


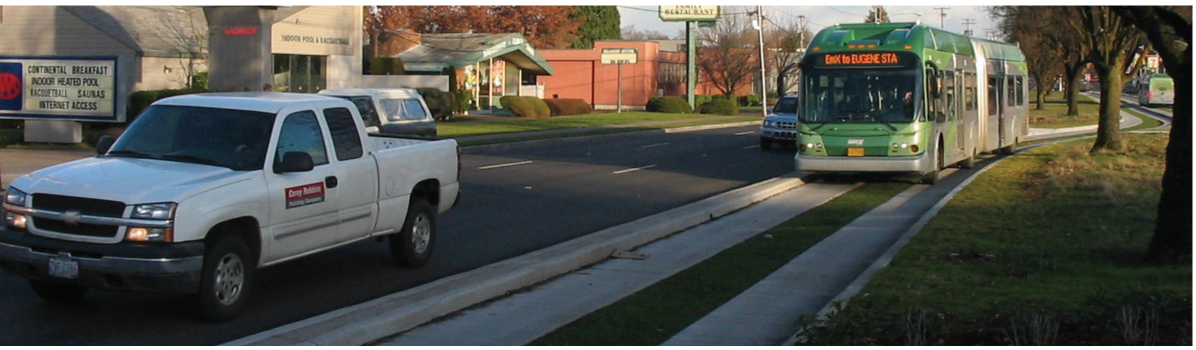

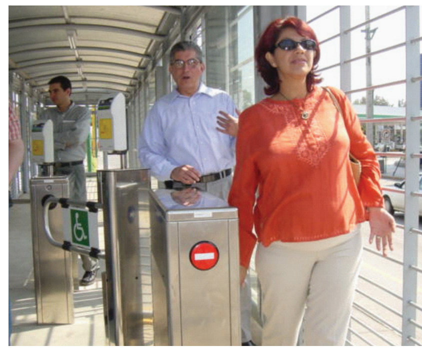

MCDOT Countywide Bus Rapid Transit Study

Consultant's Report
Executive Summary (Draft)
April 26, 2011

MONTGOMERY COUNTY MARYLAND
1776
GARDEZ BIEN
DEPARTMENT OF TRANSPORTATION

PB
125 YEARS ®

Countywide Bus Rapid Transit (BRT) Study

Consultant's Report

Executive Summary (Draft)

Prepared for:

Montgomery County Department of Transportation (MCDOT)

Prepared by:

Parsons Brinckerhoff

April 26, 2011

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1. Context for the Study

The Montgomery County Department of Transportation (MCDOT) initiated the Countywide Bus Rapid Transit (BRT) Study to identify key corridors within the county that could facilitate premium rapid transit service. The intent of this effort was to complete a planning-level analysis to draw conclusions regarding the feasibility of a network of BRT routes. The background for the study was established by conducting several individual corridor studies that explored BRT service through analysis conducted by the Metropolitan Washington Council of Governments (MWCOG), through a regional premium transit study, and through a BRT system concept developed by Montgomery County Councilmember Marc Elrich.

The consulting team was directed by the MCDOT to explore the feasibility of constructing a set of BRT corridors within the available constrained rights-of-way on county and state roads. The study provided analysis results at a level to allow MCDOT to identify possible BRT routes, determine treatments that would enhance speed, reliability, rider comfort, and convenience, and measure the system's performance in the horizon planning year 2040.

Based on the study's proposed implementation of BRT treatments—including exclusive transitways, transit signal priority (TSP) and queue jump lanes, and improved stations—a system of BRT routes could operate effectively within the county. The recommended 150-mile network of BRT routes could significantly increase daily transit use, with 210,000 to 270,000 BRT riders and 85,000 new transit trips in Montgomery County, which would represent an increased peak-hour mode share from 9 to 11 percent.

2. What is BRT?

The study focused on implementing a BRT system that would emulate light rail operations in terms of the features provided, but would operate on the arterial roadway system in the county. This BRT system would rely on walk access, local bus transfers, and some park-and-ride access, and would combine the most attractive features of light rail with the lower costs of bus technology. Instead of trains and tracks, BRT invests in improvements to vehicles, roadways, rights-of-way, intersections, and traffic signals to speed up bus transit service.

BRT service differs from commuter bus service, which focuses on peak-period service during the weekday with a limited schedule, intermediate stops, and dependence on park-and-ride access. BRT was assumed for this study to be premium bus service operating with the following characteristics:

- All-day service
- Higher service frequencies
- Stops at 0.5- to 1-mile spacing
- Provision for exclusive lanes where possible

- Transit signal priority and other queue jump lanes where appropriate
- Enhanced stations with greater passenger amenities
- Real-time passenger information
- Potential for off-board fare collection
- Efficient boarding and alighting

2.1. Key BRT Elements

2.1.1 Stylish Vehicles

Many BRT vehicles have sleek, modern designs that emulate light rail features. They can be standard, 40-foot or articulated 60-foot buses (as assumed for this study). They should have level floors and multiple wide doors for easy boarding and alighting. Vehicles should have comfortable interiors designed for different configurations, including space for bicycle storage.

Eugene Emx
(Source: LTD)

2.1.2 Attractive Stations

BRT stations should reflect the level of investment and permanence of the system. They should welcome passengers and feature a comfortable, attractive design. Stations should provide a variety of passenger amenities, including real-time information displays, benches, substantial shelters, and security features. Station platforms should be at the same level as the floor of the BRT vehicle to accommodate efficient boarding and alighting. This study assumed level-floor boarding for all stations.

Cleveland Healthline Station
(with protective shelter, ticket vending, and information kiosk)

2.1.3 Faster Fare Collection

On- or off-board fare collection options can help reduce BRT dwell time at stations and increase speed of service. Some on-board fare collection options include exact change payment and pass scanners. Examples of off-board fare collection include the use of ticket vending machines as proof of payment and special prepayment boarding areas. Pass scanners, such as those using the SmarTrip system in the Washington, DC region, provide complete integration with the area-wide transit system.

On-Board Smart Card Reader
(Source: WMATA)

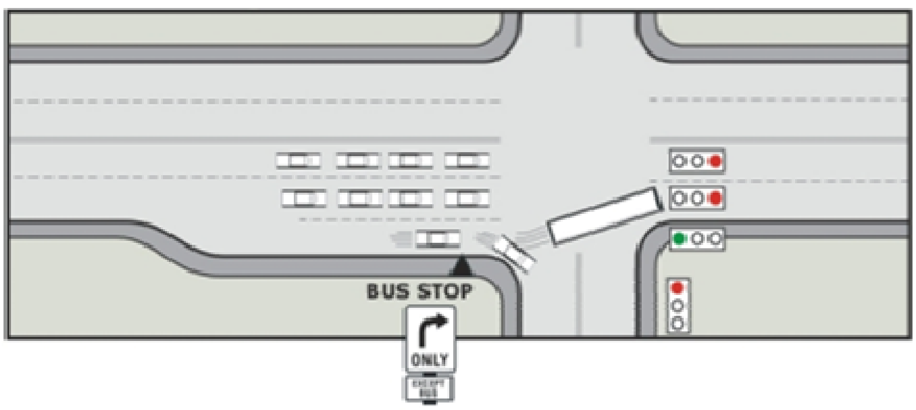
2.1.4 Guideways

Guideways can serve to increase BRT travel speeds, improve service reliability, and reinforce the system's permanence by separating the vehicles from mixed traffic. Examples of guideways applicable to BRT include median, side-of-road, or separate busways and exclusive bus lanes within the roadway cross section.

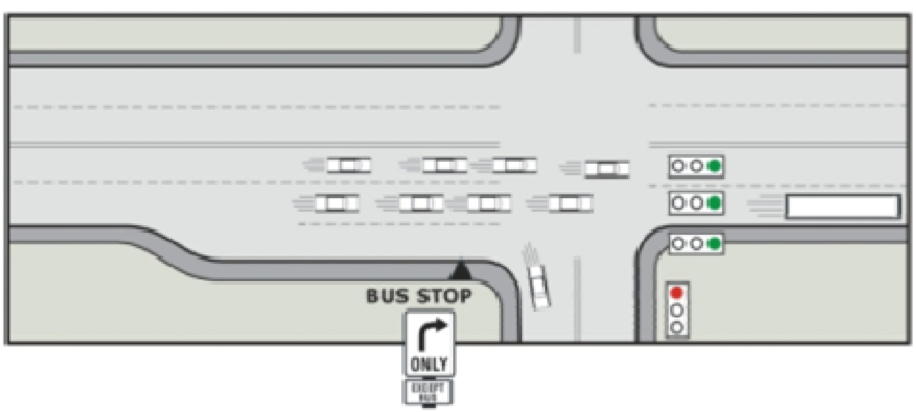
EmX Median Guideway
(Eugene, Oregon)

BRT vehicles may operate in mixed traffic in areas with constrained rights-of-way. In these conditions, implementing queue jumps can help increase operating speed and service reliability. A queue jump (Figure 1), as assumed in this study, is when a rapid transit vehicle can use an auxiliary lane (such as a right-turn lane) at a signalized intersection to bypass the general traffic queue at the intersection. An advanced green signal would allow the vehicle to move through the intersection unimpeded ahead of general traffic.

Figure 1: Queue Jump Operation Example



(a) Bus receives green signal before other vehicles

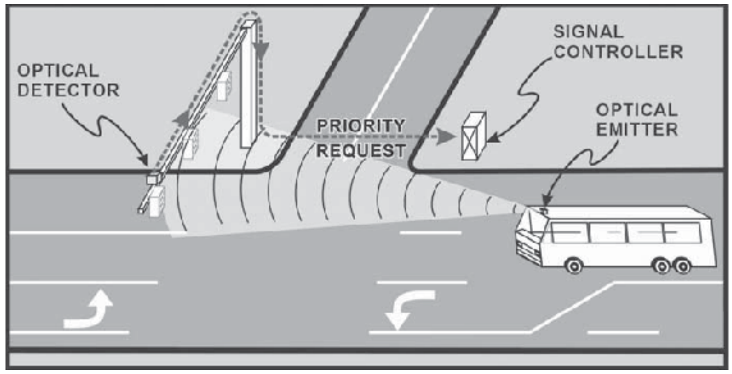


(b) Other vehicles proceed a few seconds later

Source: TCRP Report 118

2.1.5 Intelligent Transportation Systems (ITS)

Figure 2: Transit Signal Priority Example



Using ITS technology can help increase quality of service, improve operations, and provide passengers with timely and reliable information about BRT service. A key ITS application assumed for this study was transit signal priority (TSP). TSP technology allows a vehicle to request priority through a signalized intersection (Figure 2) by extending the green phase or truncating the red phase by a few seconds. This is a different application from signal pre-emption, which is often applied at locations of emergency vehicles where signals are controlled to stop all traffic. Typically TSP saves only a few seconds per intersection. TSP implementation may be conditional, depending on whether the vehicle is behind schedule.

TSP, in this study, was assumed to be feasible where the roadway level of service (LOS) was in the C or D range. LOS A or B represents more free-flow traffic conditions, where priority would not give a BRT vehicle an extra advantage. LOS E or F represents failing traffic conditions, where congestion would be so great a BRT vehicle cannot effectively actuate priority calls. In those cases, BRT would provide minimal benefit to bus operations and increase overall delay to other vehicles.

Other ITS applications can aid passengers with travel decisions by providing timely and reliable information. Riders can learn of the next BRT vehicle to arrive or route delays over the internet, through real-time information displays at BRT stations, or through a user's mobile phone. This study assumed the use of real-time passenger information for the proposed network.

Real-time information display in shelter

2.1.6 Operations

BRT service should provide reliable, frequent service with fewer stops compared to local bus service. It should also provide connectivity to other transportation modes such as local buses, rail, park-and-rides, and bicycle and pedestrian paths. Routes should be easy to understand and designed for passengers to have a one-seat ride to the extent possible. Local transit service should be re-oriented to provide access to BRT corridors.

2.1.7 Land Use

BRT routes operating along corridors with high concentrations of development that support transit make BRT service more effective as a transportation option. Transit-oriented development is a key component for successful BRT. BRT takes advantage of the pedestrian and customer activity found in areas with higher land use densities and a mixture of types of development, including residential, retail, employment, and entertainment.

Dense land use near Cleveland Healthline Station

Automobile use and parking needs can decrease where there are clusters of such development. BRT corridors require a minimal level of concentrated development. For this study, a threshold of at least six households or five employees per acre was used during early analysis as a method for identifying corridors where BRT service may be appropriate. The planning horizon year of 2040 includes the recently approved White Flint, Great Seneca Science Corridor and the Germantown Plans, all of which focus on transit–oriented communities.

2.1.8 Station Access

Improved bicycle, pedestrian and auto access to stations, and the correct placement of the station locations are critical factors in the success of a BRT system. Considerations for station locations in this study included placement at existing bus stops, Metrorail or planned light rail stations, transit centers, and park-and-ride lots. Detailed corridor implementation programs following this study should also consider the surrounding physical environment to enhance or improve access to BRT stations. BRT stations also must be accessible to passengers with varying levels of physical abilities.

Ensure BRT is accessible to all riders

2.1.9 Strong Brand Identity

Branding of BRT service conveys to new transit users and users unfamiliar with BRT that they are encountering a premium transit system with enhanced service and amenities. Typical branding methods include:[1]

- Branding stations and terminal features such as bus/BRT stop signs, passenger information boards, fare collection equipment, and media.
- Giving vehicles a special styling, unique livery, added passenger amenities, and marketing panels.

BRT Branding - Orange Line

[1] TCRP Report 118: Bus Rapid Transit Practitioner's Guide

- Branding running ways by using special paving materials, colors, and markings.
- Branding marketing materials such as route maps, route schedules, web sites, and media information.

3. Study Methodology

This feasibility study consisted of several tasks to identify a final set of viable BRT routes that could operate along state and county roadways in Montgomery County. These tasks were as follows:

1. Conduct an initial screening to identify a set of county roads that exhibit characteristics consistent with BRT operations.
2. Conduct field reviews and planning level right-of-way analysis along potential BRT corridors to determine potential design options, primarily within the existing right of way.
3. Determine travel demand along identified corridors.
4. Determine capital and operating costs for the BRT network.

Figure 3 depicts the study methodology in flow chart form and identifies the steps taken to determine the final network and analyze that network for viability.

The work conducted for these tasks ultimately produced a network of 16 high-investment BRT routes that would incorporate most of the key elements discussed in Section 2.1 and could be built within the existing right-of-way. The conceptual level of this study did not involve identifying the locations of right-of-way impacts; therefore, this proposed network would involve realigning roadway cross-sections, sometimes beyond the existing right-of-way. For example, exclusive guideways would be constructed through the spaces of existing medians and left-turn lanes at signalized intersections. However, constructing exclusive guideways would include replacing the left-turn lanes to maintain similar levels of traffic operations along the corridors.

4. Study findings

4.1. Proposed BRT Network and Treatments

Table 1 summarizes the proposed BRT network of 16 routes forecasted by 2040 to be viable BRT corridors. Figure 4 illustrates this network.

The specific guideway and intersection treatments options for each route can be found in the main body or the report.

Figure 3: Final Corridor Analysis and Selection Process

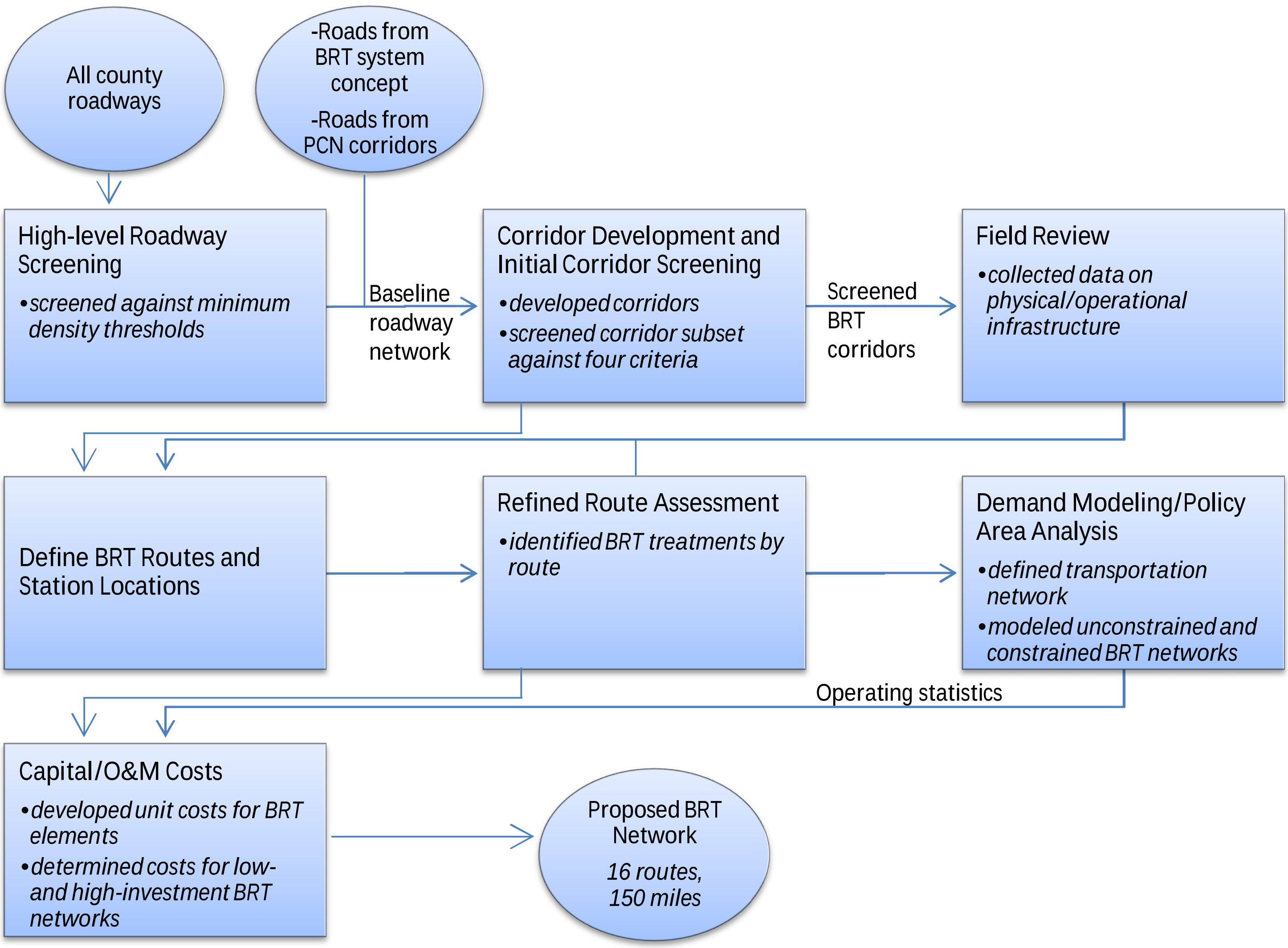
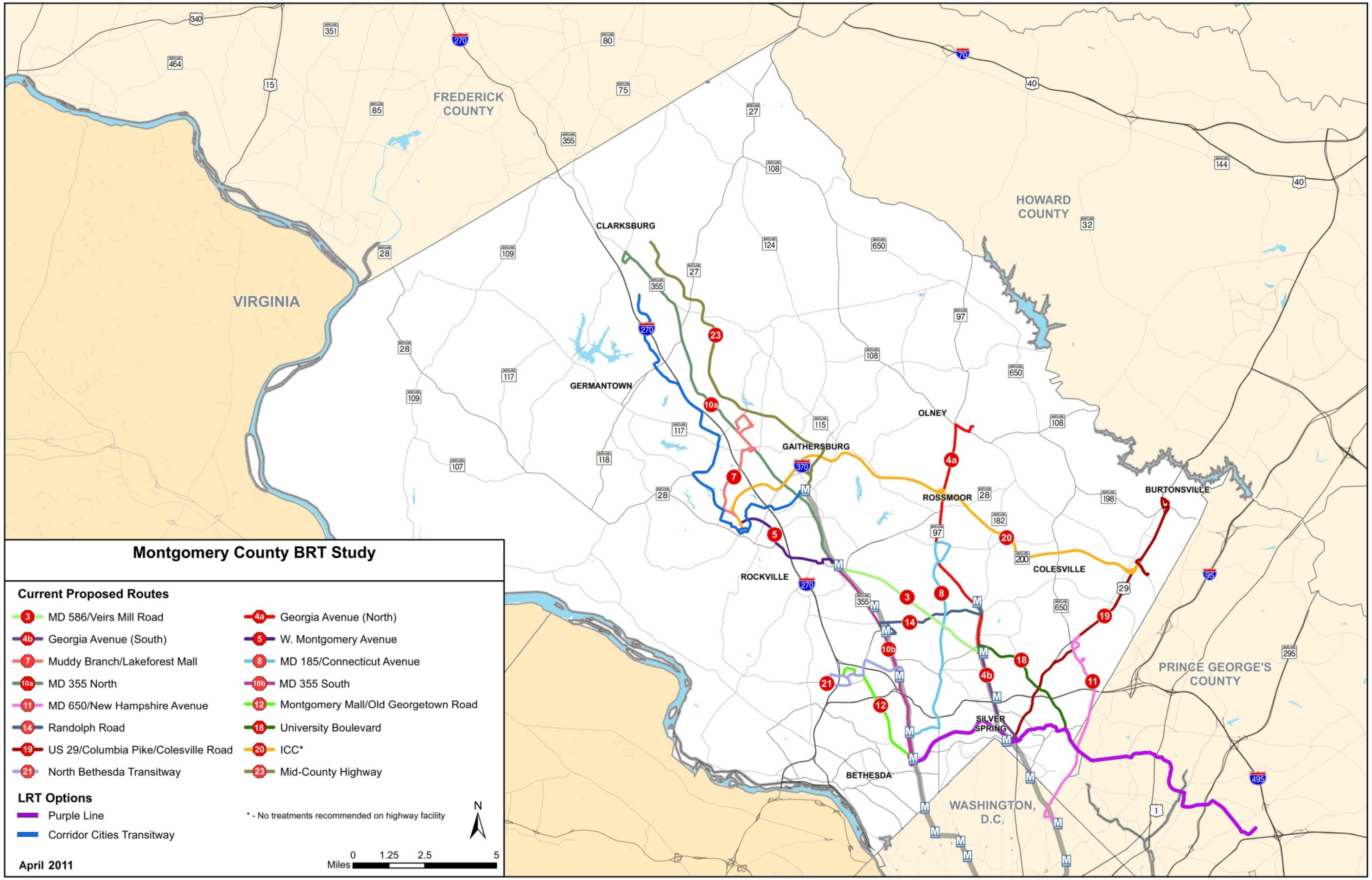


TABLE 1: BRT NETWORK – ROUTE SPECIFICS

Route Number	Corridor	From	To	Route Length (miles)	Number of Stations
3	MD 586/Veirs Mill Road	Rockville Metrorail Station	Wheaton Metrorail Station	6.7	11
4a	Georgia Avenue North	Montgomery General Hospital	Wheaton Metrorail Station	9.8	12
4b	Georgia Avenue South	Wheaton Metrorail Station	Silver Spring Transit Center	3.9	6
5	Rockville Metrorail-Life Sciences Center	Life Sciences Center	Rockville Metrorail Station	5.3	7
7	MD 124/Muddy Branch Road	Lakeforest Mall	Life Sciences Center	7.2	10
8	MD 185/Connecticut Avenue	Georgia Avenue and Bel Pre Road	Medical Center Metrorail Station	9.5	10
10a	MD 355 North	MD 355 and Stringtown Road	Rockville Metrorail Station	14.6	16
10b	MD 355 South	Rockville Metrorail Station	Bethesda Metrorail Station	8.8	13
11	MD 650/New Hampshire Avenue	White Oak Transit Center	Fort Totten Metrorail Station	8.8	9
12	Montgomery Mall/ Old Georgetown Road	Montgomery Mall Transit Center	Bethesda Metrorail Station	6.9	9
14	Randolph Road	White Flint Metrorail Station	Glenmont Metrorail Station	5.5	7
18	MD 193/University Boulevard	Wheaton Metrorail Station	Takoma/Langley Park Transit Center	6.4	9
19	US 29/Columbia Pike/Colesville Road	Burtonsville Park-and-Ride Lot	Silver Spring Transit Center	13.5	11
20	ICC	Life Sciences Center	Briggs Chaney Park-and-Ride lot	22.9	3
21	North Bethesda Transitway	Montgomery Mall Transit Center	Grosvenor Metrorail Station	5.1	7
23	Midcounty Highway	Snowden Farm Parkway and Stringtown Road	Shady Grove Metrorail Station	13.4	10
Total				**148.3**	**150**

Figure 4: Proposed BRT System Map



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4.2. Ridership and Operating Costs

The study applied the transit forecasting model developed by the Maryland Transit Administration and accepted by the Federal Transit Administration for use on the Purple Line and Corridor Cities Transitway Alternative Analysis projects. Forecasts were developed for the proposed BRT network, and ridership and operating costs were determined for the planning forecast year of 2040. In addition to the 16 proposed BRT routes, the modeled transportation networks assumed some modified commuter local bus service to reflect enhanced commuter access to the western county and to other regional transit options.

Model outputs used to determine ridership and operating costs were based on travel times developed from field work. Table 2 identifies the end-to-end travel times for the routes and compares highway and local bus travel times. Table 3 shows a similar comparison based on highway and local bus speeds and BRT speeds, as generated by the forecasting model.

TABLE 2: FORECASTED (2040) TRAVEL TIMES (HIGHWAY, LOCAL BUS, BRT)

Route Number	Average Highway Time (min)	Average Local Bus Time (min)	Average BRT Time (min)	BRT Time Savings over Local Bus (min)	% BRT Time Savings over Local Bus
3	20.5	28.1	19.5	8.6	31%
4a	28.6	35.8	25.6	10.2	28%
4b	15.1	20.7	18.7	2.0	10%
5	19.3	28.8	22.4	6.4	22%
7	30.1	42.1	33.1	9.0	21%
8	31.9	42.6	29.2	13.4	31%
10a	43.1	63.4	45.4	18.0	28%
10b	34.2	50.2	34.7	15.5	31%
11	32.6	45.0	38.1	6.9	15%
12	19.1	26.4	20.5	5.9	22%
14	16.9	22.5	17.3	5.2	23%
18	17.5	24.7	16.1	8.6	35%
19	40.9	55.7	38.2	17.5	31%
20	37.7	41.7	37.7	4.0	10%
21	11.7	16.8	14.5	2.3	14%
23	32.7	42.7	32.7	10.0	23%
Average	***27.0***	***36.7***	***27.7***	***9.0***	***24%***

TABLE 3: FORECASTED (2040) TRAVEL SPEEDS (HIGHWAY, LOCAL BUS, AND BRT)

Route Number	Average Highway Travel Speed (mph)	Average Local Bus Speed (mph)	Average BRT Travel Speed (mph)	BRT Speed Increase over Local Bus (mph)	% BRT Speed Increase over Local Bus
3	18.8	13.7	19.8	6.1	45%
4a	20.3	16.2	22.7	6.5	40%
4b	13.8	10.1	11.2	1.1	11%
5	14.8	9.9	12.8	2.9	29%
7	11.4	8.2	10.4	2.2	27%
8	15.3	11.5	16.8	5.3	46%
10a	19.1	13.0	18.1	5.1	39%
10b	15.3	10.4	15.1	4.7	45%
11	13.9	10.1	11.9	1.8	18%
12	15.7	11.4	14.7	3.3	29%
14	15.9	12.0	15.6	3.6	30%
18	21.7	15.3	23.6	8.3	54%
19	18.0	13.2	19.3	6.1	46%
20	30.2	27.3	30.2	2.9	11%
21	15.4	10.7	12.4	1.7	16%
23	23.3	17.8	23.3	5.5	31%
Average	***17.7***	***13.2***	***17.4***	***4.2***	***32%***

Detailed analyses of forecasts (highway networks, land use, speeds, etc.) were developed for the year 2040 to determine the functioning of the system in the forecast planning horizon year. In response to a request from MCDOT staff, the consulting team also conducted an analysis of land use projections *only* for the year 2020 (keeping all other factors constant for 2040) as a method to determine information that could be used for later decision making on corridor phasing. This information is presented in Table 4 and Table 5 to provide context on assumed ridership and operating costs by the year 2040, as well as assumed by 2020. The forecasted ridership for 2040 is almost double the ridership for existing Ride On service throughout the county.

TABLE 4: FORECASTED (2040) RIDERSHIP FOR BRT ROUTES (SORTED BY DAILY BOARDINGS PER ROUTE MILE, $2011)

Route Number	Route Name	Daily Boardings	Daily Boardings/ Route Mile	Required Peak Headway (min)	% of 2040 Achieved w/ 2020 LU
10b	MD 355 South	28,200 - 35,300	3,600 - 4,500	2.8 - 2.3	72%
14	Randolph Road	16,000 - 20,000	3,500 - 4,400	3.9 - 3.2	82%
4b	MD 97/Georgia Avenue South	10,500 - 13,100	3,000 - 3,800	3.0 - 2.5	92%
10a	MD 355 North	37,600 - 47,000	2,700 - 3,400	2.4 - 2.0	72%
21	North Bethesda Transitway	8,200 - 10,200	2,700 - 3,400	4.6 - 3.8	80%
18	MD 193/University Boulevard	14,600 - 18,300	2,300 - 2,900	2.9 - 2.5	84%
5	Rockville Metro-LSC	10,000 - 12,500	2,100 - 2,600	5.9 - 4.9	77%
3	MD 586/Veirs Mill Road	12,700 - 15,900	2,000 - 2,500	6.1 - 5.1	84%
7	Lakeforest Mall/Muddy Branch Road	9,400 - 11,700	1,600 - 2,000	6.5 - 5.4	73%
12	MD 187/Old Georgetown Road	7,700 - 9,600	1,500 - 1,900	7.0 - 5.8	95%
4a	MD 97/Georgia Avenue North	14,700 - 18,400	1,500 - 1,900	3.1 - 2.6	88%
11	MD 650/New Hampshire Avenue	10,600 - 13,200	1,400 - 1,800	5.2 - 4.3	81%
19	US 29	14,700 - 18,400	1,200 - 1,500	3.1 - 2.6	92%
8	MD 185/Connecticut Avenue	6,600 - 8,300	800 - 1,000	5.7 - 4.7	94%
23	Mid-County	6,700 - 8,400	600 - 700	6.8 - 5.7	83%
20	ICC	4,900 - 6,100	200 - 300	8.1 - 6.8	44%
Total		*213,100 - 266,400*	*1,600 - 2,000*		80%

TABLE 5: OPERATION AND MAINTENANCE COSTS (2040) FOR BRT ROUTES (SORTED BY FAREBOX RECOVERY RATIOS, $2011)

Route Number	Route Name	Annual O&M Cost	O&M Cost/ Boarding	Farebox Recovery Ratio*
14	Randolph Road	$5,480,000 - $6,576,000	$0.92 - $1.11	87% - 69%
3	MD 586/Veirs Mill Road	$4,855,000 - $5,826,000	$1.03 - $1.23	78% - 62%
5	Rockville Metro-LSC	$4,580,000 - $5,496,000	$1.23 - $1.48	65% - 52%
21	North Bethesda Transitway	$3,827,000 - $4,592,400	$1.26 - $1.51	64% - 51%
18	MD 193/University Boulevard	$7,574,000 - $9,088,800	$1.39 - $1.67	58% - 46%
12	MD 187/Old Georgetown Road	$4,064,000 - $4,876,800	$1.42 - $1.70	56% - 45%
10b	MD 355 South	$16,152,000 - $19,382,400	$1.54 - $1.84	52% - 42%
4b	MD 97/Georgia Avenue South	$6,497,000 - $7,796,400	$1.66 - $1.99	48% - 39%
7	Lakeforest Mall/Muddy Branch Rd	$5,845,000 - $7,014,000	$1.67 - $2.00	48% - 38%
10a	MD 355 North	$26,657,000 - $31,988,400	$1.90 - $2.28	42% - 34%
4a	MD 97/Georgia Avenue North	$11,747,000 - $14,096,400	$2.14 - $2.57	37% - 30%
11	MD 650/New Hampshire Avenue	$8,495,000 - $10,194,000	$2.15 - $2.58	37% - 30%
8	MD 185/Connecticut Avenue	$6,836,000 - $8,203,200	$2.77 - $3.32	29% - 23%
19	US 29	$15,735,000 - $18,882,000	$2.87 - $3.44	28% - 22%
23	Mid-County	$7,922,000 - $9,506,400	$3.15 - $3.78	25% - 20%
20	ICC	$8,230,000 - $9,876,000	$4.55 - $5.46	18% - 14%
Total		*$144,496,000 - $173,395,200*	-	*44% - 35%*

* Farebox recovery ratio is the percentage of annual O&M costs regained from fares, based on an assumed trip fare.

4.3. Capital Costs

4.3.1 Capital Costs

The capital costs for the proposed network were derived using estimating methods. Unit costs used were taken from Maryland State Highway Administration's 2010 Price Index. Professional experience on other BRT system and corridor studies nationwide, and documentation of unit costs from the FTA *Characteristics of Bus Rapid Transit for Decision-Making* report and TCRP *Report 118: Bus Rapid Transit Practitioner's Guide* also were applied. The costs do not include right-of-way, as right-of-way was not assessed for this study.

Costs comprise the following elements:

- BRT guideway and exclusive bus lane treatments.
- Intersection treatments: TSP and queue treatments, as well as widening of signalized intersections.
- Construction of station platforms, concrete bus pads for BRT vehicles serving curb-side stations while operating in mixed traffic.
- Articulated BRT vehicles.
- Maintenance facility.
- Add-ins, totaling 25 percent of route and system costs, include preliminary engineering, final design, construction management, insurance, and start-up costs for the system.
- 40 percent contingency applied to guideways, intersection treatments, station elements, and maintenance facilities.

The cost of the system, a network of approximately 150 route miles including all the elements listed previously, is estimated to be $2.5 billion (without right-of-way costs) in current year dollars. This reflects the cost of incorporating the highest level of design possible for the proposed BRT system. Actual total system costs would vary based on anticipated funding availability and implementation strategy.

Table 6 summarizes the elements comprising the network.

TABLE 6: SUMMARY OF TREATMENT ASSUMPTIONS FOR THE NETWORK

Elements	Quantity	
Guideway and bus lane segments	Absolute total	Percentage of network
two-way guideway only	*24 route miles*	*16%*
one-way guideway only	*48 route miles*	*32%*
guideway and bus lane	*27 route miles*	*18%*
bus lane (both directions)	*1 route mile*	*< 1%*
bus lane (one direction)	*7 route miles*	*5%*
no guideway and bus lanes	*44 route miles*	*29%*
Queue jumps		
by location	*26 intersections*	
by direction	*37 queue jumps*	
TSP	176 intersections	
Stations		
by location	*150 sites*	
by platforms	*367 (median and curb)*	
Concrete pads	209 pads	
Articulated vehicles	360 buses (peak period); 430 buses (total fleet)	

A 40 percent contingency was applied to the derived construction costs, given the conceptual nature of the study. This contingency does not assume right-of-way purchase. The consulting team allocated a portion of the estimated costs to utility modifications, pavement drainage, and maintenance of traffic. However, refined costs for elements such as major utility relocation and structures (including drainage structures and overhead lane use control structures) and off-roadway stormwater detention were not included in the capital costs but would be covered by the construction contingency. The estimated capital costs derived for this study are to be considered only as a planning level assessment. More detailed studies identifying specific alignments, cross-sections, and roadway characteristics along each of the 16 routes would be required to develop a more specific estimate.

5. Key Considerations

This study presents a conceptual high-investment BRT network operating within the rights-of-way of county and state roadway corridors. While it provides a foundation for a viable network, several considerations must be addressed as individual routes are refined and prepared for implementation.

5.1. Costs

It is difficult to know all the impacts along a corridor based on the level of analysis consistent with a feasibility study. Constructing a high-investment BRT network affects elements such as right-of-way and utility relocation. While the consulting team allotted some of the capital costs and applied contingencies toward utility reconstruction and pavement drainage systems, detailed corridor studies would extensively document the infrastructure impacts of constructing and implementing BRT treatments. Additionally, detailed field reviews and measurements would identify specific right-of-way impacts expected. Again, right-of-way estimates are not included in the cost estimates generated by this study.

5.2. Land use and BRT branding

Two of the key BRT elements—land use and branding—can significantly affect system ridership. Additional studies should consider whether increased transit-oriented development is warranted along individual BRT corridors to help assure the viability of the system. The county should institute a branding campaign should this network advance to implementation. Attracting passengers who associate BRT with a form of premium transit service would be expected to increase the system's chance of strong, sustained ridership.

5.3. Implementation

Next steps toward implementation based upon the findings of this study will be defined by the County Executive, County Council, MCDOT, M-NCPPC, Maryland State Highway Administration, and Maryland Transit Administration. Refined studies focused on specific corridors would identify more factors affecting the success of BRT routes, and consider the refined package of facility and service improvements based on anticipated funding availability.