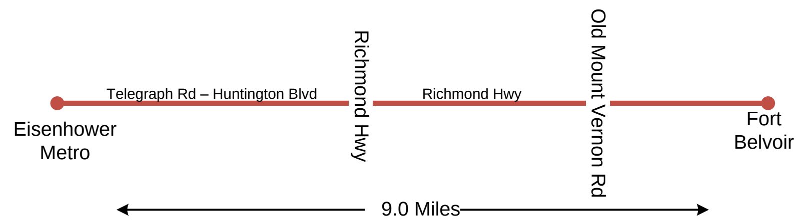
Richmond Highway Express (REX)[4]

Overview of Corridor

The Richmond Highway Express (REX) is a limited stop, branded service that runs on Richmond Highway (US 1) from Fort Belvoir (including on-post circulation) to the King Street Metrorail Station. In the regional PCN evaluation, PCN Corridor 2 covered Richmond Highway from the Eisenhower Avenue Metrorail Station to Fort Belvoir. TSP is in place along the corridor to give green signals to buses.

The 9-mile Richmond Highway corridor is split about evenly between inner-suburban and outer-suburban land use densities, with the northernmost mile of the corridor exhibiting urban densities. The entire corridor (Figure 25 and Table 12) is a major arterial, which eases the implementation of a certain level of priority service, as has already been done. About 40% of the corridor has three lanes in each direction, and the entire length of the corridor contains medians and/or parking lanes that could potentially be used as bus lanes.

Figure 25: Schematic of PCN Corridor 2: Richmond Highway (US-1)



Ridership on the REX has grown each year since the inception of its service. The REX currently has an average weekday ridership of 4,741, with 49 average boardings per trip. The REX bus is routinely crowded; on many trips, a seat is not available for all passengers. The population that REX serves is largely low-income, its ridership is 79% minority and 50% of REX passenger households do not own a vehicle. Residential developments on the northern part of Richmond Highway are predominately low-income, as is much of the residential development throughout the entire corridor. A number of senior centers, assisted living facilities for seniors and the disabled, two homeless shelters and several affordable housing developments are also present on Richmond Highway. Aside from the big-box retailers that line Richmond Highway, there are no major employers on the central part of the corridor. Towards the northern section of Richmond Highway, near I-95, there is a medium concentration of employers.[5]

[4] Refer to Figure F-3 on Page 161 of *An Evaluation of the Metrobus Priority Corridor Networks Final Report* for a map of the route.

[5] Information provided by Fairfax County DOT.

Characteristics of Roadway

Table 12: Roadway Characteristics – Richmond Highway

Characteristic	Result	Data Source
Roadway curb-to-curb width (including gutter pan)	79.2 Feet curb-to-curb, Richmond Highway at Mohawk Lane 101.6 Feet curb-to-curb, Richmond Highway at Belford Lane	Fairfax County DOT
Number of lanes and lane widths	Richmond Highway at Mohawk Lane – 2 11-foot SB lanes, 1 19.2-foot SB curb lane, 1 11-foot NB left turn lane, 1 11-foot NB lane, 1 11 foot NB and right turn lane Richmond Highway at Belford Lane – 3 SB lanes, 2 12-foot, 1 11.8-foot, 6-foot median, 12-foot NB left turn lane, 11.8 –foot right hand turn lane	Fairfax County DOT
Presence or lack of left turn lanes at intersections	Left turn lanes are present at all intersections served by REX bus	Observation
Presence or lack of right turn lanes at intersections	Most intersections have a right hand turn from the travel lane, some have a right hand turn only lane	Observation
Traffic volumes (daily and both AM and PM peak hour)	AADT Mt. Vernon Memorial Highway – 35,000 North Mt. Vernon Highway - 60,000 North Kings Highway – 45,000	VDOT
Number of intersections	29 on Richmond Highway	Fairfax County DOT
Number of signalized intersections	18	Google Maps
Average distance between intersections/number of intersections per mile	0.5 miles	Google Maps
Signal cycle lengths		
Any improvements made or planned to road surface or to roadway drainage	Pedestrian safety improvements are planned for all intersections	Fairfax County DOT, Richmond Highway Public Transportation Initiative

Bus Service

The REX runs the entire span of PCN Corridor 2, and beyond, traveling on-post on Fort Belvoir and extending beyond the Eisenhower Metro Station to the King Street Metro Station. At Fort Belvoir's REX bus stops, no local bus service is available. On Richmond Highway, the REX is complemented by local services from Fairfax Connector routes **151/152 Richmond Highway Circulator, 161/162 Richmond Highway Circulator, and 171 Richmond Highway Line.** The DASH Bus, operated by the City of Alexandria, has two routes that overlap with the final, northernmost section of REX service, the **AT 6** and the **AT 7**, which both travel between the Eisenhower and King Street Metro Stations.

Table 13 shows that the overall run time for the REX is much shorter than the local route that covers all of the REX stops outside of Fort Belvoir, the 171. The 171 is a much longer route than the REX, serving the communities of Lorton and Springfield to the west of the REX route. Bus stop spacing is much closer together for the local routes, with stops approximately every quarter mile to every half mile. Less than half of the passengers on the 171 are traveling to a Metrorail station; where they have the ability to reload their SmarTrip fare cards. This results in many riders loading their SmarTrip cards on the bus significantly increasing vehicle dwell time. The combination of more frequent stopping and greater dwell times associated with reloading fare cards result in the 171 rarely operating on time. Often taking the 171 more than 90 minutes to make a single complete (end-to-end) trip. In contrast, the REX bus stops are all at least 0.5 miles apart and only at key intersections with major attractions (large shopping centers, government center) or transfer points to local bus routes, allowing the REX to offer more reliable and faster trips.

TABLE 13: BUS SERVICE ON RICHMOND HIGHWAY

Express Bus Service (REX)		
Run Time (Minutes)[6]	SB AM/PM 46/49	NB AM/PM 48/50
Span of Service (Start of Trips)	5:57 AM - 7:36 PM, All Stops, 8:05 PM - 10:07 PM, Excludes Fort Belvoir Stops	5:12 AM- 8:28 PM, All Stops; 9:04-10:07, Excludes Fort Belvoir Stops
Headway (minutes)	Peak -12; Non-Peak - 30	Peak -12; Non-Peak - 30
Number of Stops/Stop Spacing	18 (3 on Fort Belvoir); On Richmond Highway stops are 0.5-1 mile apart, between Huntington and King Street Metro Stations 1 mile - 1.5 miles	18 (3 on Fort Belvoir); On Richmond Highway stops are 0.5-1 mile apart, between Huntington and King Street Metro Stations 1 mile - 1.5 miles
Type of Route (i.e., primarily commuter vs. corridor connector)	Corridor Connector	Corridor Connector
Local Bus Service (151/152, 161/162, 171)		
Run Time (Minutes)[5] ***by schedule***	151 - 84 minutes, 152 - 81 minutes, 161 – 46 minutes, 162 – 40 minutes, 171 – 90 minutes	
Span of Service	All Day	
Headway (minutes)	161, 162, 171 - 30; 152 - 30 peak, 60 off-peak; 151- 30 peak, 15 peak partial route PM only, 60 off-peak	
Number of Stops/Stop Spacing	70 stops, approximately one quarter to one half mile apart	
Composite Bus Service		
Number of buses per hour	At Huntington Station – 12 in both northbound and southbound directions	
Boardings/Alightings per Hour	Avg. Boardings Per Trip: REX – 49, 171 – 53, 162 – 21, 161 – 24, 152 – 50, 151- 45	
Maximum stop volume (and location)	(Observed) REX – King St. Metro (NB) – 13; Ft. Belvoir (SB) - 3	

SUMMARY

Observations on the REX (Table 14) were made on Tuesday, May 11, 2010 on two trips: the 2:35 PM northbound trip from Fort Belvoir to King Street Metro Station and the 3:37 PM southbound trip from King Street Metro Station to Fort Belvoir. On the afternoon that the trip was made it was raining, and the weather had a negative effect on ridership. The on-board pictures that were taken on a non-branded REX bus were taken on Wednesday, May 19th to provide a more accurate representation of typical REX ridership levels. Due to the faster operating speed and shorter travel time riders use REX to travel on Richmond Highway to connect to local bus routes for trips to or from Metrorail, instead of using the slower local bus route for their complete trip. The REX schedule is not coordinated with the local bus routes, but when a local bus and a REX happen to meet at a bus stop, there is often a rush of riders transferring from the local bus service to the REX.

Although the REX terminates at a location on Fort Belvoir, and is used by a handful of installation-bound commuters, it is not primarily used by commuters. This may change with the implementation of the Base Realignment and Closure Act (BRAC), which mandated the relocation of 19,000 employees to Fort Belvoir by 2011, many of whom are expected to commute from residential locations north of the installation.

[6] Note: Run times for the routes listed are from end to end for the entire route. They are not a comparison of similar segments.

Field Check Observations

Table 14: Field Observations -- REX

Characteristic	Observation
Is passing of a stopped bus by another bus permitted?	The passing of a stopped bus by another bus is not permitted as a policy, but it routinely happens.
Type and extent of bus priority	REX has TSP and is a branded, limited-stop service, but it lacks an exclusive bus lane. However, non-branded Metrobuses are used for some REX trips.
IF TSP is used, the type of TSP and the duration of extension or early-call provided	TSP is used, but it is unclear what type.
Signage provided to denote PCN	The only REX signage used is the branded REX sign on bus stop poles.
Enforcement mechanisms	None apparent.
Use of bus lane by right turning vehicles?	There is no bus lane, but the bus stays in the right-hand lane for both northbound and southbound trips. This can contribute to traffic queuing.
Number of PCN stop improvements	Most PCN stops (but not all) have a covered bus shelter, but not shelters that are large enough to accommodate the size of the crowds waiting.
Nature of PCN stops and any special designations or features	Two bus stops (Mohawk Lane and North/South Kings) have newer, larger bus stops.
Are boarding areas at normal sidewalk height or are they raised?	Normal sidewalk height
Do local buses use express stops?	Yes and the REX primarily serves as a connection for passengers transferring to local buses.
On-board vs. off-board fare collection	On-board fare collection
Type of route (i.e. primarily commuter vs. corridor connector)	Corridor connector, serving primarily a transit dependent population transferring to local routes.
Presence of commercial districts with street front stores	The Richmond Highway segment of the bus route is lined with big-box strip retail, setback from the curb with numerous service roads and large surface parking lots.
Accommodations for commercial vehicle loading and unloading	Commercial vehicle loading does not occur on Richmond Highway, loading occurs off-street at big-box loading bays.
Curb lane parking?	None

Ridership

- Ridership was affected by the rain on the afternoon observations were taken, but even if ridership was lower than typical on the REX bus both the northbound and southbound trips were fairly full. On the northbound trip the maximum number of riders the bus carried at one time was 25, on the southbound trip the maximum number of riders the bus carried was 34.
- Ridership on the May 19th trip was more typical, with several standing passengers and all seats full most of the trip.
- The REX serves a corridor with a heavily transit dependent population.

Shelters/Stops/Amenities

- All bus stops in right hand travel lane, some bus stops had pullouts to accommodate the bus, and others were just at the curb.
- All of the REX stops had a REX branded sign, but the current shelters are not large enough to accommodate the number of people waiting at them.
- Several REX and local bus stops lack shelter or adequate pedestrian treatments. The stop at Richmond Highway and Old Mill Road and the stop in the northbound direction at Richmond Highway and Belford Drive were of particular concern. The stop at Belford Drive offers no shelter, and only a small sidewalk space right next to the curb of the right travel lane. The stop is located very close to an assisted living facility for seniors and a couple of seniors boarded at this stop on the observation trip.

Rolling Stock

- Both observation trips were on new, distinctively branded REX buses, however, the route sometimes uses non-REX branded buses.
- Several of the REX buses have televisions that were installed as a part of a pilot program, but these are not found in most REX buses.

Schedule Adherence

- The northbound trip left on schedule, and arrived at the King Street Metro Station just 2 minutes behind schedule.
- The southbound trip left 3 minutes behind schedule, but actually hit the next four of nine time points at or a minute ahead of schedule. At the very end of the corridor the bus began to fall behind schedule, which seemed curious since traffic and ridership

at the southern end of the route were both light, and it arrived 6 minutes behind schedule. Although the bus has TSP, it did not appear that the driver used it when entering Fort Belvoir.

Traffic

- Traffic northbound in the afternoon was fairly light, and the REX's interaction with northbound traffic was relatively unproblematic. The speed cars travel on Richmond Highway appeared to make it a little difficult for drivers to exit pullouts or right-turn only lanes. The posted speed limit on Richmond Highway is 45 miles per hour.
- Traffic southbound in the late afternoon was also relatively light and non-problematic. Fort Belvoir experiences an earlier than normal PM rush hour that typically begins at 3:30, but the REX does not currently interact with traffic exiting the base, as the main point of entry/departure for Fort Belvoir traffic is the main gate, which is further south on Richmond Highway. The non-Fort Belvoir traffic rush hour, which typically begins in the 4:00 hour, is currently somewhat heavy but it is not truly comparable to the level of traffic and delay found on the regions' major highways.

Runningway

- Most of the runningway has three travel lanes, and all major intersections have left turn lanes. The presence of right turn lanes varies, at a few intersections there are dedicated right turn only lanes, at others, the right turn is from the travel lane.
- Even at right turn only lanes, these lanes are sometimes blocked by buses stopped at bus stops at these intersections. This happens most often at busy strip shopping center entrances.
- Alongside much of the runningway, in both the northbound and southbound directions, are relatively unused service roads. While these are not contiguous throughout the corridor, they could be considered for use as future bus pullouts or for use in the creation of dedicated busways.

Comparison to Local Buses

- In comparison with traveling on the local Fairfax Connector route 171, the REX offers a much faster, more reliable trip with shorter headways.
- Unlike local bus routes, according to data provided by the Fairfax County DOT, 73% of weekday REX riders board or alight the bus at a Metrorail station, while just 49% of weekday riders of the 171 are boarding or alighting at a Metrorail station. The REX provides a complementary service connecting residents of Richmond Highway to the rail service that serves the greater urban region.

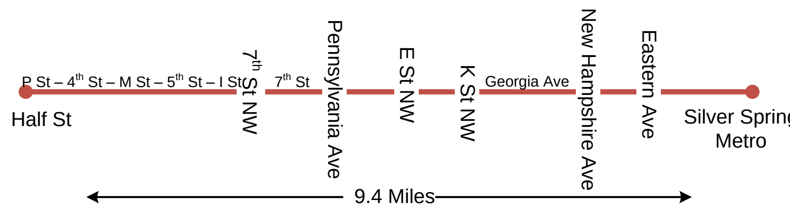
Metrobus 79 Georgia Avenue Extra Line[7]

Overview of Corridor

In the regional PCN evaluation, Corridor 3 begins at the Silver Spring Metrorail Station. Heading south, the corridor follows Georgia Avenue through Brightwood and Petworth to Howard University, where the avenue turns into 7th Street NW (Figure 26 and Table 15). At Rhode Island Avenue southbound buses turn right and then left to follow 9th Street as 7th Street becomes one-way north. The PCN corridor crosses the National Mall into Southwest DC before making additional turns to end up near the Washington Nationals' baseball stadium on South Capitol Street. Major trip generators include Silver Spring, Walter Reed Army Medical Center[8], Colombia Heights, Howard University, and downtown DC.

Land use along the route is 40% inner-suburban and 60% urban, with less dense development near the Silver Spring station. The corridor is almost all major arterials, along with a few connector roads. Most of the corridor has three lanes in each direction.

Figure 26: Schematic of PCN Corridor 3: Georgia Avenue / 7th Street



Characteristics of Roadway

Table 15: Roadway Characteristics – Georgia Ave / 7th St

Characteristic	Result	Data Source

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[7] Refer to Figure F-4 on Page 162 of *An Evaluation of the Metrobus Priority Corridor Networks Final Report* for a map of the route.
[8] Note: Walter Reed Army Medical Center is scheduled to close in late 2011 and its future impact as a trip generator is unknown at this time.

Characteristic	Result	Data Source
Roadway curb-to-curb width (including gutter pan)	Georgia Ave: 49-60 Feet 7th Street: 50-76 Feet	Metro*EXTRA* Service Plan , Georgia Avenue – 7th Street Corridor , November 2006
Number of lanes and lane widths	Georgia Ave: between Eastern Avenue Shepherd Road 3 in each direction; Shepherd Road to Bryant Street, 2 in each direction; Brant Street to Florida Ave., 1 in each direction 7th Street: Florida Ave to N Street, 1 in each direction; Mt. Vernon Place to Mass. Ave, 4 NB, 1 SB; Mass. Ave and Penn Ave, 1 in each direction + 1 NB transit lane; Penn Ave to Constitution Ave & Independence to C Street, 2 in each direction; Constitution Ave to Independence Ave, 3 lanes in each direction	Metro*EXTRA* Service Plan , Georgia Avenue – 7th Street Corridor , November 2006
Presence or lack of left turn lanes at intersections	Georgia Ave: 7th Street:	Google Earth
Presence or lack of right turn lanes at intersections	Georgia Ave: 7th Street:	Google Earth
Traffic volumes (Peak Hour Only)	Georgia Ave: 865-1,724 7th Street: 759-1,267	Metro*EXTRA* Service Plan , Georgia Avenue – 7th Street Corridor , November 2006
Number of intersections	63	Google Earth
Number of signalized intersections	52	Google Earth/Google Maps
Average distance between intersections/number of intersections per mile	Georgia Ave: .11/9 7th Street: .08/12	Google Earth
Signal cycle lengths	Unknown	

Characteristic	Result	Data Source
Any improvements made or planned to road surface or to roadway drainage	Unknown	

Bus Service

The 79 Metro Extra Line follows the PCN corridor south from Silver Spring Metro bus and terminates at the National Archives on Constitution Avenue. The previous 79 bus was re-branded as a Metro Extra Line with limited stop service. The 79 route operates Monday to Friday from 6 AM to 7 PM, in both directions but with additional service in the direction of peak flow. A study commissioned by WMATA in 2006 suggested additional improvements to infrastructure at stops and introduction of TSP.

Local bus service is provided by the 70 and 71 buses, which operate the whole length of the PCN corridor with minor variations at the southern terminus, where the 71 bus continues past Fort McNair to Buzzard's Point. The all-day 70 bus provides service throughout the corridor to southwest DC, terminating next to the Nationals' stadium. During peak periods, every other bus is a 71 bus, with service extending further south to Buzzards Point on the waterfront.

Many other Metrobus routes overlap the 70 line bus routes in downtown DC on Seventh Street for approximately a mile across the National Mall. The DC Circulator operates a route between the Convention Center and the Waterfront along 7th Street. This route operates between 7 AM to 9 PM with no scheduled headway.

Table 16: Bus Service on Georgia Avenue / Seventh Street

Express Bus Service (79)		
Run Time (Minutes)[9]	SB AM/PM: **42**/46	NB AM/PM – 36/**48**
Span of Service (Start of Trips)	6:00 AM–7:04 PM	6:03 AM – 7:06 PM
Headway (minutes)	AM: 6-8 Midday: 12 PM: 10	AM: 10 Midday: 12 PM: 8
Number of Stops/Stop Spacing	16 stops / approx. 1/2 mile	16 stops / approx. 1/2 mile
Type of Route (i.e., primarily commuter vs. corridor connector)	Commuter	Commuter
Local Bus Service (70 and 71)		
Run Time (Minutes)[6] ***by schedule***	(Silver Spring – National Archives) SB AM/PM: 52/59	(National Archives – Silver Spring) NB AM/PM: 53/**55**
Span of Service	All Day	
Headway (minutes) Peak Period	10	10
Number of Stops/Stop Spacing	About every 1/5 to 1/4 mile	
Composite Bus Service (70, 71, and 79)		
Number of buses per hour	(Silver Spring – National Archives) AM: 15 Midday: 9 PM: 12	(National Archives – Silver Spring) AM: 12 Midday: 9 PM: 13
Boardings/Alightings per Hour	60	
Maximum stop volume (and location)	By observation for 79: Inbound trip: ~40 pax at 9th & Massachusetts. Outbound trip: ~25 pax at Georgia & Blair.	

[9] Note: Run times for the routes listed are from end to end for the entire route. They are not a comparison of similar segments.

Table 16 shows that, according to schedule, the 79 bus has a significantly better travel time, 10 minutes in the morning and 7 minutes in the afternoon, over the 70/71 local buses. This appears primarily to be due to the reduction in dwell-time from serving only limited stops. There was no evidence of TSP benefitting the 79 bus, with several locations where an extended or early green would have enabled faster service.

Summary

Observations on the 79 route were made on May 12, 2010 (Table 17). The morning observation was made in the southbound direction, departing from Silver Spring at 6:00 AM. The afternoon observation was northbound, departing National Archives at 2:39 PM. The 79 express buses did offer reduced travel time with fewer stops.

Field Check Observations

Table 17: Field Observations – Route 79

Characteristic	Observation
Is passing of a stopped bus by another bus permitted?	Yes
Type and extent of bus priority	Limited Stop
IF TSP is used, the type of TSP and the duration of extension or early-call provided	None apparent
Signage provided to denote PCN	Bus stops shared with local buses. Only distinguishing feature was blue Express bus sign.
Enforcement mechanisms	None apparent
Use of bus lane by right turning vehicles?	Yes
Number of PCN stop improvements	None specific to PCN, though most stops had new shelters
Nature of PCN stops and any special designations or features	Bus stops shared with local buses. Only distinguishing feature was Metrobus Express sign.
Are boarding areas at normal sidewalk height or are they raised?	Normal sidewalk height
Do local buses use express stops?	Yes
On-board vs. off-board fare collection	Onboard
Type of route (i.e. primarily commuter vs. corridor connector)	Commuter
Presence of commercial districts with street front stores	~65% of corridor
Accommodations for commercial vehicle loading and unloading	Some parking areas designated as loading zones, but all meant to be clear in peak periods/direction.
Curb lane parking?	Yes, though meant to be clear in peak periods/direction.

Ridership

- Ridership was high on both trips. The inbound AM trip had all seats filled with 7-8 standees. The outbound PM trip had most seats filled. Most passengers alighted near the end of the trips.
- Customers used approximately 60% smart cards, 20% passes, and 20% cash to make fare payment.

Shelters/Stops/Amenities

- All bus stops in right hand travel lane, mostly on the near side of intersections.
- Stops were shared with local buses. Almost all express stops had the Express blue rectangular sign in addition to the standard Metrobus stop signs, which list all bus routes using that stop. However, there is no indication which route is express. (Note: the 7th & H Streets stop had only the Nextbus circular sign, and not even the standard Metrobus stop sign let alone the Express bus sign.
- Almost all stops had schedules for the 79, but again there is no mention on the schedule of the 79 being express service. Only the few stops had a route 79 map indicating it was express service, or had the DDOT bus map posted with that information. (Note: this route seemed to have consistently more up-to-date versions of the DDOT map than the S9 line.)

Rolling Stock

- Both trips were made on new Metrobus buses (#2814 and #2804), with specific livery to indicate Metro Extra service.
- Internal stop displays showed and made audio announcements for all stops. During the afternoon trip, the display malfunctioned, but the driver was able to quickly reset it.

Schedule Adherence

- The AM inbound trip started to fall behind schedule at the Georgia and Kennedy time point, completing the trip 5 minutes late.
- The PM outbound trip fell behind schedule as well, ending the trip 11 minutes late. However, half of this was due to traffic congestion at the Silver Spring terminus, the bus losing 5 minutes getting to the last time point.
- Both trips lost most of their time (5 minutes) between Gallery Place and Georgia Avenue-Petworth.

Traffic

- While traffic was heavy, it flowed smoothly at most points and the buses were able to keep up with cars.
- Most bus stops were near side, and often buses were stopped short of the stop by right-hand turning traffic. In several cases, the bus opened doors in the travel lane for customers to board/alight, as the pull-in space was blocked by auto traffic or another bus and/or reduced in size due to parked cars.
- Specific trouble spots included Walter Reed Army Medical Center, where the southbound bus moved to the left-hand through lane to avoid the long queue of traffic trying to turn right into the center.
- In one case, a commercial vehicle was off-loading during a time when the loading zone is meant to be vacant.

Runningway

- Some parts of the northern half of the route had three lanes of runningway, though there were specific segments where parking took up the left hand lane. As observations were outside the peak no parking times, it was not clear if this parking falls within those restrictions.
- South of New Hampshire runningway is two lanes, while south of Massachusetts Avenue there is a bike lane and parking.
- At Newton Street, construction took up one lane, allowing only one through lane.

Comparison to Local Buses

- Local buses were passed on both observed trips, when pulled into local stops.

Metrobus 37 Wisconsin Avenue Express / Metrobus 39 Pennsylvania Avenue Express[10]

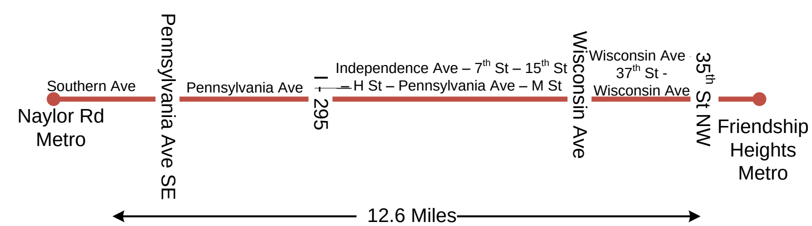
Overview of Corridor

In the regional PCN evaluation, Corridor 6 begins at the Friendship Heights Metrorail Station on the District-Montgomery County border. Heading south, the corridor follows Wisconsin Avenue NW through Tenleytown, Cleveland Park, and into Georgetown. The corridor then turns east along M Street NW, heading into the center of the District along Pennsylvania Avenue NW (Figure 27 and Table 18). A slight detour is made following Eye and H streets NW (one-way pair) turning south on 15th Street NW to bridge the gap around the White House. After rejoining Pennsylvania Avenue at Freedom Plaza, the corridor continues to the National Archives at 7th Street NW. The corridor then turns south on 7th Street and turns east on Independence Avenue to bridge the gap around the Capitol before joining Pennsylvania Avenue SE. Pennsylvania Avenue SE is followed across the river into Anacostia and all the way to the District Line, where the route turns south-west onto Southern Avenue and runs to the access road for the Naylor Road Metrorail Station.

Major trip generators include Friendship Heights, Downtown DC, Capitol Hill, and Anacostia. The corridor is served primarily by Metrobus routes 31, 32, 34, 26, and the Metrobus Express (limited stop) 37 and 39.

Land use along the route is 75% inner-suburban and 25% urban, with less dense development near the Naylor Road station. The corridor is almost all major arterials, along with a few connector roads. Most of the corridor has three lanes in each direction.

Figure 27: Schematic of PCN Corridor 6: Wisconsin Avenue / Pennsylvania Avenue



The 37 and 39 express lines were introduced in 2008 as the result of a joint WMATA and DDOT study, providing limited stop peak-period and peak-direction only service. The 37 route operates the north-western half of the corridor, from Friendship Heights Metrorail Station to the Archives Metrorail Station along Wisconsin Avenue and Pennsylvania Avenue NW. The 39 bus operates the south-eastern half of the corridor, from the Naylor Road Metrorail Station in along Pennsylvania Avenue SE and past the Capitol to the Archives Metrorail Station, continuing on to the State Department.

[10] Refer to Figure F-6 on Page 164 of *An Evaluation of the Metrobus Priority Corridor Networks Final Report* for a map of the route.

Roadway Characteristics

Table 18: Roadway Characteristics – Wisconsin Avenue / Pennsylvania Avenue

Characteristic	Result	Data Source
Roadway curb-to-curb width (including gutter pan)	Wisconsin Ave NW: 72 Feet Pennsylvania Ave NW: 64 Feet Independence Ave SW: 80 Feet Pennsylvania Ave SE: 119 Feet	Google Earth
Number of lanes and lane widths	Wisconsin Ave NW: 3 lanes in each direction, 9 Feet Pennsylvania Ave NW: 3 lanes in each direction, 9 Feet Independence Ave SW: 3 lanes in each direction, 8 Feet Pennsylvania Ave SE: 4 lanes in each direction plus median, 8 Feet	Google Earth
Presence or lack of left turn lanes at intersections	Wisconsin Ave NW: None Pennsylvania Ave NW: 4 Independence Ave SW: None Pennsylvania Ave SE: None	Google Earth
Presence or lack of right turn lanes at intersections	Wisconsin Ave NW: None Pennsylvania Ave NW: 3 Independence Ave SW: None Pennsylvania Ave SE: None	Google Earth
Traffic volumes (Average Annual Weekday Volumes, expressed in thousands, rounded to the nearest 100)	Wisconsin Ave NW: 31.1 Pennsylvania Ave NW (at 7th St): 30.0 Independence Ave SW: 26.7-30.0 Pennsylvania Ave SE: 32.5.38.6 Pennsylvania Ave SE (Across Anacostia River): 26.2-50.4	DDOT 2008 Traffic Volumes
Number of intersections	82	Google Earth
Number of signalized intersections	81	Google Earth/Google Maps
Average distance between intersections/number of intersections per mile	Wisconsin Ave NW: .1-.15/8-9 Pennsylvania Ave NW: .8-.1/10-11 Independence Ave SW: .16/6 Pennsylvania Ave SE: .12/8	Google Earth
Signal cycle lengths	Unknown	
Any improvements made or planned to road surface or to roadway drainage	Unknown	

Bus Service

The 37 and 39 routes operate Monday to Friday, during peak-periods and in peak-directions only (inbound AM, outbound PM) (Tables 17 and 18). Only selected stops are served. The 37 route has one significant detour from PCN Corridor 6, heading east from Wisconsin Avenue at the National Cathedral to run along Massachusetts Avenue NW to near DuPont Circle (approximately 2 miles) before turning onto on 20th and 21st Streets NW (one-way pair) to rejoin the corridor at Pennsylvania Ave and Eye Street NW.

The all-day 32 and 36 buses provide frequent local service throughout the northwestern part of the corridor and along Pennsylvania Avenue SE, but once across the Anacostia River to L'Enfant Square at Minnesota Avenue, turn southwest at different points to follow routes through the Garfield and Hillcrest communities respectively. The 36 bus terminates at the Naylor Road Metrorail Station, but the 32 bus terminates a mile to the southwest at the Southern Avenue Metrorail Station. During the peak periods, additional short trips operate in both directions, typically beginning or ending downtown.

The all-day 31 route operates along the northwestern part of the corridor, between Friendship Heights and the State Department (Potomac Park) at Virginia Avenue and 21st Street NW. The all-day 34 route operates the southeastern part of the corridor, from the Naylor Road Metrorail Station but along Naylor Road to L'Enfant Square at Pennsylvania and Minnesota Avenues SE, and then following Pennsylvania Avenue into downtown DC to the National Archives.

Many other Metrobus routes overlap portions of the corridor, especially downtown, but generally for short distances of less than a mile.

Table 19: Bus Service on Wisconsin Avenue / Pennsylvania Avenue (North Side)

Express Bus Service (37) - Northwestern Part of the Corridor: Friendship Heights – National Archives		
Run Time (Minutes)[11]	SB (AM only) 39	NB: PM (only) 45
Span of Service (Start of Trips)	7:00 AM –9:15 AM	4:22 PM – 6:22 PM
Headway (minutes)	15	15
Number of Stops/Stop Spacing	14 stops / approx. 3/4 mile	14 stops / approx. 3/4 mile
Type of Route (i.e., primarily commuter vs. corridor connector)	Commuter	Commuter
Local Bus Service (31, 32, and 36)		
Run Time (Minutes)[7] ***by schedule***	(F. Heights – National Archives) SB AM/PM: **53**/62	(National Archives – F. Heights) NB AM/PM: 54/**62**
Span of Service	All Day	
Headway (minutes) Peak Period	32 and 36: 6 – 8 minutes (though some headways are only a minute apart) 31 Bus: 15 minutes	32 and 36: 6 – 8 minutes (though some headways are only a minute apart) 31 Bus: 15 minutes
Number of Stops/Stop Spacing	About every 1/5 to 1/4 mile	
Composite Bus Service (31, 32, 36, and 37)		
Number of buses per hour	(F. Heights – National Archives) AM Peak: 11 PM Peak: 8 Off-Peak: 6 (Cathedral – National Archives) AM Peak-only: 14	(National Archives – F. Heights) AM Peak: 10 PM Peak: 11 Off-Peak: 6 (National Archives – Cathedral) PM Peak-only: 16
Boardings/Alightings per Hour	43 (for both North and South ends of the corridor)	
Maximum stop volume (and location)	By observation for 37: AM inbound: 28 pax at 21st & M.	

Table 20: Bus Service on Pennsylvania Avenue (South Side)

Express Bus Service (39) - Southeastern Part of the Corridor: National Archives – Naylor Road Metro		
Run Time (Minutes)	WB (AM only) **33**	EB: PM (only) **32**
Span of Service (Start of Trips)	6:35 AM –8:39 AM	4:01 PM – 6:09 PM
Headway (minutes)	15	16
Number of Stops/Stop Spacing	20 stops / approx. 3/4 mile	19 stops / approx. 3/4 mile
Type of Route	Commuter	Commuter
Local Bus Service (32, 34, and 36)		
Run Time (Minutes) ***by schedule***	(Naylor Road – National Archives) WB 34 Bus AM/PM: **36**/35	(National Archives – Naylor Road) EB 34 Bus AM/PM: 32/42
Span of Service	All Day	
Headway (minutes) Peak Period	(L'Enfant Sq – National Archives) 32 and 36: 6 – 8 minutes (though some headways are only a minute apart) 34 Bus: 15	(National Archives – L'Enfant Sq) 33 and 36: 6 – 8 minutes (though some headways are only a minute apart) 34 Bus: 15
Number of Stops/Stop Spacing	About every 1/5 to 1/4 mile	
Composite Bus Service (32, 34, 36, and 39)		
Number of buses per hour	(L'Enfant Sq – National Archives) AM Peak: **17** Off-Peak: 6 PM Peak: 10	(National Archives – L'Enfant Sq) AM Peak: 10 Off-Peak: 7 PM Peak: **16**
Boardings/Alightings per Hour	43 (for both North and South ends of the corridor)	
Maximum stop volume (and location)	By observation for 39: PM outbound: ~23 pax at Pennsylvania Ave SE & Potomac	

[11] Note: Run times for the routes listed are from end to end for the entire route. They are not a comparison of similar segments.

Table 19 shows that, according to schedule, the 37 bus saves about 14 to 17 minutes over the local service, primarily by avoiding Georgetown and taking the two-mile alternate route on Massachusetts Avenue NW. The 39 Bus (Table 20) on the southwestern part of the corridor has much less of a time advantage, saving only 3 minutes in the AM versus the 34 Bus and with no time advantage in the PM period. This agrees with direct observation, in which only one local bus was passed during the observation. The only advantage to the 39 is the reduction in dwell-time from serving only limited stops; however, this appears to offer little real savings in travel time.

Summary

Observations on the 37 and 39 were made on May 12, 2010 (Table 21). The observation of the 37 route was made during the morning in the southbound direction, departing from Friendship Heights at 8:45 AM. The observation of the 39 route took place in the afternoon in the eastbound direction, departing from Potomac Park at the State Department at 5:37 PM (boarded at H & 17th Streets NW). The 37 express bus did offer reduced travel time by having a more direct route from Friendship Heights to National Archives with fewer stops. No advantage was observed on the 39 bus in the southwestern corridor.

Ridership

- Ridership was moderate on both buses, reaching ~25 passengers on each (1/2 of seats filled).
- One customer took the 37 bus from Friendship Heights to the closest stop to DuPont Circle, indicating a preference for the bus over the rail option on this trip.
- Almost all passengers on the 37 bus used smart cards, and alighting/boarding on both buses was quick.

Field Check Observations

Table 21: Field Observations – Routes 37 and 39

Characteristic	Observation
Is passing of a stopped bus by another bus permitted?	Yes
Type and extent of bus priority	Limited Stop
IF TSP is used, the type of TSP and the duration of extension or early-call provided	None apparent
Signage provided to denote PCN	Bus stops shared with local buses. Both routes have blue 30s line sign. 37 bus has Express sign at stops as well, but 39 bus stops did not.
Enforcement mechanisms	None apparent
Use of bus lane by right turning vehicles?	Yes.
Number of PCN stop improvements	None specific to PCN, though most stops had new shelters
Nature of PCN stops and any special designations or features	Bus stops shared with local buses. Only distinguishing feature was 30s line sign.
Are boarding areas at normal sidewalk height or are they raised?	No
Do local buses use express stops?	Yes
On-board vs. off-board fare collection	Onboard
Type of route (i.e. primarily commuter vs. corridor connector)	Commuter
Presence of commercial districts with street front stores	~25% of corridor
Accommodations for commercial vehicle loading and unloading	Some parking areas designated as loading zones, but all meant to be clear in peak periods/direction.
Curb lane parking?	Yes, though meant to be clear in peak periods/direction.

Shelters/Stops/Amenities

- All bus stops in right hand travel lane, mostly on the nearside of intersections.
- Stops were shared with local buses. The 30s line has a colorful rectangular sign posted at all stops. In addition, the 37 route has the Express sign at its stops, but the 39 bus stops generally did not have this sign.

Rolling Stock

- Both trips were made on new MB Express model buses (#6441 and #6445), with specific livery to indicate Metro Express service.
- Internal stop displays showed and made audio announcements for all stops.

Schedule Adherence

- The 37 bus (AM, SB) was consistently 5 minutes behind schedule from start to finish. This was due to congestion at the terminus; the bus took 4 minutes to make the turn into the Friendship Heights bus station from Wisconsin Avenue.
- The 39 bus (PM, EB) started on schedule but was negatively impacted by heavy rain, reaching its terminus at Naylor Road 17 minutes late. All of the delay was due to traffic in the center city, and from the Capitol on the driver was able to make up time.

Traffic

- While traffic was heavy, it flowed smoothly at most points and the buses were able to keep up with cars. Once the 37 bus is on Massachusetts Avenue and the 39 bus is on Pennsylvania Avenue SE they move quickly. Travel time is slow in the center city and when making turns.
- One specific issue for both routes was delays at the stops in front of metro stations. In several cases, automobiles were stopped dropping off people at the bus stops or along the lanes in front of the stations. More visible pavement markings (e.g., a red lane),), signage (e.g., no stopping), and enforcement at these locations could save travel time here for both express and local buses.
- Specific trouble spots included Observatory Circle NW (queued / turning vehicles impeding progress of the bus), special parking in front of the Ronald Reagan Federal Building on Pennsylvania Ave NW, which both impeded the bus' progress and caused difficulty reaching the adjacent bus stop traveling eastbound, and Freedom Plaza, where queued and parked vehicles both impeded the bus' progress and caused difficulty reaching the adjacent bus stop traveling westbound
- General traffic had widespread violations of traffic laws that impacted bus operations, including U-turns across double yellow lines and much "blocking of the box" downtown.

Runningway

- Most of the running way was three through lanes, except for Massachusetts Avenue and by Freedom Park, and on Southern Avenue into the Naylor Road metro station.

Comparison to Local Buses

- Local buses were passed by express buses on both observed trips when they pulled into local bus stops. Similarly, the express buses were sometimes passed by the local buses, as many of them tend to be used less frequently in favor of the faster express service, necessitating fewer actual stops by the local buses. Finally, the local and express buses often were stopped at traffic signals together.

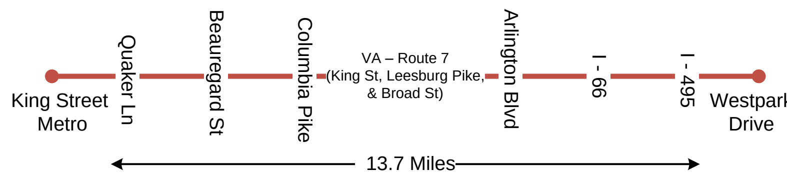
METROBUS 28X: BAILEY'S CROSSROADS-TYSONS CORNER[12]

OVERVIEW OF CORRIDOR

In the regional PCN evaluation, Corridor 9 begins at the King Street Metrorail Station in Alexandria and ends at the Tysons West Park bus transit station in Tysons Corner, Fairfax County (Figure 28 and Table 22). The corridor is primarily served by the Metrobus 28 line, including the 28A, which serves the length of PCN Corridor 9, the 28FG which operates between Southern Towers and Columbia Pike and Carlin Springs Road (the terminal stop for the 28X) and the 28T which operates between the West Falls Church Metro Station and Tysons Corner. As of December 2009 the 28X, a limited stop overlay service began operating between Bailey's Crossroads and Tysons Corner. The 28X operates only in the westbound direction in the AM peak period and only in the eastbound direction in the PM peak period.

The 13.7 mile Leesburg Pike corridor is split about 40%/60% between urban and inner-suburban land use densities. The entire corridor is a major arterial. About four miles of the corridor have three lanes in each direction, but the entire corridor contains medians and/or parking lanes that could potentially be used as bus lanes. The current 28X covers approximately 8.6 miles of the Leesburg Pike Corridor.

FIGURE 28: SCHEMATIC OF PCN CORRIDOR 9: LEESBURG PIKE



The Leesburg Pike corridor is the subject of a study conducted by WMATA that was completed in the fall of 2009. In addition to some stopgap measures to make minor improvements, the study recommended introduction of the 28X service (it is planned to eventually go all the way to King Street) as well as implementing intersection improvements and bus lanes in the longer term. Intersection improvements specifically recommended include six queue jumps and consideration of TSP, given the fifty traffic signals along the corridor, approximately 30 of which are located on the current 28X route. Finally, the study recommends branding the express service and making bus stop improvements.

Along the 28X route from Columbia Pike at Carlin Springs Road through Leesburg Pike and Seven Corners Shopping Center is a concentration of low to moderate income housing, a significant Hispanic immigrant community, and numerous discount retail strip shopping centers, including Bailey's Crossroads and Seven Corners Shopping Center.

[12] Refer to Figure F-9 on Page 167 of *An Evaluation of the Metrobus Priority Corridor Networks Final Report* for a map of the route.

Characteristics of Roadway

Table 22: Roadway Characteristics – Leesburg Pike

Characteristic	Result	Data Source
Roadway curb-to-curb width (including gutter pan)	Leesburg Pike at Bailey's Crossroads: 133 feet, travel lane width, 11 feet Broad St. and Washington St., 55 feet, travel lane width, 10 feet	Google Earth
Number of lanes and lane widths	3 lanes travel in each direction Tysons Corner to Ramada/Lisle, and at Seven Corners Center; all other segments 2 travel lanes in each direction	WMATA Leesburg Pike Enhanced Service Evaluation Study
Presence or lack of left turn lanes at intersections	West Falls Church to West St; Glen Carlyn Rd to Columbia Pike: Two-Way Left Turn Lanes	WMATA Leesburg Pike Enhanced Service Evaluation Study
Presence or lack of right turn lanes at intersections	Right turn lanes present at Pimmit Drive, Patrick Henry Drive and Glen Carlyn Road	WMATA Leesburg Pike Enhanced Service Evaluation Study
Traffic volumes (daily and both AM and PM peak hour)	**ADT:** Tysons Corner to Ramada/Lisle: 63,000 Ramada/Lisle to West Falls Church: 43,000 West Falls Church to West St: 28-34,000 West St to Seven Corners: 22,000 Seven Corners to Columbia: 41-43,000	WMATA Leesburg Pike Enhanced Service Evaluation Study
Number of intersections	30	WMATA Leesburg Pike Enhanced Service Evaluation Study, Google Maps
Number of signalized intersections	30	WMATA Leesburg Pike Enhanced Service Evaluation Study, Google Maps
Average distance between intersections/number of intersections per mile	Approximately every 0.5 miles (Leesburg Pike)/ Approximately 2	Google Maps
Signal cycle lengths	Tysons Corner to Ramada/Lisle: 180 (AM), 190 (PM) Ramada/Lisle to West Falls Church: 210 West Falls Church to West St: 140 West St to Seven Corners: 100 Seven Corners to Columbia: 150	WMATA Leesburg Pike Enhanced Service Evaluation Study
Any improvements made or planned to road surface or to roadway drainage	No improvements to the roadway surface of roadway drainage listed	WMATA Leesburg Pike Enhanced Service Evaluation Study

Bus Service

The 28X operates Monday to Friday, during peak-periods only, running westbound in morning and eastbound in the afternoon (Table 23). The plans to extend the 28X service from Bailey's Crossroads to King Street Metrorail station would bring the 28X service parallel with the local service on Metrobus 28A and would extend the express bus service to serve the entire length of PCN Corridor 9. The 28X serves 12 stops on its eastbound trip and 13 stops on its westbound trip. However, on the observation trips no passengers boarded or alighted the bus at the stop or stops in Tysons Corner between the Lisle Avenue/Ramada Road stop and Tysons Corner Center, thus only 11 stops were made on the observational trip.

When the 28X service was established, the former local route, 28AB, was restructured into the existing 28A. Information provided by Fairfax County DOT on the operations and rider demographics for the former 28AB line revealed that only 35% of riders of the 28AB were boarding or alighting the bus at a Metrorail station. This confirms field observation that most of the current riders using the 28X and the 28A local service are using the bus for travel on Leesburg Pike. The former 28AB service combined to form one of the top five Metrobus lines by ridership in Virginia, with an average of 5,000 weekday boardings with more than 80 daily trips, according to the WMATA Leesburg Pike Enhanced Service Evaluation Study.

The 28F and the 28G overlap with a portion of the 28A service at Southern Towers, but do not overlap the current 28X service. The 28T line travels between West Falls Church Metro and Tysons Corner. Some bus routes on the Metrobus 16 line– 16A, 16B, 16D, 16E and 16F, which travel on Columbia Pike, also stop at the 28X terminal stop at Columbia Pike and Carlin Springs Road, but no transfer activity between any 16 line bus and the 28X was observed.

TABLE 23: BUS SERVICE ON LEESBURG PIKE

Express Bus Service (28X)		
Run Time (Minutes)[13]	WB AM 44	EB: PM 50
Span of Service (Start of Trips)	5:54 AM – 8:16 AM	3:45 PM – 6:15 PM
Headway (minutes)	30	30
Number of Stops/Stop Spacing	13 / stops all approximately 0.5 to 1.5 miles apart, most stops about 1 mile apart	17 stops / stops all approximately 0.5 to 1.5 miles apart, most stops about 1 mile apart
Type of Route (i.e., primarily commuter vs. corridor connector)	Primarily Corridor Connector/Some Commuter	Corridor Connector
Local Bus Service (28A)		
Run Time (Minutes)[8] ***by schedule***	(King Street-Tysons Corner) WB AM/PM: 90/93 (Columbia Pike and Carlin Springs Road-Tysons Corner) WB AM/PM: 57/56	(Tysons Corner-King Street) EB AM/PM: 72/92 (Tysons Corner to Columbia Pike and Carlin Springs) EB AM/PM: 74/65
Span of Service	All Day	
Headway (minutes) Peak Period	30	30
Number of Stops/Stop Spacing	90/About every 1/5 to 1/4 mile	
Composite Bus Service (28A/28X)		
Number of buses per hour	Off-Peak/AM Peak: 4 PM Peak: 2	AM Peak: 2 Off-Peak/PM Peak: 4
Boardings/Alightings per Hour	Avg. Boardings per Trip (former 28AB): 67	
Maximum stop volume (and location)	By observation for 28X: AM westbound: ~ 12 riders at Tysons Corner Center PM eastbound: ~ 4 riders at Columbia Pike and Carlin Springs Road	

[13] Note: Run times for the routes listed are from end to end for the entire route. They are not a comparison of similar segments.

Table 23 shows that, according to schedule, the running time for the 28X is 12-15 minutes faster than its local route, the 28A. There was only one transfer of a passenger from the 28X to the 28A observed, on the PM peak period trip. The transferring passenger was surprised that she had to wait 30 minutes for the 28A to arrive. The 30 minute headways between the 28A and 28X make it difficult for residents of the Bailey's Crossroads and Seven Corners area to use the express service and then transfer to the local service and decrease their total trip travel times. Bus stop spacing throughout the length of the 28A is much closer than the 28X, with stops occurring approximately every 0.25 to 0.5 miles.

SUMMARY

Observations on the 28X were made on May 18, 2010 in PM peak service on the 4:45 trip departing Tysons Corner, and on May 20, 2010 in AM peak service on the 8:13 trip departing Columbia Pike and Carlin Springs Road (Table 24).

Field Check Observations

Table 24: Field Observations – Route 28X

Characteristic	Observation
Is passing of a stopped bus by another bus permitted?	Yes
Type and extent of bus priority	Limited Stop
IF TSP is used, the type of TSP and the duration of extension or early-call provided	None, but there are plans to implement TSP and bus queue jumps on the corridor.
Signage provided to denote PCN	None, there was nothing to denote special or express service, the only indication of a 28X stop was the listing of 28X on the normal Metrobus pole sign.
Enforcement mechanisms	None apparent.
Use of bus lane by right turning vehicles?	No particular bus lane, but where the bus was in a right turn lane it did block right turning traffic. It should be noted though that this was really only problematic at Bailey's Crossroads Shopping Center. Other right turn only lanes with bus stops were not heavily trafficked at the time of observation, although two were located at school sites which undoubtedly are busy during school drop-off and pick-up times.
Number of PCN stop improvements	No specific PCN stop improvements, although a number of stop and pedestrian access improvements were recommended in the recent WMATA study.
Nature of PCN stops and any special designations or features	The quality of PCN bus stops varied widely, 10 bus stops in the eastbound direction have shelters, while just 6 in the westbound direction have them. The bus stops at the curb in the City of Falls Church provided ample standing space, while the westbound curb stop at Patrick Henry Drive provided no paved standing space, and was just a small patch of grass between a service road and the right hand turn lane.
Are boarding areas at normal sidewalk height or are they raised?	Normal sidewalk height.
Do local buses use express stops?	Yes.
On-board vs. off-board fare collection	Onboard.
Type of route (i.e. primarily commuter vs. corridor connector)	Primarily corridor connector although on the AM peak trip a number of commuters boarded at the West Falls Church Metro Station and alighted at Tysons Corner.
Presence of commercial districts with street front stores	Much of the corridor is lined with strip retail, with surface parking lots providing setback from the roads.
Accommodations for commercial vehicle loading and unloading	All commercial loading occurs off-street.
Curb lane parking?	None.

Ridership

- The 28X PM peak trip was not crowded at all, with a peak ridership of just 11 passengers. Five people boarded the bus at Tysons Corner and four people alighted the bus at the terminal stop at Columbia Pike and Carlin Springs Road. Only one of the passengers alighting at the terminal stop transferred to the 28A local service, there is a 30-minute wait for passengers transferring from the 28X to the 28A.
- On the 28XAM peak trip the bus was considerably more crowded. Up until the West Falls Church Metro Station peak ridership was 15 passengers, but at the West Falls Church Metro Station a number of Tysons Corner bound commuters boarded, increasing ridership to 28, with almost every seat full. Twelve passengers alighted the bus at its terminal stop, Tysons Corner Center, but 13 passengers alighted the bus at Leesburg Pike and Towers Crescent Drive, the second to last stop, which serves a Tysons Corner office development.
- On the PM peak and AM peak trips, the ridership was heavily Hispanic and non-English speaking. On the AM peak period trip ridership was predominantly Hispanic; many of these riders appeared not to be able to speak English, until the bus picked up Tysons-bound commuters at the West Falls Church Metro Station.
- According to information provided by the Fairfax County DOT for the former 28AB line, nearly 50 percent of riders of the local service have no auto available in their households and have household annual incomes of less than $30,000, and 64 percent of riders belong to a minority group.
- While the route is located near approximately a dozen senior centers, no seniors were observed on the 28X.

- At least one rider on the AM peak trip appeared not to know that the 28X was an express service, and wanted to exit at a local stop.

Shelters/Stops/Amenities

- All bus stops are in the right hand travel lane, mostly on the near side of intersections.
- Stops were shared with local buses, with no distinguishing features as express bus stops; the 28X was simply present on the normal Metrobus sign alongside the local bus route numbers. There was no indication which bus route was express service.
- The only indication that the 28X was an express service was found on an advertisement placard on the 28A bus, which provided information on the 28X service in both Spanish and English.
- As previously noted, the bus stop at Leesburg Pike and Patrick Henry Drive is in need of significant pedestrian amenity improvements, with its westbound stop just a pole in a small patch of grass between a service road and a right turn lane. The bus shelter at Patrick Henry Drive in the eastbound direction was blocked by a utility pole and located right at the curb, and there was no sidewalk to connect the bus stop to the street or to the low-to-moderate income residential developments located nearby. Several Hispanic women with small children were observed waiting at each of these stops, and crossing Leesburg Pike at this location.
- Ten bus stops in the eastbound direction had shelters, while just six in the westbound direction had shelters. Five bus stops were at the curb, some in right turn lanes and some in right travel lanes. The origin stop for the AM peak period service, Columbia Pike and Carlin Springs Road, has three benches but no shelter.

Rolling Stock

- The AM peak period trip was made on an older model Metrobus, but this may have been because the observed trip was the last 28X trip, and this bus then became the 28A at Tysons for a return eastbound trip.
- The PM peak period trip was on a newer model Metrobus, but it was branded as Metrobus Local, and not Metrobus Express.
- Internal stop displays showed and made audio announcements for all stops on the eastbound PM peak period trip.

Schedule Adherence

- The AM trip (WB) and the PM trip (EB) both adhered to schedule and arrived at their terminal stops on-time.

Traffic

- With most of the 28X and local stops in the right travel lanes, traffic flow was impeded by the buses when they were at stops in the right turn lane. There are also two bus stops which are in right turn only lanes at secondary schools, and one which is in the right turn only lane entering Bailey's Crossroads Shopping Center.
- On both observed trips, traffic flow was heavy, but the bus did not appear to have a significant impact on the overall traffic flow.

Runningway

- Most of the running way was two through lanes, with left turn lanes present in the median, and a few right turn only lanes.
- Three travel lanes were present near Tysons Corner, where traffic was heaviest.

Comparison to Local Buses

- The 28X offers a much faster trip than the 28A, but it was much less crowded than the 28A.
- The $3.00 express bus fare may discourage the use of the 28X, particularly for trips on Leesburg Pike between Bailey's Crossroads and Seven Corners Shopping Center.
- The 30-minute headways between the 28A and 28X may discourage use of the 28X as a complementary connector to local bus routes.

- The 28X terminal stop at Columbia Pike and Carlin Springs Road may also be deterring riders from taking advantage of the limited stop service by switching from the 28A to the 28X. Few riders were observed boarding or alighting at this point, and those traveling to or coming from further towards Alexandria cannot use the 28X.

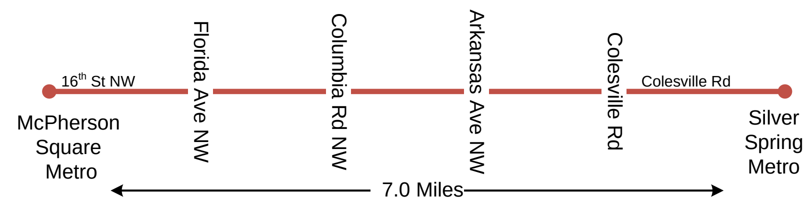
Metrobus S9: Silver Spring – McPherson Square Line[14]

Overview of Corridor

In the regional PCN evaluation, Corridor 8 begins at the Silver Spring Metrorail Station, just inside Montgomery County. Heading south, the corridor follows Colesville Road to the District line and then corresponds with Sixteenth Street Northwest all the way into downtown DC, ending near the McPherson Square Metrorail Station (Figure 29 and Table 25). Major trip generators include downtown Silver Spring, Walter Reed Army Medical Center, and downtown DC. With the exception of Walter Reed[15], residential and employment density is low after leaving Silver Spring heading south, gradually building the nearer to downtown DC. The corridor is served primarily by Metrobus routes S1, S2, and S4 and the Metrobus Express (limited stop) S9.

Land use varies along the route, with large sections of the corridor through low-density suburban or park areas, but with high-density development near the termini. The corridor is mostly a major arterial with some parts considered as collector roads. Most of the corridor has three lanes in each direction and most of the corridor contains medians and/or parking lanes that could potentially be used as bus lanes. The corridor has the third most heavily used Metrobus service in the metropolitan area.

Figure 29: Schematic of PCN Corridor 8: 16th Street (DC)



WMATA and the District Department of Transportation (DDOT) commissioned a study (completed in February 2009) that identified potential improvements along the corridor for limited-stop bus service. The study also recommended introducing a bus-only lane, implementing TSP improvements, and installing queue jumper lanes. The S9 was implemented in March 2009 as a limited-stop bus service, offering faster travel speed and increasing the overall frequency of bus service along the corridor.

[14] Refer to Figure F-8 on Page 166 of *An Evaluation of the Metrobus Priority Corridor Networks Final Report* for a map of the route.
[15] Note: Walter Reed Army Medical Center is scheduled to close in late 2011 and its future impact as a trip generator is unknown at this time.

Roadway Characteristics

Table 25: Roadway Characteristics – 16th St / Colesville Rd

Characteristic	Result	Data Source
Roadway curb-to-curb width (including gutter pan)	16th Street, 50 Feet Colesville Road, 85 Feet (Includes Median)	Google Earth
Number of lanes and lane widths	16th Street: 2 lanes in each direction; 8 Feet 16th Street between Spring and Irving St NW, 2 lanes in each direction, one middle, reversible traffic lane Colesville Road: 3 lanes in each direction, separated by a median; 9 Feet	Google Earth
Presence or lack of left turn lanes at intersections	Present at all intersections starting at Varnum St NW, after the reversible lane ends	Google Earth
Presence or lack of right turn lanes at intersections	None	Google Earth
Traffic volumes (Average Annual Weekday Volumes, expressed **in thousands, rounded to the nearest 100)**	16th Street: Farragut Square to Euclid St: 23.7 Euclid St. to Park Road: 27.7 Park Road to Kennedy St: 24 Kennedy St to Kalima Road: 30.8 16th Street and Colesville Road: 32.8	DDOT 2008 Traffic Volumes
Number of intersections	45	Google Earth
Number of signalized intersections	33	Google Maps
Average distance between intersections/number of intersections per mile	.25 to .30/3 to 4	Google Earth
Signal cycle lengths	Unknown	
Any improvements made or planned to road surface or to roadway drainage	Unknown	

Bus Service

The S9 operates Monday to Friday during peak-periods only, running both north and south (Table 26). Only selected stops are served. The S4's route corresponds with all but one mile of PCN Corridor 8, following an alternate route for the first mile in the District along Alaska and Eastern Avenues. Due to current reconstruction of the transit center at the Silver Spring Metrorail Station, the S9's makes at loop at its northern terminus, stopping approximately 100 yards southwest of the Metrorail station entrance. The District Line time point is the northernmost common stop.

Of the other S-line buses, the all-day S4 bus starts at Silver Spring and follows the entirety of the PCN corridor 8, continuing on further into downtown DC to terminate at Constitution Hall. The all-day S2 follows the length of the corridor with the exception of the Alaska and Eastern Avenue route south of the DC border (similar to the S9). During the peak periods, additional S2 buses operate in the peak direction only (southbound in AM and northbound in PM), entering or leaving service at 16th & Colorado (northern time point is 16th & Buchanan). Some AM-only southbound buses also enter into service at the District line.

The S1 route is also peak-period only in the peak direction, and operates along the southernmost two-thirds of the corridor, between McPherson Square and 16th & Missouri Avenue. Both the S1 and S2 have their downtown terminus at the National Archives. A previous service, the S3, was discontinued when the S9 was implemented.

Other Metrobus routes along the corridor include the one-trip only (AM and PM) D31 and D33 Deal Junior High School routes and W45 Wilson High School line.

Table 26: Bus Service on 16th Street

Express Bus Service (S9)		
Run Time (Minutes)[16]	SB AM/PM: **35**/36	NB: AM/PM 33/**38** (to District Line)
Span of Service (Start of Trips)	6:30 AM – 10:00 AM/ 3:30 PM - 6:12 PM	6:36 AM - 9:15 AM / 3:00 PM - 7:00 PM
Headway (minutes)	10/10	10/10
Number of Stops/Stop Spacing	15 stops / approx. 3/4 mile	17 stops / approx. 3/4 mile (Note: S9 bus makes loop at northern terminus)
Type of Route (i.e., primarily commuter vs. corridor connector)	Commuter	Commuter
Local Bus Service (S2 and S4)		
Run Time (Minutes)[9] ***by schedule***	(District Line – McPherson Sq) S4: SB AM/PM: **34**/38 S2: SB AM/PM: **38**/40	(McPherson Sq – District Line) S4: NB AM/PM: 36/**38** S2: NB AM/PM: 38/**40**
Span of Service	All Day	
Headway (minutes) Peak Period	(Silver Spring – McPherson Sq) S2 and S4: 7 – 12 minutes (16th & Buch. – McPherson Sq) S1, S2 and S4: 2-3 minutes	(McPherson Sq – Silver Spring) S2 and S4: 8 – 10 minutes (McPherson Sq –16th & Buch.) S1, S2 and S4: 2-3 minutes
Number of Stops/Stop Spacing	About every 1/5 to 1/4 mile	
Composite Bus Service (S1, S2, S3, and S4)		
Number of buses per hour	(District Line – McPherson Sq) Peak: 15 Off-Peak: 7 (16th & Buch. – McPherson Sq) AM Peak-only: 30	(McPherson Sq – District Line) Peak: 17 Off-Peak: 7 (McPherson Sq –16th & Buch.) PM Peak-only: 26
Boardings/Alightings per Hour	53	
Maximum stop volume (and location)	By observation for S9: AM southbound: ~ 50 riders at 16th & P PM northbound: ~ 45 riders at 16th & U	

[16] Note: Run times for the routes listed are from end to end for the entire route. They are not a comparison of similar segments.

Table 26 shows that, according to schedule, the running time for the S9 is only 2-3 minutes faster over the identical route as the S2 (between McPherson Square and the District Line). This agrees with direct observation, in which only one local bus was passed during AM and PM ridechecks.

The only advantage to the S9 is the reduction in dwell-time from serving only limited stops; however these stops are among the most significant for boardings/alightings. Local buses serve all stops, but many of these tend to be used less frequently by customers and local buses are often able to pass them by. Bus stop spacing is much closer together for the local routes, with stops between every fifth and every fourth of a mile, while the S9 express route has stops about every three-quarters of a mile.

Summary

Observations on the S9 were made on May 12, 2010 on two trips: the 7:30 AM southbound trip from District Line to McPherson Square (boarded at 16th & Sheridan) and the 4:20 PM northbound trip from McPherson Square to District Line (boarded at 16th & I Street) (Table 27). Overall, the S9 bus did not offer any special convenience besides a very modest travel time advantage over the local buses (passing one local bus on both trips).

Field Check Observations

Table 27: Field Observations – Route S9

Characteristic	Observation
Is passing of a stopped bus by another bus permitted?	Yes
Type and extent of bus priority	Limited Stop
IF TSP is used, the type of TSP and the duration of extension or early-call provided	None apparent
Signage provided to denote PCN	Yes, Metro Express signs (blue rectangles) posted at all PCN stops
Enforcement mechanisms	None apparent
Use of bus lane by right turning vehicles?	Yes. Only very limited exclusive lane (HOV) along corridor.
Number of PCN stop improvements	None specific to PCN, though most stops had new shelters
Nature of PCN stops and any special designations or features	Signage at all stops. Schedules and route maps posted at most stops for PCN bus.
Are boarding areas at normal sidewalk height or are they raised?	No
Do local buses use express stops?	Yes
On-board vs. off-board fare collection	Onboard
Type of route (i.e. primarily commuter vs. corridor connector)	Commuter
Presence of commercial districts with street front stores	~50% of corridor
Accommodations for commercial vehicle loading and unloading	Some parking areas designated as loading zones, but all meant to be clear in peak periods/direction.
Curb lane parking?	Yes, though meant to be clear in peak periods/direction.

Ridership

- The S9 bus was crowded during both peak period observations, with the southbound driver repeatedly asking drivers to move back within the bus (occupancy over 50 passengers). Passengers stood for over half of the route. It was noticeable that a significant proportion of ridership was schoolchildren.
- The bus was so crowded that standing passengers could not reach the stop cords that hang around the windows, instead shouting to the driver their desire to alight at the next stop. WMATA should consider installing stop request buttons in the stanchions.
- The current northern terminus of the S9, stopping short of the significant origin/destination of Silver Spring Metrorail station after an awkward loop, appears to negatively impact ridership. Ridership was low near this terminus compared with other buses, and few passengers were seen connecting with the Metrorail.
- It was noticeable at bus stops along the routes that if both the local and express bus arrived together, certain customers would deliberately choose either the local or express bus (as opposed to boarding the nearer or leading bus).
- Many passengers had smart cards, but some passengers paid in cash, causing delays. Restricting cash-paying customers on express buses would improve travel times.
- Passenger circulation within the buses was poor when crowded, leading to passengers alighting from the front door causing delays for newly boarding passengers. Conversion of the seated area opposite the rear door to standing room could improve circulation and possible reduce dwell time; particularly if an "exit at the rear only" policy was implemented.

Shelters/Stops/Amenities

- All bus stops in right hand travel lane, mostly on the nearside of intersections.
- Stops were shared with local buses, with no distinguishing features as express bus stops besides the blue rectangular sign added to the standard Metrobus sign pole. There was no indication which bus route was express service.
- Many District bus stops had new shelters, as well as DDOT bus maps. At several shelters the DDOT maps were out of date, not showing the S9 route.

Rolling Stock

- Both trips were made on new MB Express model buses (#6434 and #6427), with specific livery to indicate Metro Express service.

- Internal stop displays showed and made audio announcements for all stops.

Schedule Adherence

- The AM trip (SB) adhered within one minute to schedule.
- The PM trip (NB) fell behind schedule, running 5 minutes late at the 16th & Buchanan and 16th & Somerset time points, but made the time up by the end of the route

Traffic

- Delays behind traffic and other buses common, but overall the corridor moved smoothly. The most significant trouble for the buses appeared to be at the termini, when several turning movements and other bus traffic made the last ¼ mile exceptionally slow.
- Note that often buses frequently make only partial pull-ins at stops (rear-end in travel lane). This prevents other traffic, including the express bus, from getting by stopped local buses.
- Specific trouble spots included 16th & Florida and at McPherson Square SB; 16th & Columbia/Mt. Pleasant mega-intersection NB. Traffic was slow near Walter Reed Army Medical Center on both trips due to large turning volumes.

Runningway

- Most of the running way was two through lanes, with left turn lanes present in the median.
- Three lanes were present at some areas, but turning traffic often backed these up.

Comparison to Local Buses

- One local bus passed on both observed trips, when pulled into local stops.

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