CHAPTER 3

BRT Definition

In this study, the focus is upon integrating transit operations and infrastructure into a manged lane network which would provide consistent running speeds in the corridor. The potential to accelerate current express bus services, reduce travel times, and provide quick on/off access from the highway for intermediate stops along various routes, for the purposes of this study, is being considered a Bus Rapid Transit (BRT) mode of service. The Federal Transit Administration (FTA) further defines BRT as offering an easily distinguishable service, through branding, advanced technology, or other user-friendly features. This section further explores the definition of BRT, through both functional and operational characteristics. These features distinguish this mode from other bus-based, and similarly performing transit systems already in place in the I-95/I-395 corridor.

Further defining BRT for this study is important because comparable BRT systems that do exist or are in advanced planning stages, span a wide spectrum. Examples include of service that includes carrying large numbers of people in urban corridors with stations and exclusive running ways similar to the Metrorail system, to features resembling express bus, where service is focused on longer distance work trips similar to Virginia Rail Express (VRE) service. With BRT's flexibility to encompass such a wide variety of applications, each tailored to a particular set of travel markets and physical environments, it is necessary to identify consistent terminology for a regional BRT system that could potentially serve several corridors within Northern Virginia.

VIVA BRT station

From the rider's perspective the BRT service is expected to provide rail-like service along commuter corridors, as well as facilitate improved or prioritized operating conditions for local and regional bus services that, leverage use of the facilities and BRT running ways. A regional BRT system for the Northern Virginia area will provide additional connections to and from major activity centers along the managed lane corridors. The BRT system would complement existing transit operations, including services provided by WMATA, PRTC and VRE.

A variety of existing and planned commuter routes currently replicate BRT services within the I-95/I-395 corridor. This study will test the impact of low-density development in the outlying southern segment of the corridor to see if they generate any demand stopping at all intermediate stations, which is typically what differentiates BRT from express bus operations. With other routes having similar schedules and access to the same infrastructure, another approach to differentiating service is through branding, which could establish a hierarchy of service, stations and amenities.

3.1 BRT Components

BRT is not a one-size fits all solution, but common features can be found in real-world applications. The elements of a successful BRT system enhance performance and ultimately produce tangible benefits (**see Exhibit 3-1**). This section will further describe each of the various elements.

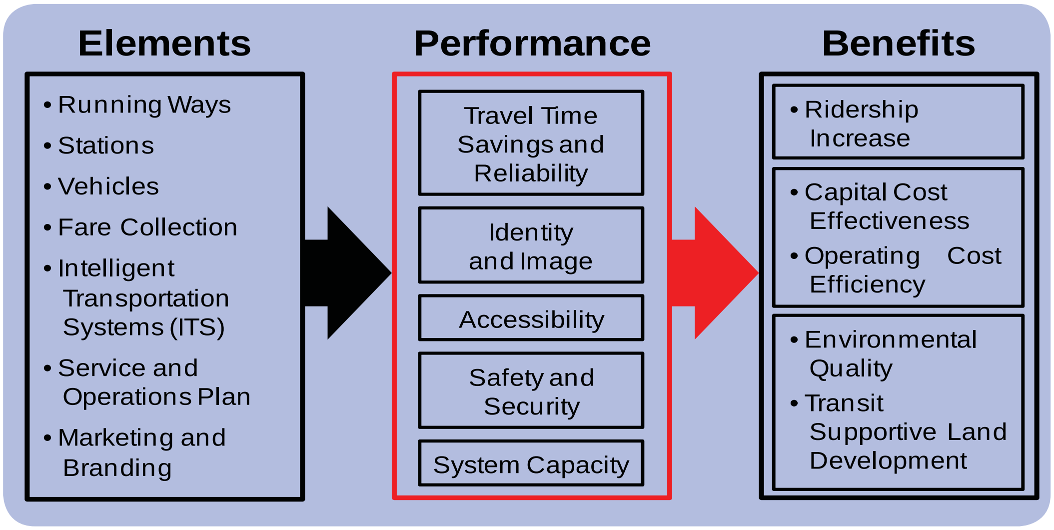


Exhibit 3-1: Major Elements of BRT

3.2 Running Ways

While BRT can operate in a wide variety of physical and operating environments, the network primarily considered in this study focuses on managed freeway lanes and along major arterials with access control for potential running ways. Managed lanes (HOV/HOT) provide schedule reliability by limiting the amount of congestion that results from unrestricted automobile travel demand. When BRT vehicles travel outside of managed running ways, such as along general purpose freeway lanes, surface streets, through intersections and traffic signals, it is important to provide transit priority treatments to assure this mode retains travel time savings. The following tables in **Exhibit 3-2** introduce typical BRT running ways within busways, limited access freeways, and along major arterial roads.

3.3 Stations

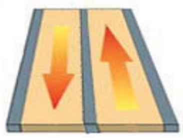
The station location for a BRT system in a transit corridor can be determined by several factors, namely:

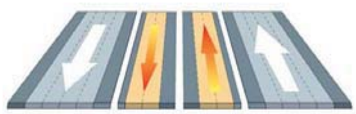
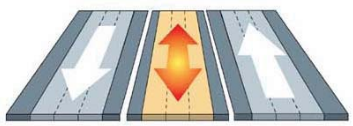
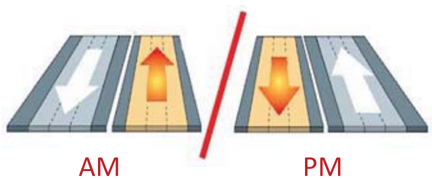
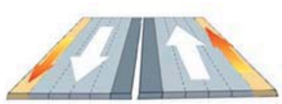
Operations – With point-to-point service (few, if any, intermediate stops) and where there is little demand for walk-up passengers, an indirect location within a large park-and-ride facility may be appropriate;

Major Activity Centers – Locations particularly favorable to generating transit demand should be served directly where possible, with an emphasis on pedestrian connections and opportunities to serve a variety of activity types within the same station area (e.g., employment, retail, medical, etc.);

Land Use Plans – Locations will be coordinated with local land use plans to be consistent with proposed developments and to provide the complimentary interaction between the proposed BRT investment and the adjacent uses to promote ridership;

Transit Oriented Development (TOD) – TOD proposals take maximum advantage of the benefits provided by BRT station development. Uses are identified and located to maximize ridership, with such developments typically being smaller, higher-density, and featuring a mix of uses in a more environmentally sustainable design. TOD proposals are closely linked with the land use and specific development plans and require coordination with the local planning agencies;

Exclusive Access Guideway	Notes	Locations
Busway – Bus-Only 	This running way represents dedicated and grade separated lanes which eliminate all interference from general traffic. It provides for the most "rail-like" operations, but requires new or expanded right-of-way and substantial capital investment.	None considered in this study

Limited Access Freeway	Notes	Locations
Central Lanes 	Can utilize access ramps directly into the managed lanes (preferred) or requires a weave into general purpose lanes to access on/off ramps.	Capital Beltway (I-495) future Dulles Airport Access Road
Reversible Lanes 	Ramps/facility design often not favorable to multiple on/off movements in peak direction, which may be required for transit station access. In-line stations not accessible from non-peak direction.	I-95/I-395
Peak Only Managed Lanes 	Conversion of general purpose lanes into managed lanes in peak direction during peak travel period only. At all other times, the freeway functions as a general purpose facility in both directions.	I-66 (Inside Capital Beltway)
Bus-Only Shoulder Lanes 	May not require a significant amount of right-of-way, and is applicable in constrained locations. However, conflicts will exist with general traffic at access points, impacting safety, operating speeds, and schedule reliability.	I-66 Dulles Toll Road

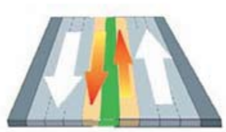
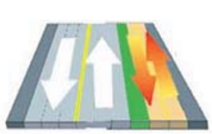
Access Controlled Arterial	Notes	Potential Locations
Median Lanes 	A central median location minimizes traffic interference and can preserve a parking lane. One platform can potentially serve both directions of travel, however specialized vehicles with left-side doors are required for median stations.	None considered in this study
Opposite Curbside Lanes 	Curbside lanes permit utilizing existing or improved bus stop locations, but traffic conflicts with vehicles parking, turning, and entering the arterial can impact schedule reliability and safety.	None considered in this study
Same Curbside Lanes 	Requires a major reconfiguration of existing and traditionally auto-oriented arterials, and is most appropriate for corridors with mixed-use and pedestrian-friendly features in more urban settings.	None considered in this study

Exhibit 3-2: BRT Running Ways Examples

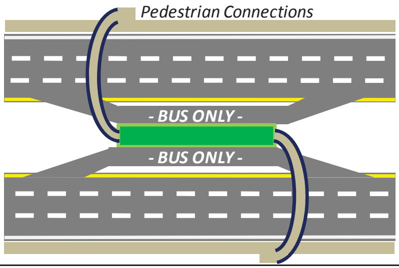
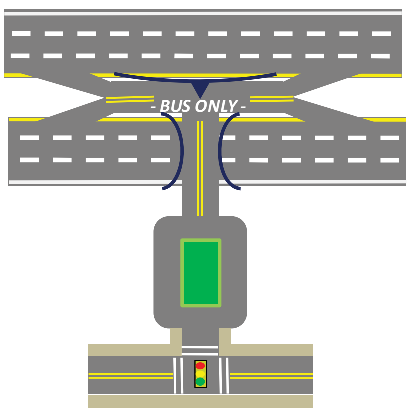
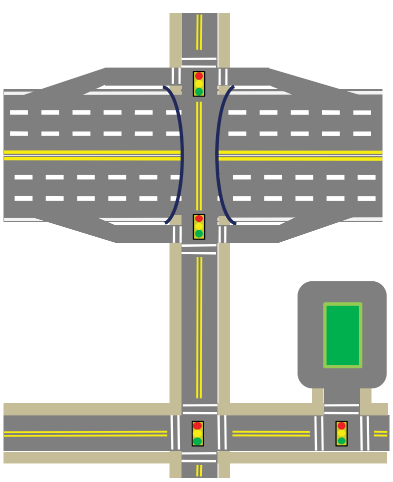
Station Type	Notes	Potential Locations
In-Line (Freeway) 	Lowers in-vehicle travel time and improves reliability by avoiding need for BRT vehicle to divert from the transit corridor. Locations in median of freeway, however, will require longer walk distances to reach destinations on either side of the highway facility. Generally requires left-side doors; not compatible with existing commuter and express bus services.	I-66 I-95 I-395
Direct Access 	Achieved through bus only ramps allowing access from the transit corridor to an adjacent station/ intermodal center. Local services can also access the same bus bays and can enter the corridor at this location after collecting passengers on local streets. Travel time outside the corridor is minimized, walk times reduced, and improves land use integration.	I-66 I-95 I-395
Indirect Access  *Transit Station/Platform*	Vehicles would travel through general purpose ramps and traffic signals to reach a transit facility located outside the corridor. This approach allows existing stations to be utilized by new BRT services, however the impact to running times during the time spent outside the corridor degrades overall travel time. This station location challenges the tolerance of through passengers already onboard the vehicle to lose time in a deviation that could be spent reaching their desired station stop further down the line. Would require transit signal priority and other treatments to speed bus travel on local roadways.	I-66 I-95 I-395

Exhibit 3-3: BRT Station Site Examples

Physical Constraints – Ideal locations for in-line freeway stations occur at highway overpasses, where passengers can, with a minimum of walking, transfer to/from local feeder bus services above or below the mainline. However, bridge pier locations, exit ramp configurations, and corridor width may preclude placement at these locations;

Access – Vehicular, bicycle, and pedestrian – All modes of access were considered in the location and layout of the stations. Pedestrian and bicycle access are important, particularly in the more developed areas, to minimize traffic congestion. The provision of parking was also closely coordinated with station ridership, the local area land use plans, and local roadway network. Parking is less important at urban intermodal stations than for stations located in suburban/exurban areas;

Existing Transit Facilities – Where there is a pre-existing transit station for another mode, assuming a high demand for transfers or a location at a major activity center, service via a BRT system should be weighed against the additional time required to reach the site;

Interconnectivity Points – Station layout will facilitate efficient transit operations in station access/egress and direct connections to other transit services.

Exhibit 3-3 presents three general station location sites, namely in-line or directly within the transit corridor, and off-line which requires vehicles to divert from travel lanes, either via direct access or indirect access to a station facility.

The level of station design correlates strongly with the level of running way segregation. BRT systems with designated lanes on arterials or segregated in-line stations require more-substantial station features. Station sites provide the permanent identity for the system and typically feature shelters, benches, lighting, ticket vending/validating machines, security features, and passenger information. Many BRT systems have adopted a “kit-of-parts” approach to develop modular station design concepts with a consistent appearance that can allow the infrastructure to be scaled based on the passenger demand requirements and also to be adapted to the character of the unique areas in which they are located. Freeway located stations require lengthy pedestrian access ramps and bridges that should be made safe and inviting. Finally, public art may be incorporated.

Also important in station design is the fact that BRT systems serve high demand corridors, having only a limited number of stops, with passenger volume at each station being significantly higher than would be the case for a stop along a local bus line. With higher volumes, platform size and height can dictate vehicle dwell times. **Exhibit 3-4** and **Exhibit 3-5** illustrate prototypical components and a possible freeway station concept, respectively. As will be discussed in the following sections, in-line stations were originally envisioned and identified for this corridor, but as part of this analysis it was determined that less-expensive off-line stations are feasible.

CURB HEIGHT – Higher than normal curb height is preferable to ease passenger loading/ unloading and discourage passengers from walking into the bus bay.

SIGNAGE – Common signage at stations, however other transit provider signage should be co-located, indicating all services available at the station location.

Exhibit 3-4: BRT Architectural Identity Elements

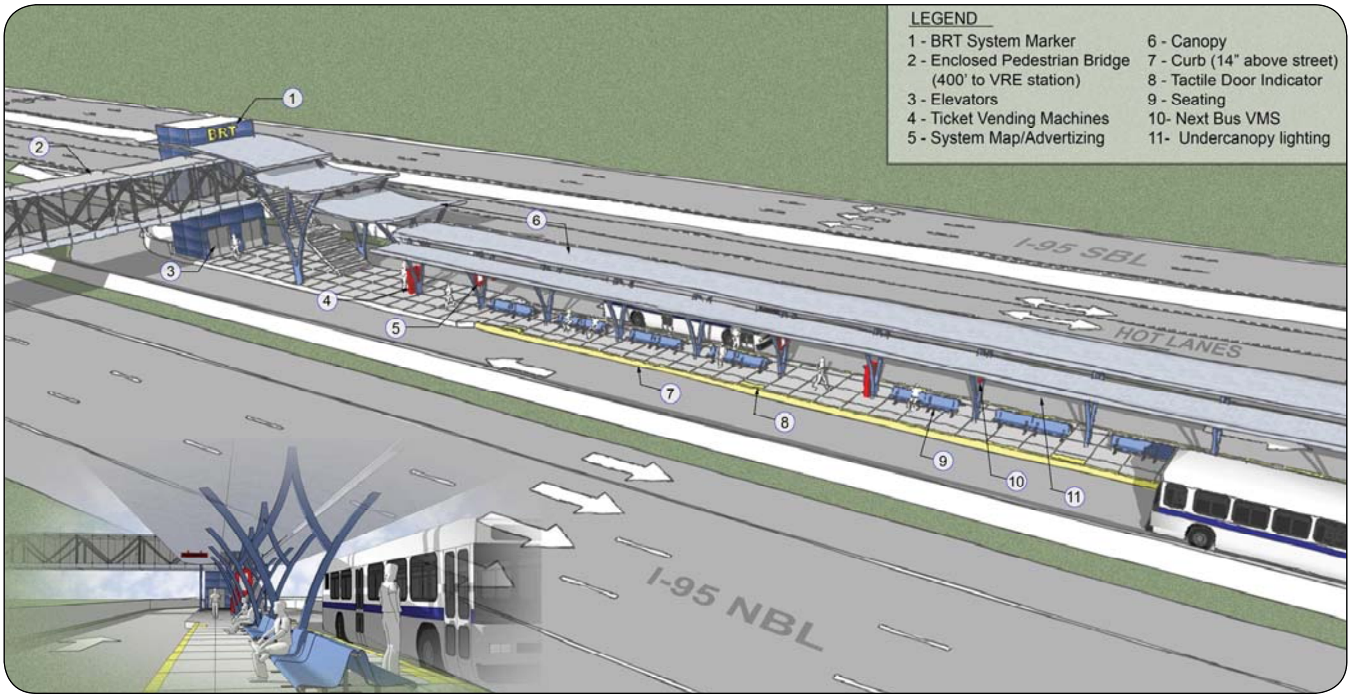


Exhibit 3-5: Overview of Prototypical BRT In-Line Station Features

3.4 Vehicles

Sleek, rail-inspired vehicles with modern interior designs can distinguish BRT from older styled buses and project an upscale identity. The popularity of “stylized” BRT vehicles plays a strong role in increasing the use of BRT services, particularly by choice riders. This supports the idea that vehicle design is central to conveying a service that provides the style, amenities and capacity beyond ordinary express bus operations. In Northern Virginia, all envisioned stations would be shared by a variety of vehicles (from different operators), which will interact with the BRT routes. The distinction between vehicle types and trip purpose is essential in differentiating these BRT services. **Exhibit 3-6** highlights two BRT vehicle types and their features in relation to the other transit vehicles envisioned to serve the same station locations.

3.5 Fare Collection

The goal of the BRT fare system is to speed the boarding process. This can be achieved by forcing fare payment and validation to take place prior to boarding the vehicle. Ticket vending/validating machines can be provided on the BRT station platform for patrons to buy and validate their ticket prior to boarding and using a proof of payment system to enforce fare payment.

Fare collection consists of both the media and the payment method:

Fare Media

Smart Card technology is preferred, as this supports faster and more flexible fare collection systems. It can feature either touch/tap or contactless proximity systems, which typically represent the most expensive to implement media and fare processing technology. Smart Card fare media (i.e., SmarTrip) is already in use in the Washington, D.C. region.

Mode		Description	Example
Commuter Bus		Over the road coach with single door, holding all seated passengers. Favors comfort, not designed for frequent stops and high volumes of passenger on/ off movements. Right-side doors.	OmniRide
BRT Articulated		Larger vehicles to offer maximum seating on longer trips. Features left-side and/or right-side doors to accommodate center platform loading/unloading.	Las Vegas MAX
BRT - Standard		Stylized, standard length vehicles, better suited to more frequent service with standees. Preferably powered by clean (hybrid, CNG) propulsion. May include left-side and/or right-side doors.	Las Vegas MAX
Local Bus		Typically a 40' vehicle, designed for lower speed, frequent stop service. Right-side doors.	Arlington Transit DASH Fairfax Connector
Circulator/ Shuttle		May include small transit vehicles or cut-away vans used to transport workers and small groups to a specific destination.	Pentagon Shuttles

Exhibit 3-6: Examples of Vehicle Types found along Northern Virginia Transit Corridors

Payment Method

On-Board Payment – This system is typical of most bus systems and involves a transaction adjacent to the drivers' position. It requires the passengers to board at a single location and pay as they enter (either with cash, tokens, transfer, pass or machine readable fare media). This can result in longer dwell times, which when combined with the door and internal layout of the bus can result in significant delays, particularly at high volume boarding and alighting points on the route. The advantage, however, is that there is negligible fare evasion as a result of each passenger passing the driver.

Barrier Enforced Payment – This system requires the provision of turnstiles or ticket agents to allow access to a secure location whereby passengers can board a bus without having to pay either on entry or on-board the vehicle. Essentially the fare-control area operates similar to a subway platform; however, this would be an expensive option and would require all bus operations serving such a station to feature the same fare policy. This is unlikely, as it would reduce the operating flexibility of BRT lanes shared by other bus modes.

Proof of Payment System – This requires the rider to carry a valid (usually by time and day) ticket or pass when on the vehicle. Riders are subject to a random check of tickets/passes by roving inspectors. The advantage of such a system is that it supports the use of multiple door boardings and thus lower dwell times. There is however, a greater chance of fare evasion. This is the typical payment system on newer light rail systems (e.g., Baltimore, Denver, Portland).

3.6 Intelligent Transportation System

BRT incorporates Intelligent Transportation System (ITS) applications for faster and more convenient trips. ITS and highway modifications become especially important when vehicles are operating outside of managed lanes, where interaction with general traffic, pedestrian movements, and traffic signals can impact overall travel time and schedule reliability. Key components for incorporation into a regional BRT system where route segments operate outside managed lanes include:

Signal Priority – Signal priority allows buses to maintain a swift service and to better adhere to their schedules. Since transit vehicles can hold many people, giving priority to transit can also potentially increase the throughput of an intersection per person.

Queue Jumps – These provide an additional travel lane on the approach to a signalized intersection. This lane is often restricted to transit vehicles only, with the intent of the lane to allow the higher-capacity vehicles to advance in front of waiting vehicles, reducing the delay caused by the signal and improving the operational efficiency of the transit system. An early signal can give the transit vehicle a "head-start" over other queued vehicles and permit a merge into the regular travel lanes immediately beyond the signal.

Passenger Information – This technology group includes various methods of providing real-time information to passengers so they can make the best use of their time. Information about the vehicle schedule can be provided via monitors at the station/stop as well as on the vehicle. Providing schedule information to travelers via PDA, cell phone, or similar device and supporting trip planning are other functions that can be provided. All the passenger information functions improve passenger satisfaction, help to reduce actual and perceived wait times, and can increase ridership.

Advanced Transit Management Capabilities – Use of an integrated system of GPS-based automated vehicle location technology and computerized GIS-based scheduling is an essential requirement for achieving increased operations management capabilities to improve: service performance, on-time performance, service reliability, transfer connections, and to provide service status information to the public via the internet, at stations/stops and via PDAs, cell phones, and similar devices.

3.7 Service and Operations Plan

BRT systems generally include rapid transit features like all day service spans, greater spacing between stations, and more frequent service than local bus service. The flexibility and lower cost of BRT allow it to provide greater network coverage. In commuter-oriented applications of BRT, such as within the I-95/I-395 corridor, the most prominent question regarding operational approach centers on if the system provides Trunk or Shared Operations, reflecting transfers or one-seat rides from the passenger's perspective (see **Exhibit 3-7**).

These operating approaches for BRT services hinge on expanding the mix of services already offered in the corridor. While existing express bus routes focus on direct point-to-point service, the introduction of new facilities and infrastructure opens the possibility to provide service stopping at intermediate stations along the route. The patterns of stopping, however, can vary based on the travel market and the potential to better utilize vehicles and resources during the peak commute times, by enabling vehicles to have sufficient time to return to other locations and perform multiple runs during the peak commute. The operating methodologies considered in the planning process include:

All Stop - Vehicles stop at each intermediate station. This will result in the longest travel times between two points, as vehicles incur various forms of delays associated with passengers entering and exiting, and the time

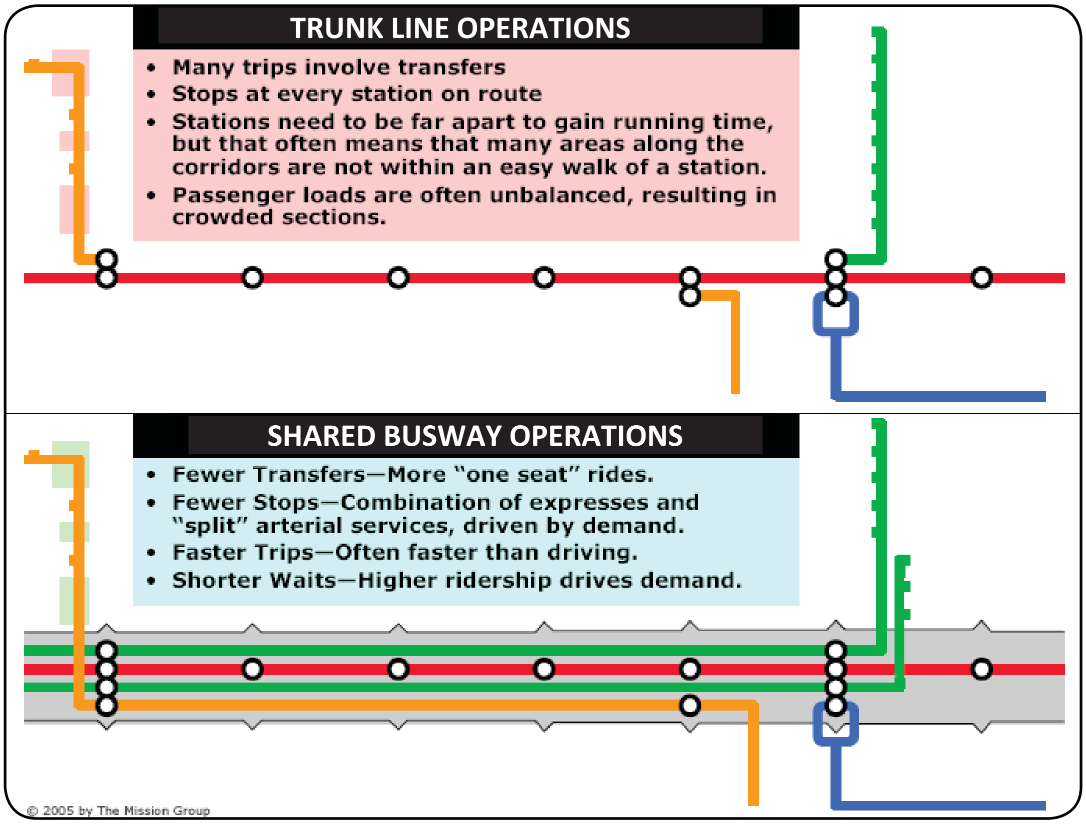
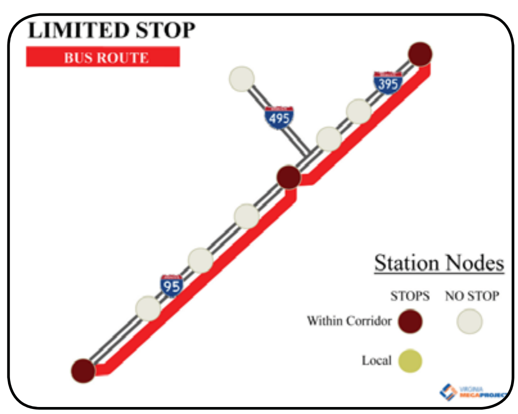


Exhibit 3-7: Two Typical Operating Plans for Corridor BRT Service

spent in traffic or at lower speeds during access to the stations. For direct-access and indirect access stations, the amount to travel time outside the corridor to reach the station locations can amount to a significant portion of the end-to-end travel time. Model results will be analyzed to determine the passenger movements at intermediate stations along an all stop route. If only passengers are boarding, the route performs more as a feeder and vehicle seating capacity constraints may eventually be reached. If not all intermediate stations serve as destinations in the peak direction, and fail to entice a certain amount of passengers to exit the vehicle, all stop service may not be justified and other methods should be investigated.

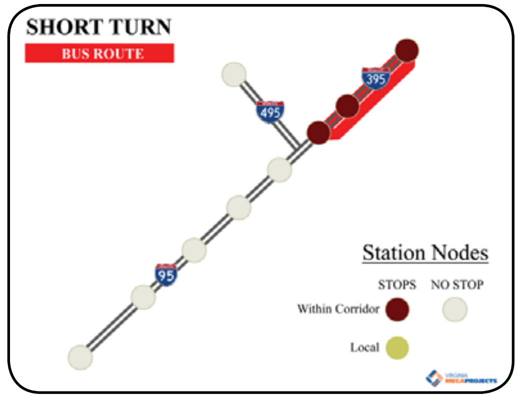
Direct - Vehicles originate from one location and then proceed directly to a specific destination. The vehicles are ideally full upon their initial departure and therefore no intermediate stops are required.

Limited Stop - In this scenario, vehicles would stop only at large multi-modal stations, to facilitate transfers among routes. Favorable stations considered in this study include a Lorton in-line station and service to Franconia-Springfield Metro station. This scenario recognizes that only stations of sufficient service level and surrounding destinations would generate the demand for transfers.



Express - This method of operations assumes that vehicles are gathering passengers from numerous outlying locations, potentially stopping at numerous intermediate stations. Once the vehicle is full, it would then proceed directly to a destination and would by-pass the intermediate stations located closer to its destination.

Short-turn - Most scenarios for this BRT operational analysis focus on service on significant portions of the I-95/I-395 corridor. A short-turn scenario recognizes that certain segments of this corridor may generate more ridership and therefore enhanced vehicle utilization can be gained by not always traveling larger distances where ridership is less. Short turn routes could focus primarily on fleet resources, and turn back toward outlying areas once they reach a major transfer location. Routes could also focus on more dense segments of the corridor (such as inside the Capital Beltway) and operate in this segment only. When combined with the longer distance routes, this provides a higher overall frequency at stations served by both routes.



3.8 Marketing and Branding

A BRT system ideally is distinguished through the adoption of station design guidelines, vehicle specifications, and other passenger amenities which target the passenger experience. This creates a recognizable BRT service with a different set of expectations that operates along with other routes, often serving the same station locations. In this way, BRT branding will distinguish the service from commuter and express bus operations while enhancing the overall bus market.

HealthLine BRT website

3.9 Corridor Considerations

The I-95/I-395 managed lanes are designed to be reversible, operating only in the peak direction (northbound in the morning, southbound in the evening) and would serve as the "guideway" for the BRT system as proposed. This unique corridor characteristic impacts schedule reliability in the off-peak direction and limits vehicle movements at most potential station locations to the peak period direction only. Thus, for our definition of BRT within the corridor this means that there is a lack of priority treatment in the off-peak direction, requiring BRT vehicles to travel among traffic in general purpose lanes. Additionally, if there were ever any in-line stations located within the highway facility in the future, those stations would not be reachable in the off-peak direction –another reason that off-line or direct access stations may be preferable in this corridor.

The focus on commuter and peak travel also dictates that new ramp configurations are designed to feed traffic from only one direction, therefore complicating rapid on/off access to the managed lanes. Ideally, BRT vehicles should have reasonably free-flowing and direct access to managed lanes from major activity centers, key rail stations, and park and ride lots, so that transit buses do not have to cross several congested general purpose lanes. The current and proposed future arrangement of access ramps, on I-95/I-395 which accommodate peak direction movements at various locations, requires BRT vehicles to travel for extended distances outside the managed lanes to serve station locations adjacent to interchanges in some of the operating scenarios tested. In general, enhancing access to the managed lanes through additional access ramps for transit vehicles or slip ramps is recommended as one way to reduce the need for buses to operate in the more congested general purpose lanes. As part of this study, the configuration of access points reflects the CLRP network from MWCOG, as currently coded. The future configuration is not known at this time. As long as consistent travel speeds and access are provided along the corridor for BRT vehicles, it is estimated that the demand for BRT would be similar even if alternative access configurations are developed.

Due to long running times from the southern segment of the corridor, initial scenario goals tested all in-line station locations in order allow intermediate station stops and avoid significant increases in overall travel time. In the development of these in-line station prototypes, ideal station locations would allow immediate interface with local transit providers and shuttle buses operating on the adjoining surface streets. Station locations at highway over/under passes already served by transit were favored, with access to both sides of the local arterial to allow connecting transit travel in either direction. In addition, as part of the prototype station, a separate set of waiting areas and passenger amenities would be incorporated for in-line stations at the point where they interface with the local transit network.

Vehicles currently in use for the express bus market in this corridor include the standard over-the-road coaches used for point-to-point commuter services. Initial prototypes of in-line stations featured a center platform served by one lane only, based on the peak direction of travel. A potential consideration for BRT operations on reversible lanes is for vehicles with left-side doors to be incorporated in order to use the non-peak lanes and effectively double the capacity of this style of station design. Additional doors on BRT vehicles also favor more on/off movements which are not associated with express bus service. In this corridor, BRT vehicles need to maximize seated passenger capacity, due to the long running times and distance between station stops. Some closed-BRT systems feature oversized vehicles, which while maximizing passengers per vehicle, are not readily operable on

Swift BRT station

local street networks. An articulated vehicle is best suited to this corridor as it still enables easy maneuverability for off-corridor travel to locations such as Franconia-Springfield, Tysons Corner, and downtown Washington, D.C. Besides station features, vehicle selection is an important component in creating the brand for BRT service and articulated buses were assumed as part of the development of bus needs. Bus branding and easy identification of BRT vehicles through the use of stylized features will be important to establish this new service. This is especially important to distinguish BRT vehicles, which would have different stopping patterns, from the existing and expanded commuter bus service that operates point to point along I-95/I-395.

The improvements in the I-95/I-395 corridor will support a variety of transit services within a single running way, allow provision of express, local and skip-stop operations. The expansion of managed lanes in the I-95/I-395 corridor may allow existing providers to extend services, divert local routes onto the corridor or simply expand services in conjunction with more reliable travel times. Operational aspects will be needed to preserve the identity of a new BRT system operating in the corridor, distinguishing such service from the current collection of transit operators. Corridor operations such as this typically include either a joint collaboration among operators or a separate service entity. In the I-95/I395 corridor it is further recognized that PRTC provides the significant portion of commuter operations from the southern segment, providing the potential for this operator to provide BRT services under their organizational structure. During the later stages of planning this service, establishing pricing, negotiating operating agreements, and determining additional needed facilities (maintenance/operations) is required prior to service initiation. For example, an increase in the number of transit vehicles heading into Northern Virginia during the peak AM commute creates issues with storage or necessitates deadheading vehicles back south to the corridor terminus. The ability for BRT vehicles to further provide local circulation or other off-peak services to increase their utilization during non-peak times should be investigated as an additional strategy to mitigate the need to deadhead vehicles.

Many of these suggestions would be implemented as part of the next phase of development of the BRT system within the corridor. For the purposes of this market analysis, the BRT definitions included and unique operating constraints of the corridor were used to help develop the various operating scenarios that were tested in the regional travel demand model. The methodology, scenario descriptions and results of the analysis are presented in the next chapters of this report.