Wake County Transit Plan MIS

BRT Design Standards & Performance Measures

TABLE OF CONTENTS

TABLE OF FIGURES

1 Introduction

Wake County residents passed a ballot measure that funded the Wake Transit Plan in November 2016. The Wake Transit Plan identifies 20 miles of Bus Rapid Transit (BRT) infrastructure to be implemented for the purpose of providing frequent, reliable urban mobility. BRT is an enhanced bus service that operates more like light rail than regular bus service due to infrastructure investments that make is fast and reliable. The BRT design standards and performance measures in this document are intended to establish a framework and rationale for the investment in BRT services in Wake County. Infrastructure and service design standards set the required minimum components and features for construction and operation of BRT services. Performance measures track and report on the productivity of individual service. The infrastructure design and service design standards were developed following a review of national best practices (see Task 3.2 BRT Peer Review) and should be adhered to in order to ensure that BRT service meets the performance targets. Furthermore, design standards were developed with the goal of creating BRT infrastructure and service that may generate external benefits such as mode-shift and economic development that have resulted from other successful BRT systems. The purpose of meeting the standards set in this document is to achieve all of the objectives of BRT, including providing frequent, reliable urban mobility and aforementioned external benefits. Project sponsors will be held to both the design standards and performance targets.

BRT has been implemented with a wide range of service levels and infrastructure investments in the U.S. and internationally. This document is intended to define the envisioned features of BRT in Wake County for the Wake Transit Plan's stakeholders: transit riders, transit operators, elected officials, and taxpayers.

The Federal Transit Administration Capital Investment Grant (FTA CIG) program sets minimum requirements for projects to be eligible for funding for BRT infrastructure (see Appendix A). This document meets, and in some cases exceeds those minimum requirements based on the objectives for BRT in Wake County. BRT projects can apply for funding from one of two programs, New Starts or Small Starts. Primarily, the level of capital funding required to construct the corridor determines for which program a BRT project is eligible. New Starts projects must have a total estimated capital cost of more than $300 million and must be seeking more than $100 million in CIG funding. Small Starts projects must have a total estimated capital cost of $300 million or less and must be seeking $100 million or less in CIG funding.

BRT projects must include the same service levels and design characteristics regardless of which program funds are being sought from, with one exception: Over 50 percent of the route must operate in a separated running way dedicated for transit use during peak periods in order to be eligible for New Starts funding. This is not the case for Small Starts funding. In order to avoid limiting the available federal dollars for BRT projects in Wake County, the infrastructure and service design standards in this document were developed to ensure that BRT projects are eligible for New Starts funding. In addition, adhering to the standard for dedicated running way

will ensure that BRT projects are eligible for the fixed guideway tier of the 5307 urbanized area formula program funding (see Appendix A).

Figure 1 | BRT Station Example

Key Terms:

To help clarify key terms used throughout the report, below are three important definitions:

- **BRT infrastructure** is defined as the 20 miles within which BRT-related infrastructure improvements will be implemented according to the Wake Transit Plan. BRT infrastructure includes stations, Transit Signal Priority (TSP), and dedicated running way as defined in this document.
- **BRT service** is bus service that operates within the BRT infrastructure and is branded as BRT service. While branded vehicles may operate outside of the BRT infrastructure, the standards and targets set in this document do not apply outside of the infrastructure.
- **Non-branded corridor routes** are bus routes that use some or all of the BRT infrastructure as a portion of a longer route. Non-branded corridor routes must adhere to the stop-spacing standards while operating within the BRT infrastructure, and must utilize vehicles that are compatible with the platforms at BRT stations, but otherwise are not required to adhere to the standards in this document. Standards for non-branded corridor routes are set by the Wake Transit Bus Plan Service Guidelines and Performance Measures based on the route category that the service falls under.
- A **standard** sets the minimum investment required to achieve the desired characteristics of BRT.
- A **measure** is a reference point against which performance is evaluated. Measures are evaluated against a target.
- A **target** is the defined value set for individual measures. For example, the target for productivity is 25 passengers per revenue hour.

Summary of Recommended Standards, Measures, and Targets

BRT design standards and performance measures recommended in this document are summarized in the following figures.

Figure 2 | Summary of Infrastructure Design Standards

Stop Spacing	Moderate-High Density (≥ 10 people+jobs per acre)	Low Density (< 10 people + jobs per acre)
Minimum stop spacing in miles	0.5	1
Maximum stops per mile	2	1
Dedicated Running Way	**Percentage**	
Minimum percentage of all-day dedicated running way	50%	
Intersections Priority Treatments	**Percentage**	
Minimum Percentage of signalized intersections within infrastructure with TSP	100% of intersections where TSP will provide a benefit to transit speed and/or reliability	
BRT Station Design and Amenities	**Required**	
Branded stations	100%	
Off-board fare payment	100%	
Level boarding	100%	
Real-time arrival information	100%	
Schedule and route information	100%	
Enhanced comfort (large shelters and lighting)	100%	
Bicycle parking	100%	
ADA accessibility	100%	

Figure 3 | Summary of Service Design Standards

Span of Service	Weekdays	Saturdays	Sundays
Minimum span of service	5am-12am	6am-12am	7am-12am
Service Frequencies	**AM/PM Peak**	**Midday/Evening**	**Early/Night/Sat/Sun**
Minimum service frequencies	15-minute	15-minute	20-minute
Vehicle Loading	**Peak**	**Off-Peak**	
Average vehicle loading maximums	120%	100%	

Figure 4 | Summary of Performance Measures and Targets

Passenger Boardings per Revenue Hour	All Day	Saturday	Early/Late/Sun
Minimum passenger boardings per revenue hour after 24 months of operation	25	20	15
Operating Cost per Boarding	**Dollars**		
Maximum operating cost per boarding after 24 months of operation	$6.00		
Farebox Recovery	**Percentage**		
Minimum farebox recovery after 24 months of operation	20%		
On-Time Performance (Frequency >10-minute)	**Percentage**		
% of trips leaving -1/+5 minutes of scheduled time at time of line opening	85%		
Average Operating Speed	**Speed (mph)**		
Minimum average BRT service travel speeds at time of line opening	16		

2 Infrastructure Design Standards

The Wake Transit Plan identifies 20 miles of BRT infrastructure improvements. The purpose of the infrastructure is to improve bus speed and reliability, maintain existing customer base and attract new riders through branding, and stimulate economic development. Improving speed and reliability can be accomplished by deploying the strategies defined in the sections below.

Stop Spacing

The Wake Transit Plan described BRT stations as being located at a greater spacing than local bus routes, typically ¾ miles apart. Stop spacing design standards for BRT service seek to balance speed and access within the range described by the Wake Transit Plan. Fewer stops allow for faster travel, but also reduce the number of destinations that are within a short walk of stations. In areas of moderate to high density and more activity generators, closer stop spacing is warranted to provide access to destinations. In low density areas, speed is prioritized to ensure that BRT service provides a compelling alternative to driving.

Recommended BRT stop spacing standards are shown in Figure 5. Based on today's land use, moderate to high density areas are defined as having 10 or more people and jobs per acre; low density areas are defined as having less than 10 people and job per acre. Existing population and employment densities areas are mapped in Figure 6 to illustrate where half-mile and mile stop spacing is recommended today. Stops may be spaced further apart than the standard if there are no connections or destinations that warrant service.

BRT corridors with frequent and reliable transit service can help support the development or redevelopment of areas into denser and more walkable options in the community. Wake County is projected to add hundreds of thousands of new jobs and residents by 2045 Areas that are low density today may transform into higher density areas in the future. In addition, the relative definition of low density and moderate to high density will change as the region becomes more dense as a whole. Figure 7 shows the projected 2045 population and employment densities. The breakpoint between moderate to high density and low density is defined as 20 people and jobs per acre. Higher future densities should be paired with more areas of half-mile stop spacing.

Figure 5 | Stop Spacing Standards

	BRT Service
Average Minimum Stop Spacing in Miles	
Moderate to High Density Areas	0.5
Low Density Areas	1
Average Maximum Number of Stop Per Mile	
Moderate to High Density Areas	2
Low Density Areas	1

Figure 6 | Bus Stop Spacing Standard Based on Existing Population and Employment Density

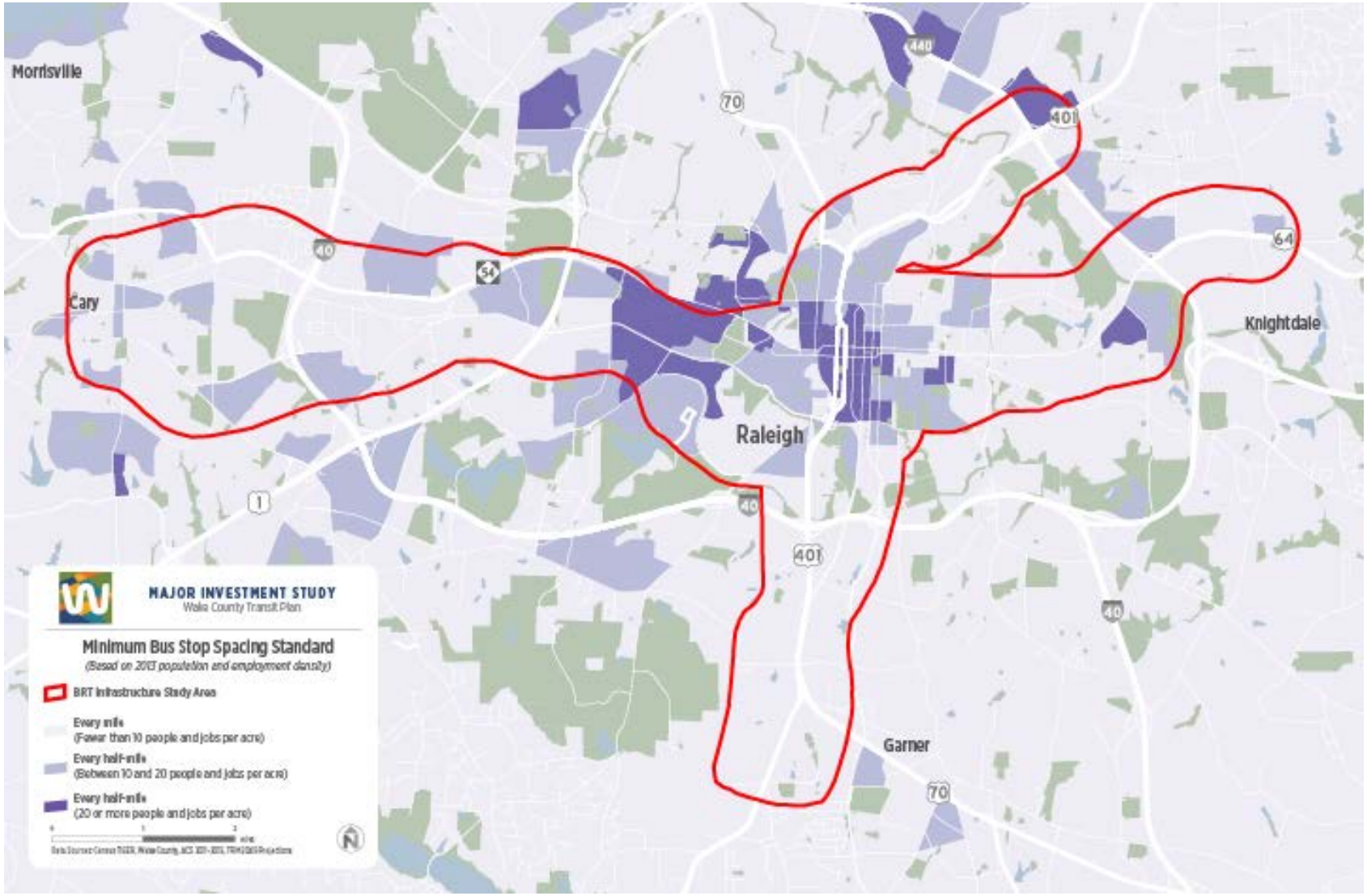
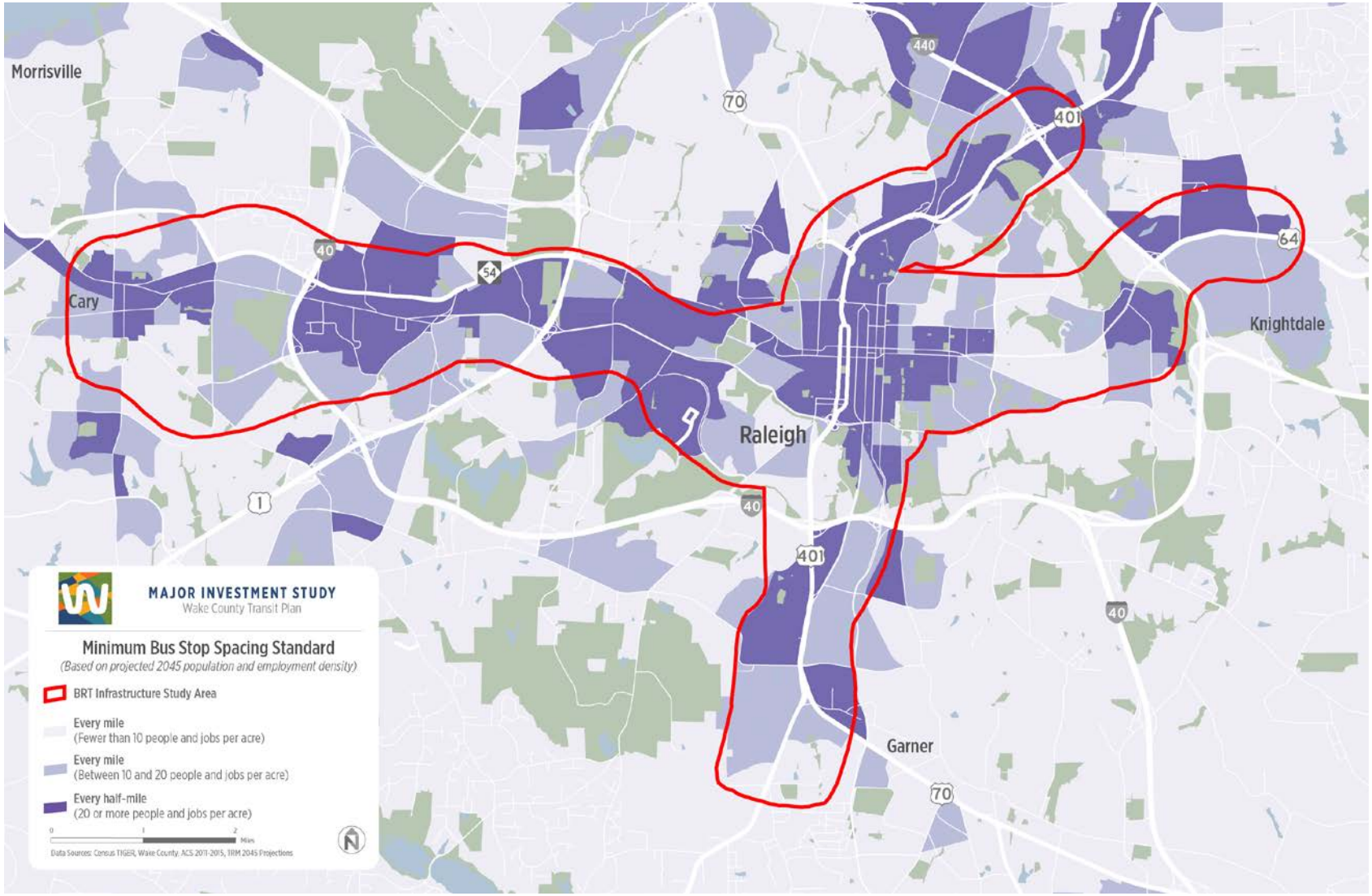


Figure 7 | Bus Stop Spacing Standard Possible Using 2045 Population and Employment Density



Dedicated Running Way

Dedicated running way is roadway space that is restricted for use by a specific set of vehicles such as transit vehicles. Dedicated running way, whether exclusive lanes or managed sharing with other vehicles, is a key contributing factor in travel time reduction for BRT. Dedicated running way ensures that buses maintain relatively consistent travel times throughout the day as regular travel lanes back up and as a result can reduce operating costs. Dedicated running way is most effective at providing fast, reliable travel when paired with intersection priority treatments. Based on review of national best practices (see Task 3.2 BRT Peer Review) BRT lines that include dedicated running way also experienced significant ridership increases and, in some cases, attract economic development to a corridor as communities respond to the reliable and regular service.

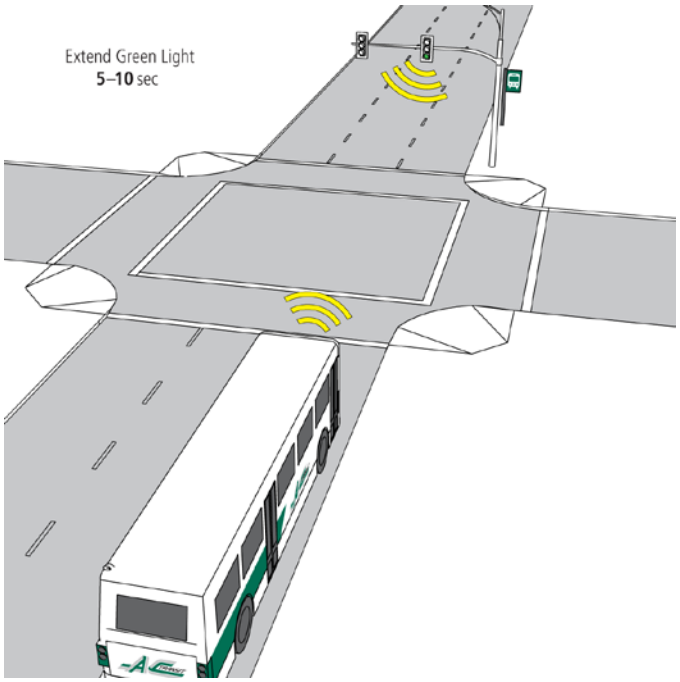
An additional consideration is federal guidelines for funding BRT services. The FTA CIG requires over 50 percent of BRT service to operate in a separated running way during peak periods to qualify for New Starts funding. As a result, a minimum recommended requirement is that dedicated running way should exist at peak times in over 50 percent of the miles of BRT infrastructure built in Wake County.

As a goal, Wake County BRT infrastructure should provide dedicated running way *at all times* in over 50 percent of the corridor. This will ensure an enhanced level of reliability at all times of day and protect against congestion whether it occurs during or outside of traditional commute times. The types of dedicated running way can vary based on the street right-of-way and operating conditions, but can include center or curb running dedicated lanes, a separate running way or busway, or other specialized lanes such as counter flow lanes or bus only access points. If center-running stations are designed for vehicles with passenger doors on the left side of the vehicle, some vehicle types will be precluded from using the BRT infrastructure.

Intersection Priority Treatments

Another key strategy for improving BRT speed and reliability is reducing delays at signalized intersections. Transit signal priority (TSP), shown in Figure 8, is an operational improvement that uses technology to reduce dwell time at traffic signals for transit vehicles by holding green lights longer or shortening red lights. The implementation level can vary from only giving late vehicles priority to having a full preemption system that allows buses to consistently traverse intersections without coming to a stop. Many light rail corridors have full preemption systems to improve vehicle speeds.

Figure 8 | Transit Signal Priority



Source: AC Transit

Queue jump lanes (Figure 9) are short dedicated transit facilities with either a leading bus interval or active signal priority to allow buses to easily enter traffic flow in a priority position. Applied thoughtfully, queue jump treatments can reduce delay considerably, resulting in run-time savings and increased reliability. In areas where a dedicated running way is not available, queue jump lanes can improve the effectiveness of TSP and reduce intersection delay.

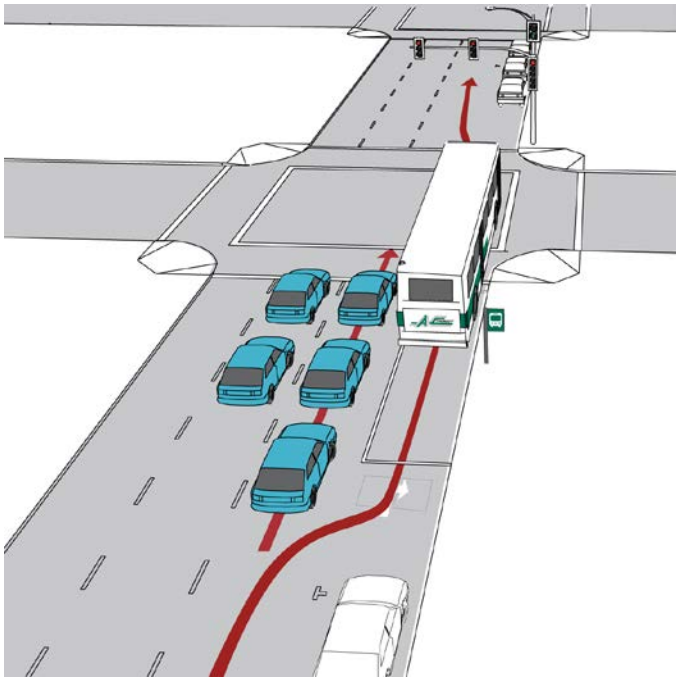
In areas where dedicated lanes are not available and significant congestion-related queues form at intersections, queue jump lanes should be added if the right-of-way is available.

Of those signalized intersections along a BRT corridor at which TSP will provide a benefit to transit speed and/or reliability, 100% should be equipped with TSP technology that will allow for either signal priority or full preemption. By implementing this technology at all intersections, the BRT infrastructure will have the ability to adapt to congestion levels over time.

The level of TSP implementation should be flexible to allow BRT service to meet minimum average speed and on-time performance targets (discussed later in this document). This may require signal priority, signal preemption, or a combination of treatments depending on the time of day, traffic levels, and planned or unanticipated intersection conflicts.

In some cases, intersections may have vehicle volumes and turning movements that preclude effective priority or preemption. In these instances, alternatives to TSP shall be fully evaluated.

Figure 9 | Queue Jump



Source: AC Transit

BRT Station Design and Amenities

BRT stations, defined as stops within the BRT infrastructure, are an integral part of the passenger experience, and their design and amenities can impact the attractiveness of the service as well as the speed of service. All BRT stations should have the following features:

- **Branded station amenities:** Each station should be easily recognizable from a distance with a consistent BRT brand that sets it apart from a regular bus stop.
- **Off-board fare payment:** Every station should require fare payment prior to boarding the vehicle. This will reduce the vehicle dwell time associated with passengers paying at the on-board farebox and also will allow all-door operation, which further decreases loading and unloading times. Every station should be equipped with appropriate technology with which customers can purchase tickets for BRT service using cash or debit/credit card. In addition, a pass validator should be included for customers with passes or stored-value cards. Under this design standard, accommodations must be made for non-BRT branded vehicles using BRT infrastructure.
- **Level boarding:** Stations should be designed with raised platforms so that patrons can easily step in and out of vehicles. This allows for faster wheelchair ramp deployment and reduces dwell time. Level boarding at stations may preclude certain types of vehicles from using the BRT infrastructure.
- **Real-time arrival information:** Stations should have electronic displays showing the predicted arrival time for vehicles serving that station using an automatic vehicle

location (AVL) system. Having access to real-time information reduces passengers' anxiety during wait time.

- **Schedule and route information:** Stations should include maps and schedules for BRT service, displayed in an easy to read format and kept up to date with schedule or service changes that may occur.
- **Enhanced comfort:** Stations should include large shelters to provide protection from sun and rain. Stations should provide appropriate and sufficient seating. Stations should be well lit to promote safety and security.
- **Bicycle parking:** Stations should be equipped with bicycle parking.
- **ADA accessibility:** All stations must be ADA accessible.

Design elements that help speed BRT branded vehicles through a BRT infrastructure corridor may introduce operational difficulties for non- branded corridor service buses using BRT infrastructure. For instance, requiring off-board fare payment at stops may be confusing for customers who are using a route that only uses a portion of the infrastructure. Payment would likely still be made on the bus, which could slow operations, and potentially delay vehicles that do utilize off-board fare payment. Likewise, the bus floor heights required for level boarding must be consistent between bus fleets. Level boarding for BRT branded buses would require that all non- branded buses using the infrastructure have similar boarding heights to the BRT fleet.

3 Service Design Standards

The BRT infrastructure can be used in multiple ways, both by branded BRT service and other bus routes. Defined BRT service does not preclude other bus routes from using the infrastructure.

This chapter summarizes the service design standards for BRT branded service in the BRT infrastructure, including definitions for span, frequency, and vehicle loadings.

Minimum Span of Service

Service design standards establish the required base span of service for BRT. The span of service varies by day of the week (weekdays, Saturdays, and Sundays), recognizing that the amount of activity, and consequently the need or demand for transit service, varies by day of the week. The standards reflect the *shortest* period of time that each service type should operate. The span of service for any individual route can be greater—but not less—than the standard. While service span may be extended for any BRT, these trips must meet the minimum productivity and efficiency expectations for that category of service (see Section 4).

Recommended minimum span of standards are shown in Figure 10

Figure 10 | Minimum Span of Service

	BRT Service
Weekdays	
Begin	6:00 AM
End	12:00 AM
Saturdays	
Begin	6:00 AM
End	12:00 AM
Sundays	
Begin	7:00 AM
End	12:00 AM

Notes: The beginning span of service refers to the departure of the first inbound trip, and the ending span of service refers to the departure time of the last peak direction trip.

Minimum Service Frequencies

Service frequency reflects the time interval between two vehicles traveling in the same direction on the same route, or how often the bus serves a particular stop. Service frequency is a critical characteristic in making BRT an attractive and viable travel mode, and significantly influences transit ridership. Service frequencies are also set to ensure there are enough vehicles on the

route to accommodate passenger volumes while not exceeding recommended loading standards.

The FTA CIG criteria require that BRT service operate short headway service for at least 14 hours on weekdays and 10 hours on weekends. Short headway service on weekdays is defined as either 15 minutes throughout the day or 10 minutes during peak times and 20 minutes during off-peak times. On weekends, short headway service is defined as 30-minute service. The Wake Transit Plan categorizes BRT service as part of the frequent network, defined as 15 minutes or better all day. Based on the review of national best practices, high quality BRT lines in the US operate at least every 10 minutes during peak times, providing an average wait time of five minutes to users, and maximizing the people-carrying capacity of BRT infrastructure. While the FTA only requires 30-minute service on weekends, more frequent service is recommended in order to ensure that BRT is a viable and convenient mode of transportation seven days per week. BRT service that operates more frequently outside of normal commute hours is more likely to attract riders to use BRT as a primary mode of transportation and generate more permanent mode shift.

Recommended minimum frequencies for BRT service are shown in Figure 11.

Figure 11 | Minimum Service Frequency (Frequency in Minutes)

	BRT Service
Weekdays	
Early AM (4am-6am)	20
AM Peak (6am-9am)	10
Midday (9am-3pm)	15
PM Peak (3pm-6pm)	10
Evening (6pm-9pm)	15
Night (9pm-12am)	20
Saturdays	
All Day	20
Sundays	
All Day	20

Vehicle Loadings

Vehicle loadings refer to the number of riders on the bus relative to the seating capacity of the vehicle. Vehicle loadings are measured in terms of maximum standards to capture the time (or portion of the route) when the greatest number of riders are on the vehicle at the same time. Transit providers can adjust services to keep the number of passengers on its vehicles at a

comfortable level, always within the limits of safety. In peak periods, this means that some passengers may be expected to stand for a portion of the trip. In off-peak periods and for service that operates longer distances, service will be designed to try to provide a seat to all customers. Transit operators maintain passenger loads within acceptable levels by matching capacity to demand. They can accomplish this by matching vehicle types with ridership levels (i.e. assign larger vehicles) or by increasing the frequency of service.

Service design standards set requirements for the maximum average vehicle loads by time of day. The standard reflects the average number of passengers relative to seating capacity for both the peak and off-peak periods, at the busiest point on the route.

The recommended maximum standard for vehicle loads on BRT service is shown in **Error! Reference source not found.**

Figure 12 | Average Vehicle Loading Maximums

	BRT Service
Peak	120%
Off-Peak	100%

4 Performance Measures

Performance measures consist of a limited set of focused metrics that capture the critical aspects of service productivity, efficiency, effectiveness, reliability, and speed; at the same time, these performance measures can be easily reproduced and communicated. Each performance measure should be monitored separately for each dedicated BRT line. These performance measures are for BRT-branded routes that only operate entirely within BRT infrastructure. They do not apply to any other type of transit service that may use the BRT infrastructure.

With the exception of the measure for average operating speed, the minimum and maximum targets set for each measure match the targets set for the Frequent Route classification developed by the Wake Transit Bus Plan. These thresholds are based on a review of performance of transit agencies operating in Wake County, as well as comparable and aspirational peer agencies across the US (see the Wake Transit Bus Plan Service Guidelines and Performance Measures for more information). As BRT projects move closer to implementation, targets may need to be adjusted to better reflect anticipated performance. BRT service should meet performance targets for measures related to productivity after 24 months of operation. This allows time for the rider market to mature. BRT service should meet performance targets for on-time performance and average operating speed at the time of service opening.

Passenger Boardings per Revenue Hour

The most common and reliable way to track transit service productivity is the number of passenger boardings for each hour of active service, or passenger boardings per revenue service hour. The target sets a minimum for the average number of passenger boardings that a route should generate for each service hour. The targets vary by day of the week and time of day.

Recommended minimum productivity levels for BRT service are shown in Figure 13.

Figure 13 | Minimum Productivity Levels (Passenger boardings per Revenue Vehicle Hour)

	BRT Service
Weekdays	
All Day	25
Early Morning	15
Late Night	15
Saturdays	
All Day	20
Sundays	
All Day	15

Note: "Early morning" and "Late Night" refers to service before and after the minimum span of service. All day refers to the complete span of service, including early morning and late night service.

Operating Cost per Passenger Boarding

The operating cost per passenger boarding reflects the cost of serving each passenger boarding. It is calculated by dividing operating and administrative costs by the total number of passenger boardings.

The recommended maximum target for operating cost per passenger boarding on BRT service is shown in Figure 14.

Figure 14 | Maximum Operating Cost per Boarding

BRT Service
$6.00

Farebox Recovery

Farebox recovery is the percentage of operating expenses recouped by farebox revenues. One of the challenges with BRT systems is relating revenues collected at stations with the service that is operated at the station, particularly if multiple different routes operate at a given station. Ridership on dedicated BRT service within the BRT infrastructure should be used, along with the fare revenues collected by either the fare machines or stored value readers at stations.

The recommended minimum farebox recovery target is shown in Figure 15.

Figure 15 | Minimum Farebox Recovery

BRT Service
20%

On-Time Performance

On-time performance is a measure of the reliability of route operations and evaluates how closely a route matches its published schedule. Measuring on-time performance provides information on whether a customer can count on a bus being there as scheduled. To precisely

measure on-time performance, a definition of on-time must be established. The recommended measure of on-time is up to one minute earlier and no more than five minutes later (-1 minute to +5 minutes) than the scheduled arrival time at all timepoints.

At very short intervals, such as 10-minute frequency, on-time performance may not accurately capture the reliability of the service from the customer perspective. For example, over the course of a peak period, every trip could depart 10 minutes later than scheduled time, resulting in 0% on-time performance. However, as long as customers experience evenly distributed, frequent bus service over that same period, the service would be perceived as reliable. If a BRT service is under performing in terms of schedule adherence during periods of 10-minute service or better, headway adherence may be an alternate measurement to gauge reliability. Vehicles on the route would be actively managed to maintain even spacing matching the published headway. Reliability would be measured as the percent of trips that leave within one minute more or less than the scheduled headway interval.

Recommended minimum on-time performance percentage is defined in Figure 16.

Figure 16 | Minimum On-Time Performance and Headway Adherence

	BRT Service
On-Time Performance	
% of trips leaving -1/+5 minutes of scheduled time	85%

Average Operating Speed

Dedicated running way, intersection priority treatments, longer bus stop spacing, and dwell-time saving amenities at stations can all combine to reduce transit travel times over existing bus service. Existing GoRaleigh bus routes that provide service in the proposed BRT corridors are scheduled to operate at average speeds of between 10 and 12 miles per hour. Buses operating in a BRT infrastructure corridor should travel at an average speed of no less than 16 miles per hour in order to provide a significant enhancement to travel time for passengers. The measurement of corridor BRT operating speeds should also include downtown Cary and downtown Raleigh.

As an example, a five-mile trip would experience travel time savings of more than 10 minutes if upgraded from an average speed of 10 miles per hour to 16 miles per hour.

Appendix A FTA Definitions

CIG BRT Definition

(1) Over 50 percent of the route must operate in a separated right-of-way dedicated for transit use during peak periods. Other traffic can make turning movements through the separated rightof-way. *(New Starts Only)*

(2) The route must have defined stations that are accessible for persons with disabilities, offer shelter from the weather, and provide information on schedules and routes.

(3) The route must provide faster passenger travel times through congested intersections by using active signal priority in separated guideway, and either queue-jump lanes or active signal priority in non-separated guideway.

(4) The route must provide short headway, bidirectional service for at least a fourteen-hour span of service on weekdays and a ten-hour span of service on weekends. Short headway service on weekdays consists of either (a) fifteen-minute maximum headways throughout the day, or (b) ten-minute maximum headways during peak periods and twenty-minute maximum headways at all other times. Short headway service on weekends consists of thirty-minute maximum headways for at least ten hours a day.

(5) The provider must apply a separate and consistent brand identity to stations and vehicles.

For more information:

Final Interim Policy Guidance, Federal Transit Administration Capital Investment Grant Program, June 2016.
https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/FAST_Updated_Interim_Policy_Guidance_June%20_2016.pdf

5307 Fixed Guideway and BRT Definitions

Fixed Guideway. The term "fixed guideway" means a public transportation facility (i) using and occupying a separate right-of-way for the exclusive use of public transportation; (ii) using rail; (iii) using a fixed catenary system; (iv) for a passenger ferry system; or (v) for a bus rapid transit system.

Bus Rapid Transit System. A bus transit system in which the majority of each line operates in a separated right-of-way dedicated for public transportation use during peak periods; and includes features that emulate the services provided by rail-fixed guideway public transportation systems, including (i) defined stations; (ii) traffic signal priority for public transportation vehicles; (iii) short headway bidirectional services for a substantial part of weekdays and weekend days; and (iv) any other features the secretary of the Department of Transportation may determine are necessary to produce high-quality public transportation services that emulate the services provided by rail-fixed guideway public transportation systems.

For more information:

Urbanized Area Formula Program: Program Guidance and Application Instructions (Circular 9030.1E), January 2015.
https://www.transit.dot.gov/regulations-and-guidance/fta-circulars/urbanized-area-formula-program-program-guidance-and