



Countywide Bus Rapid Transit System
Travel Forecasting Study
October 2013

HowardCounty maryland

SABRA, WANG & ASSOCIATES, INC.

VISION ENGINEERING & PLANNING

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I. Introduction

This report builds on the concept plans developed by the Howard County Department of Planning and Zoning, and documents the effort to define a viable network of Bus Rapid Transit (BRT) routes through Howard County. The Howard County BRT report on concept plans and preliminary cost published in April 2012 outlines the initial design of a BRT network.

The BRT routes evaluated in this study would provide high quality transit service that emulates light rail operations at a lower cost. However, the implementation of such a system would represent a significant investment for the County and should be pursued only where frequent bus service could be supported. In order to ensure that the BRT project is successful, it has to be supported by strong forecasted ridership and potential shift from private auto mode shares.

II. Study Purpose and Need

The purpose of this study is to evaluate the proposed BRT network and determine which routes are most viable given the proposed services and ridership forecasts. Four corridors are studied in this report:

1. **US 29** between Mount Hebron and Silver Spring
2. **Broken Land Parkway** between Columbia Town Center and Savage MARC Station
3. **MD 32** between Clarksville and Odenton Town Center
4. **MD 216** between Scaggsville and Odenton Town Center

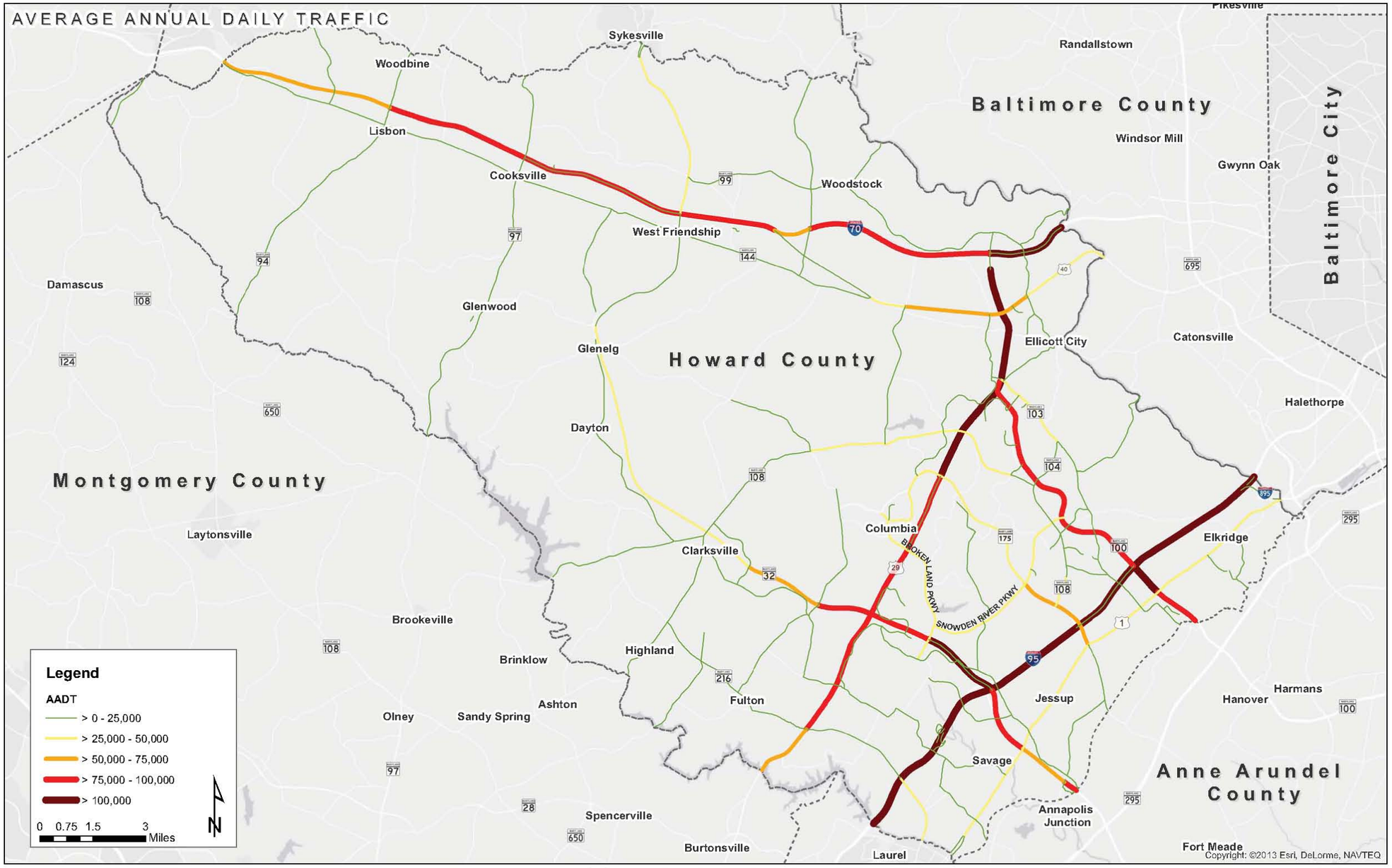
The analysis was performed with the aid of the Baltimore Metropolitan Council's regional travel demand model. As part of this study, the model was validated and minor adjustments were implemented to fit the needs of this specific investigation. The travel demand model was also used to screen measures of effectiveness (MOEs) including travel time, average annual daily traffic (AADT), and person-throughput; to refine alignments and potential stations; and to test specific operational characteristics (e.g. headways and speeds).

III. Existing Conditions

A. Study Corridors

The proposed BRT system would have buses running along arterials, freeways, and exclusive guideways. Dedicated lanes have been explored in medians, alongside existing roadways, on railroad right-of-way, and in mixed traffic. The network is proposed along four major routes: US 29, Broken Land Parkway, MD 216, and MD 32. **Figure 1** illustrates the highway network in the region along with the existing average annual daily traffic on each roadway. Connecting bus transit service to BRT stations was not tested.

Figure 1. Average Annual Daily Traffic on Regional Roadway Network



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1. US 29 Corridor

US 29 originates near Mount Hebron at MD 99 and connects Howard County with Montgomery County and Washington, DC to the south. Through Howard County, the roadway is a six-lane limited access divided highway identified as Columbia Pike with a posted speed limit of 55 mph. In Montgomery County, the speed limit drops to 40 mph as it becomes an arterial roadway named Colesville Road, turning into Georgia Avenue as it enters Washington, DC. Traffic volumes are the highest at the north end of US 29 with over 100,000 vehicles per day traveling that section. Traffic volumes drop to under 75,000 vehicles a year near the Montgomery County line. US 29 is one of the most developed corridors in the area with several clusters of commercial development distributed along its alignment. It provides regional and local access to Columbia Town Center; a major activity center, hub for Howard Transit, and focus of planned growth.

2. Broken Land Parkway Corridor

Broken Land Parkway is a six-lane divided arterial that runs from the Columbia Mall to MD 32 with a posted speed limit of 45 mph. Although only 3.6 miles long, this roadway offers important connections to commercial and residential developments within the Columbia area. Volumes along Broken Land Parkway average between 25,000 and 50,000 vehicles per day.

3. MD 32 Corridor

MD 32 is a six-lane limited access divided highway that runs southwest from Carroll County to Odenton in Anne Arundel County with a posted speed limit of 55 mph. The roadway provides an essential connection between major area freeways including I-70, MD 295, I-95, and I-97. It is heavily traveled, with an ADT of over 100,000 vehicles per day near its interchange with I-95. There are several areas of commercial, industrial, and institutional development along MD 32, including Fort Meade – one of the area's largest employment centers.

4. MD 216 Corridor

MD 216 is a four-lane arterial that runs along the southern edge of Howard County with a posted speed limit of 45 mph. Between US 29 and I-95, the roadway is divided and has few intersections, but it becomes more of a city street as it enters Laurel. The majority of neighborhoods along MD 216 are made up of low density residential properties. On the west end of its alignment, where it meets US 29, it serves the emerging activity center of Maple Lawn. This roadway carries the lowest volumes of the study corridors with an average of less than 25,000 vehicles per day.

B. Existing Transit Services

Existing transit services provided by the state and the county include local bus, commuter bus, and commuter rail. **Figure 2** illustrates the transit routes offered throughout Howard County. The County operates eight routes through the eastern part of the county branded as Howard Transit. These routes link to commuter routes and connect major employment and commercial centers in the area. Additionally, some bus routes are organized under Central Maryland Regional Transit (CMRT). CMRT works closely with Howard County and other jurisdictions in the region to provide fixed route and subscription transit services. **Table 1** summarizes the daily ridership for each of these bus routes.

Table 1. Howard Transit/CMRT Average Daily Ridership.

Route	Average Daily Weekday Ridership
Brown	475
Gold	172
Green	549
Orange	382
Purple	247
Red	521
Silver	679
Yellow	351
C	89
E	398

The Maryland Transit Administration (MTA) runs its own network of buses that serve the larger region. One express route serves the Columbia Mall area with limited stops along US 29 and Baltimore National Pike into downtown Baltimore. Additionally, six commuter bus routes provide direct connections south to Silver Spring and Washington, DC as well as north to Baltimore City. The ICC commuter service provides connections east to BWI Airport and Fort Meade and west to Gaithersburg. Both express and commuter services are geared towards getting people to and from work, operating mostly during the morning and evening commute times. **Table 2** summarizes average daily ridership for these commuter routes between July 2011 and June 2012. Ridership numbers show that the greatest demand is for travel to and from Washington, DC, with almost 80% of the trips on these routes for service in that direction.

Table 2. MTA Commuter Bus Average Daily Ridership.

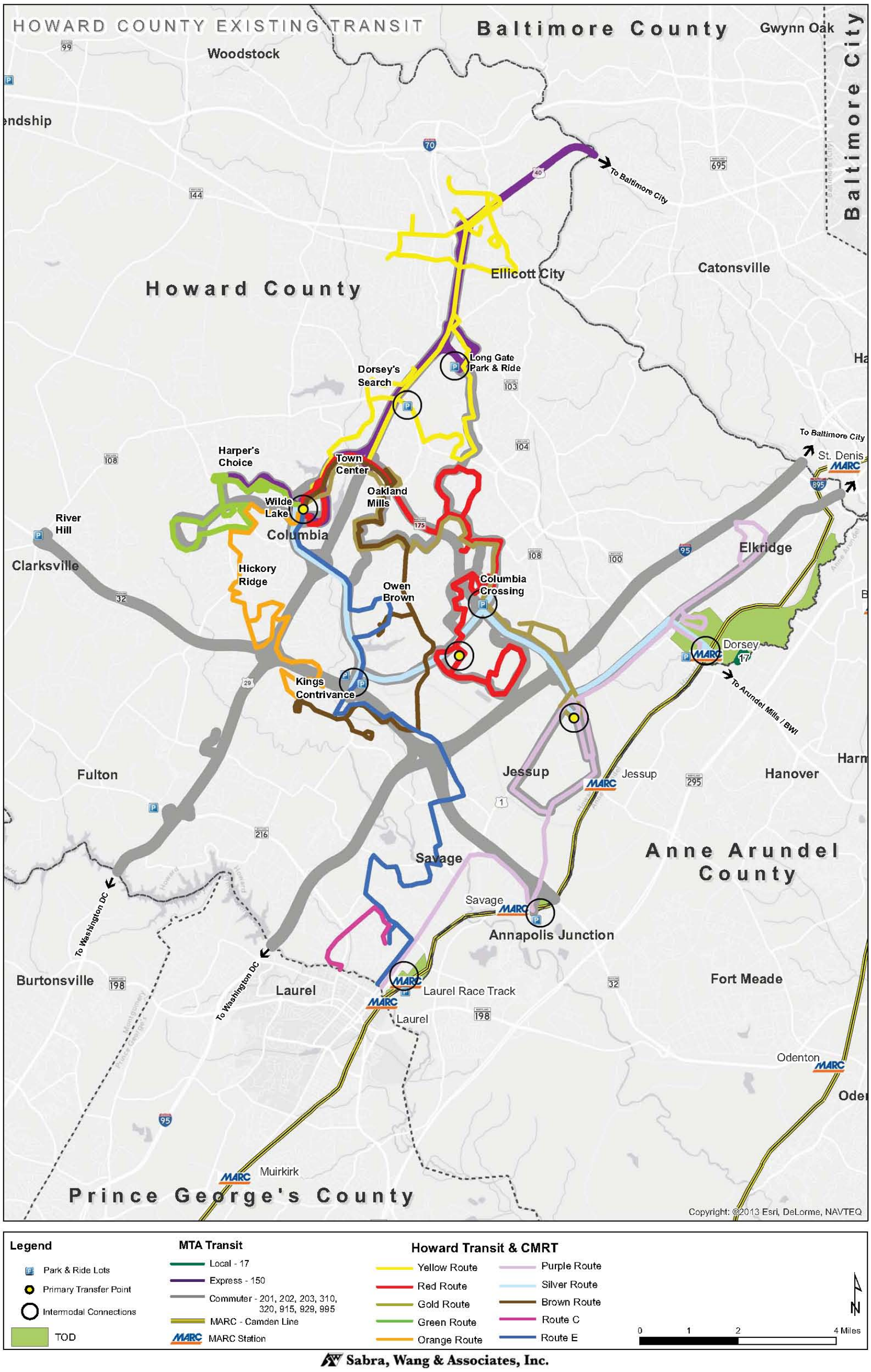
Route	Average Daily Ridership	Destination
915	875	Washington, DC
929	970	
995	1,010	
310	366	Baltimore
320	203	
201	164	Gaithersburg-BWI
202	53	Gaithersburg-Ft Meade

The MTA also operates the MARC Camden commuter rail line that connects to Baltimore and Washington, DC. There are currently four stations within Howard County in Laurel, Savage, Jessup, and Dorsey. This service also caters to commuters traveling in the traditional morning and evening peak hours.

C. Existing Intermodal Nodes

Several nodes throughout the county serve as connections for intermodal transfers. MARC stations, in particular, serve as transportation centers where connecting bus service and park-and-ride lots offer convenient intermodal connections. Additional park-and-ride lots serve commuter bus routes, allowing transit riders convenient access via private vehicle. These are located at Clarksville, Broken Land Parkway, Long Reach, Scaggsville, Long Gate Parkway, and Old Annapolis Road, illustrated in **Figure 2**. Bus-to-bus transfers are possible at several primary transfer points, illustrated in **Figure 2**, allowing commuter bus to local bus transfers to facilitate circulation within the County.

Figure 2. Existing Transit Services in Howard County.



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IV. Model Development and Validation

The model used to forecast ridership along the proposed BRT routes was developed using the Baltimore Metropolitan Council's regional travel demand model. This model uses forecasts of demographic data to assign trips throughout the transportation network. It was revised to accommodate a refined zone structure within Howard County. Due to the application of these changes, a validation of the updated model would be necessary. For details on the model validation process, see **Appendix A**.

The overall goal of the model validation effort is to improve the model's predictive capabilities and ability to provide reasonable forecasts. This is done by developing a base year model and evaluating how well the model is able to replicate existing conditions. The year 2008 was used as the baseline year for the validation of this model.

Screenlines were specified across major roadways to determine the volume of vehicles entering and exiting the regional corridors in the model for the purposes of validation. These values were compared to actual counts to determine the accuracy of model predictions. The FHWA sets guidelines for these volume-to-count ratios to determine the validity of a model. The maximum deviation acceptable for each type of roadway is as follows:

- Freeways/Expressways ±7%
- Principal Arterials ±10%
- Minor Arterials ±15%
- Collector Roadways ±25%

The major movements evaluated for the purposes of model validation are the major regional flows through the county between Baltimore and Washington – along US 29, I-95, US 1, MD 295, MD 100, MD 175, and MD 32 – as well as access to the Columbia Town Center. It was found that the regional flows were modeled reasonably well, but the trips to and from the Columbia Town Center were being underestimated. The cause was determined to be an inadequate number of short trips being assigned between the Oakland Mills area to the east of US 29 and the Columbia Town Center. Additional traffic volumes were assigned to these roadways, and the functional classification of US 1 was adjusted from primary arterial to minor arterial to reflect the speeds and land use in the Laurel and Elkridge areas. These adjustments resulted in acceptable volume-to-count ratios on all access routes with the exception of MD 32 in the Fort Meade area. To further improve the validation for these links would require modifying the Fort Meade/NSA zone structure to replicate that used in the Anne Arundel County model (referred to as the SAM2 model). While this is outside of the current scope of the Howard County model development, the county may explore this option to improve the model performance in the future. Existing and forecasted 2035 AADT are presented in Section VI.

V. BRT Network

The 2012 report, *Howard County BRT - Concept Plans and Preliminary Cost for the Envisioned System,* prepared by The Traffic Group, details the preliminary design and develops cost estimates for the proposed BRT system. Based on existing conditions and available right-of-way, the report documents potential improvements recommended along each corridor to maximize travel speed and efficiency. Designs were constrained so that construction could be completed quickly, have minimal environmental impact, require limited utility relocations, and avoid construction of new bridges. The report documents assumptions, lists constraints, and lists preliminary alignments along each of the corridors. Typical sections were developed to illustrate the configuration of the guideways along the different segments of each of the four routes. The report also follows the BRT routes and identifies where improvements should be considered, including the installation of new traffic signals, implementation of transit signal priority, and the location of BRT stations. Preliminary cost estimates forecast that the entire proposed BRT system will cost around $160 Million with the MD 216 route being the least expensive at $11 Million and the MD 32 route being the most expensive at almost $70 Million.

A. Planned Transit Projects

Several transit projects of regional importance are currently being planned in neighboring jurisdictions that could affect the proposed Howard County BRT system. Coordination with adjacent transit projects should be pursued in order to maximize the potential for system connectivity and intermodal connections. The projects listed below are currently being planned in the region.

1. Montgomery County BRT

Montgomery County is studying the feasibility of a BRT network across the county. The *Countywide Bus Rapid Transit Study* prepared by Parsons Brinckerhoff in 2011 documents efforts to identify potential corridors, define design options for each corridor, determine travel demand for selected BRT routes, and determine the capital and operating costs for the system. The analysis determined 16 routes to be viable for a system extending 150 miles – concentrated mostly along the eastern half of the County. The study corridors include:

- MD 586/Viers Mill Road
- Georgia Avenue (South)
- MD 124/Muddy Branch Road
- MD 355 North
- MD 650/New Hampshire Avenue
- Randolph Road
- US 29/Columbia Pike/Colesville Road
- North Bethesda Transitway
- Georgia Avenue (North)
- W. Montgomery Avenue
- MD 185/Connecticut Avenue
- MD 355 South
- Montgomery Mall/Old Georgetown Road
- MD 193/University Boulevard
- ICC
- Mid-County Highway

The system is expected to attract up to 207,000 daily boardings with the routes along MD 355 and US 29 forecasted to experience the highest ridership.

2. Anne Arundel County

The Anne Arundel County *Corridor Growth Management Plan* prepared in 2012 by Sabra, Wang & Associates, lists several transit improvements to be implemented along major roadways across the county. Recommendations include the implementation of high quality bus transit to supplement existing services along US 50, MD 2, I-97, MD 100, and MD 3. New local bus service is recommended along MD 295 or parallel corridors. Additionally enhancements along existing bus routes are recommended for Magothy Bridge Road and MD 173. Lastly, subscription transit services are recommended along MD 32 and MD 170 with the possibility of establishing fixed route express bus service in the future.

3. Prince George's County

Prince George's County is in the early stages of planning for the development of a BRT network in the county.

4. Yellow Line Extension

The extension of the Baltimore light rail system into Howard County would have a great impact on transportation in the county. The service is operated by the Maryland Transit Administration and a planned project intends to extend service beyond its current southern terminus at BWI Airport into Howard County to MD 32 in Columbia. The proposed Yellow Line extension has the potential to directly connect with all of the proposed Howard County BRT routes. Although the project has been discussed as a priority for the region and is included in the Baltimore region's Constrained Long Range Plan, it is still in the early planning stages of development.

B. BRT Concept

The study focused on implementing a BRT system that would emulate light rail operations in terms of the features provided with limited stops, high level platform access, and visible stations with amenities such as real time traveler information and kiosk vending. This BRT system would rely primarily on park-and-ride access with some walk access, and local bus transfers.

The BRT system 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, right-of-way and priority at intersections, and traffic signals to speed up bus transit service. BRT service differs from commuter bus service, which focuses on peak, the weekday with a limited schedule, intermediate stops, and dependence on commuter park and ride access. For this study, the BRT system was assumed to have the following characteristics:

- All-day service
- Higher frequencies
- Stops at 1/2- to one-mile spacing
- Provision for exclusive right of way
- Transit signal priority
- Enhanced stations with greater passenger amenities
- Real-time passenger information
- Potential for off-board fare collection
- Efficient boarding and alighting

Stylish Vehicles

Many BRT vehicles have sleek, modern designs that emulate light rail features. They can be standard, articulated 60-foot buses (as assumed for this study) and 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.

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's Health Line BRT

Faster Fare Collection

Off-board fare collection options can help reduce BRT dwell time at stations and increase speed of service. 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.

Pittsburgh's West BRT

Guideways and Rights-of-Way

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.

Intelligent Transportation Systems (ITS)

Using ITS technology can help increase quality of service, improve operations, and provide passengers with timely and reliable information about BRT service. 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.

Operations

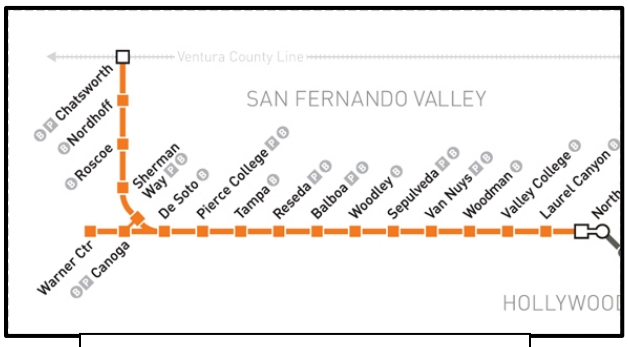
BRT service should provide reliable, frequent service with fewer stops compared to local bus service. Headways should be under 10 minutes during peak hours, and distances between stations are typically at least half a mile. It should also provide connectivity to other transportation modes such as local 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.

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. Automobile use and parking needs can decrease where there are clusters of such development. BRT corridors require a minimal level of concentrated development.

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:



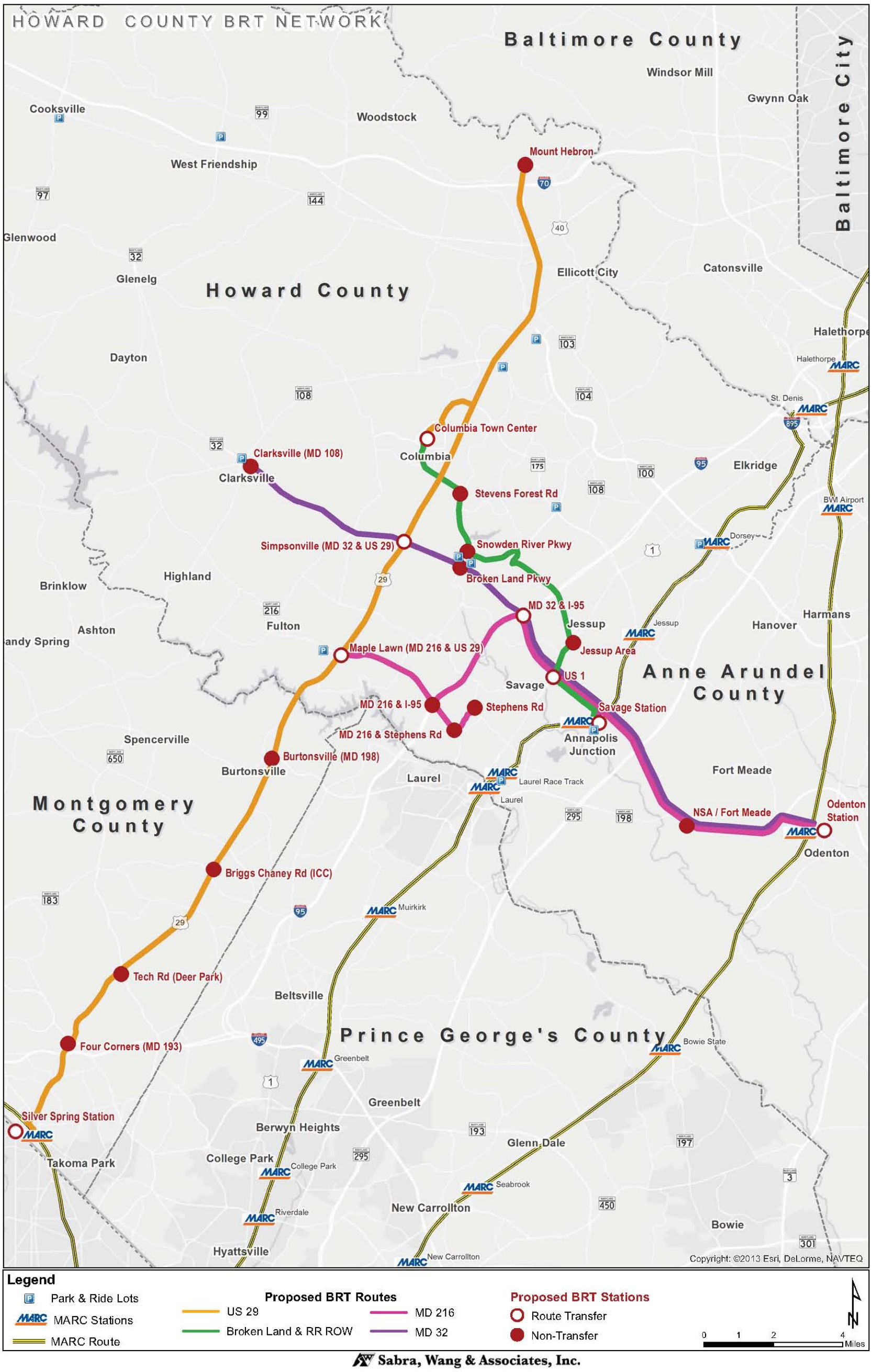
Los Angeles Orange Line BRT

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

C. Proposed BRT Network and Treatments

The proposed Howard County BRT network is composed of four separate routes, the US 29 route, the MD 32 route, the MD 216 route, and Broken Land Parkway route. The routes were modeled as dedicated right of way alignments on existing highways and streets. The service was assumed to be similar to the proposed Baltimore Red Line and existing Central Light Rail Line with hours of operation between 5:00 AM and 12:00 AM, eight minute peak hour headways and twenty minute off peak headways. Buses are assumed to travel at an average speed of 40 miles per hour whether along dedicated guideways or in mixed traffic. **Figure 3** illustrates the BRT network evaluated.

Figure 3. Howard County BRT Network



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1. US 29 BRT Route

This route would serve a critical commuting corridor to Columbia Town Center and Silver Spring and provide connections to WMATA Metrorail and continuing service to Washington D.C. and Northern Virginia. The route would start in Mount Hebron near the interchange of US 29 and I-70 and continue south on US 29 to the Silver Spring Metro station. The route characteristics are summarized in **Table 3** and **Figure 4**.

Table 3. Summary of US 29 BRT Route.

US 29 BRT Route	
Potential Stations	❖ Mount Hebron ❖ Columbia Town Center ❖ MD 32 (MD 32 Route transfer) ❖ MD 216 ❖ MD 198 ❖ Fairland (ICC) ❖ Deer Park (New Hampshire Ave) ❖ Four Corners (MD 193) ❖ Silver Spring Metro
Potential Termini	❖ Mount Hebron ❖ Silver Spring Metro
Modal Connections	❖ Howard Transit/CMRT ❖ MTA Bus ❖ ICC ❖ MARC ❖ RideOn ❖ Metrorail ❖ Metrobus

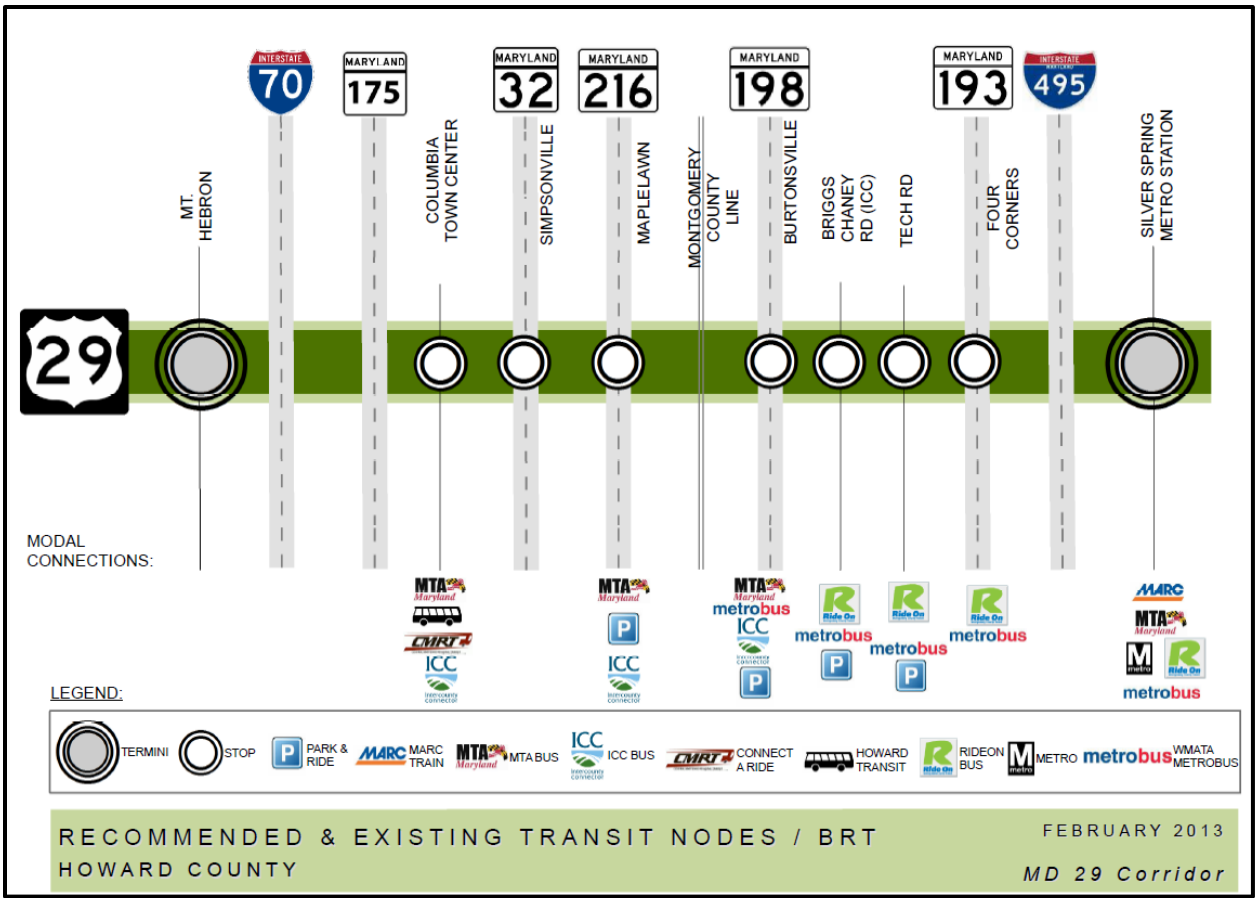


Figure 4. US 29 BRT Stations and Connections to Existing Transit.

2. Broken Land Parkway BRT Route

This route would begin at Columbia Town Center and provide service along Broken Land Parkway, Snowden River Parkway, an existing rail spur, US 1, MD 32, and Dorsey Run Road prior to terminating at the Savage MARC station. The route characteristics are summarized in **Table 4** and **Figure 5**.

Table 4. Summary of Broken Land Parkway BRT Route.

Broken Land Parkway BRT Route	
Potential Stations	❖ Columbia Town Center (US 29 route transfer) ❖ Stevens Forest Road ❖ Snowden River Parkway ❖ Jessup ❖ US 1/MD 32 (MD 32 Route transfer) ❖ Savage Station
Potential Termini	❖ Columbia Town Center ❖ Savage Station
Modal Connections	❖ Howard Transit/CMRT ❖ MTA Bus ❖ ICC ❖ MARC

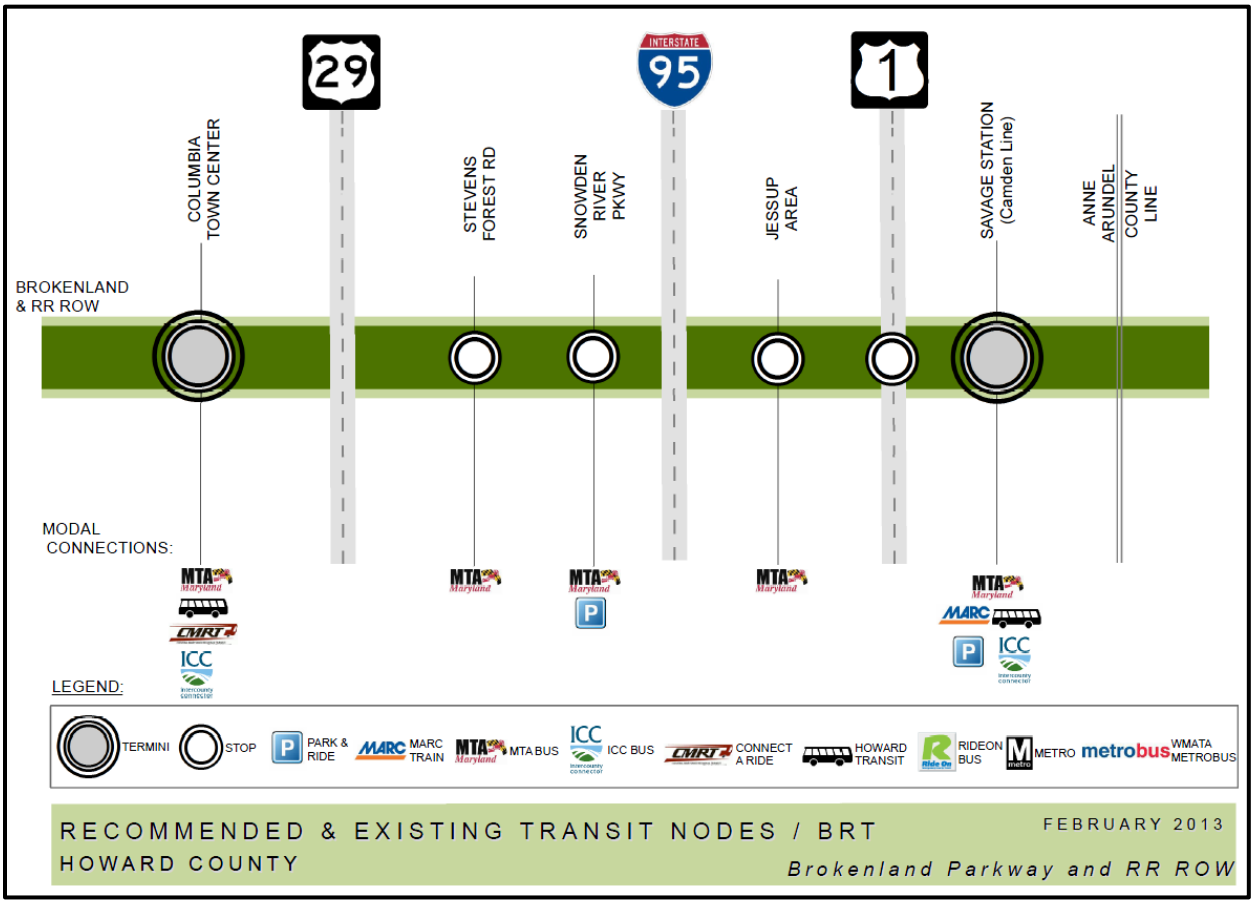


Figure 5. Broken Land Parkway BRT Route Stations and Connections to Existing Transit.

3. MD 32 BRT Route

This route would service another important commuting pattern in the county, between the Clarksville area and Fort Meade/NSA, a major employer in the region. It was assumed that the BRT would run on dedicated right of way, either in the median or on the shoulders of MD 32. The route characteristics are summarized in **Table 5** and **Figure 6**.

Table 5. Summary of MD 32 BRT Route.

MD 32 BRT Route	
Potential Stations	❖ Clarksville (MD 108) ❖ US 29 (US 29 Route transfer) ❖ Broken Land Parkway ❖ I-95 ❖ US 1 ❖ Savage MARC Station ❖ Fort Meade/NSA ❖ Odenton Town Center
Potential Termini	❖ Clarksville ❖ Odenton Town Center
Modal Connections	❖ Howard Transit/CMRT ❖ MTA Bus ❖ ICC ❖ MARC

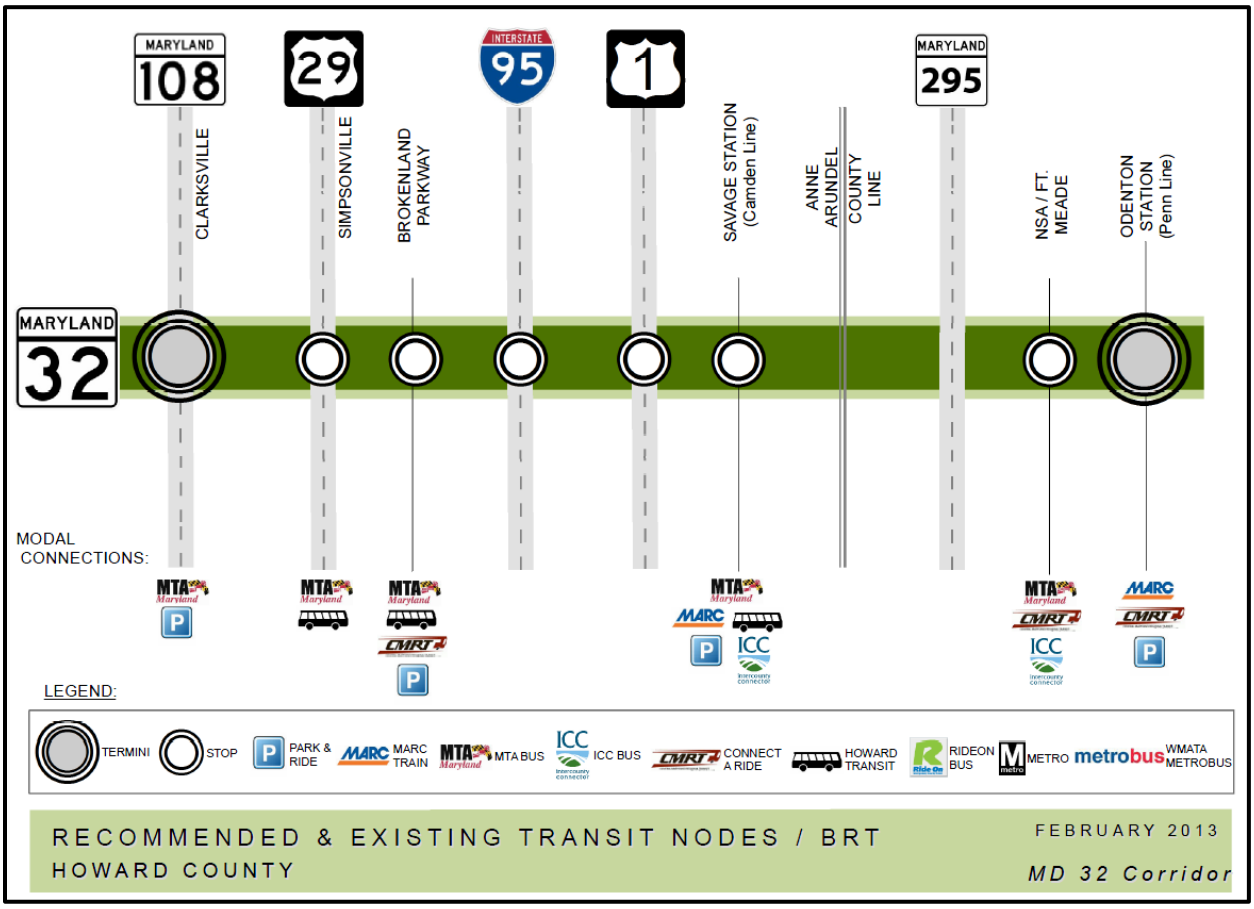


Figure 6. MD 32 BRT Route Stations and Connections to Existing Transit.

4. MD 216 BRT Route

This route would provide service between Scaggsville and Odenton Town Center via MD 216, I-95, and MD 32. Transit vehicles would run in the median or in mixed traffic and would follow the MD 32 BRT route east of US 1. The route characteristics are summarized in **Table 6** and **Figure 7**.

Table 6. Summary of MD 216 BRT Route.

MD 216 BRT Route	
Potential Stations	❖ US 29 (US 29 Route transfer) ❖ I-95 ❖ MD 216/Stephens Road ❖ Stephens Road ❖ MD 32 (MD 32 Route transfer) ❖ US 1 ❖ Savage MARC Station ❖ Fort Meade/NSA ❖ Odenton Town Center
Potential Termini	❖ US 29 ❖ Odenton Town Center
Modal Connections	❖ Howard Transit/CMRT ❖ MTA Bus ❖ ICC ❖ MARC

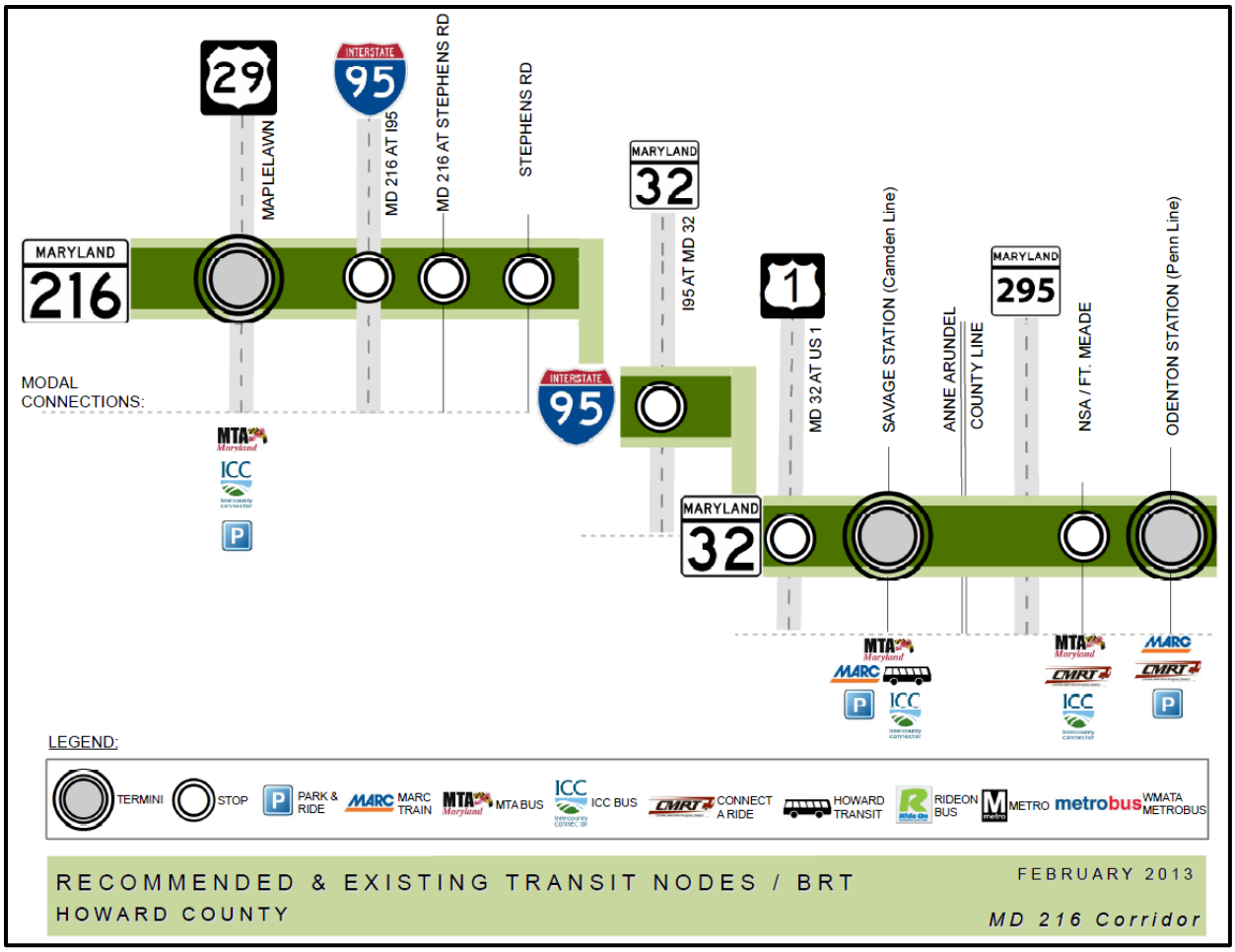


Figure 7. MD 216 BRT Route Stations and Connections to Existing Transit.

VI. Travel Forecasts

The regional travel demand model was used to develop 2035 forecasts for vehicular volumes, travel times, and transit boardings and ridership along the study corridors. The model was first validated for a base year of 2008. Once the parameters and outputs were acceptable, the model was run for the year 2035 which included the Baltimore Regional Transportation Board's *PlanIt 2035* Long Range Plan Highway and Transit Network. This model was then tested during year 2035 conditions under an assumption that the 4-corridor BRT system was fully built (e.g Build BRT) and not built (e.g. No Build BRT). The measures of effectiveness tested under these four scenarios were AADT on the study corridors, travel time along the BRT route for autos and buses, station/ transfer point boardings, transit ridership, and person throughput. Throughput is a measure of all people traveling through a corridor across all modes. An average auto occupancy of 1.46 persons per vehicle was assumed based on the BMC's *2001 Household Travel Survey: Baltimore Region Analysis* published in 2005. The study applied the transit forecasting model developed by the Maryland Transit Administration and accepted by the Federal Transit Administration for use on the Red Line project in Baltimore City.

Based on the study's proposed implementation of BRT treatments—including dedicated guideways and improved stations—a system of BRT routes in Howard County would have total projected daily boardings of 26,293. These boardings include both trips **originating** from a home or other place in the County as well as trips returning to a home or other place from **destinations** within the County. If those portions of the BRT system in Anne Arundel County and Montgomery County are considered then additional boardings of 841 and 32,782 would be included.

The 4-line BRT system would result in 4,684 unique, new ***linked*** transit trips[1] produced within Howard County and 3,584 unique, new ***linked*** transit trips attracted to Howard County, for a total of 8,268 new linked trips that are attributable directly to a new BRT system. This increases the overall transit share of trips produced in Howard County from 2.3% to 3.0% in year 2035, and specifically for home-based-work trips produced in the County increases the transit share from 4.7% to 6.3%. However, 76.5% of the increase in new linked trips arises from the US 29 and Broken Land Parkway BRT corridors in Howard County.

The projected total system daily boardings number is driven primarily by the 14,908 Howard County projected boardings and a 7,338 daily passenger load on the maximum US 29 load link. The Montgomery County portion of the US 29 BRT is forecasted to attain 32,782 daily boardings and a 10,980 daily passenger load on the maximum load link, and has a number of characteristics that are favorable for transit ridership including moderate to high residential density along the corridor, significant peak hour delays for vehicle traffic, access to major employment centers, including direct access to Silver Spring, and high cost of parking in the destination employment center. By connecting to the WMATA Metrorail, commuters would have access to downtown Washington, DC and Northern Virginia significantly improving mobility between Howard County and Washington, DC.

The Howard County portion of the US 29 BRT will not increase net person-throughput. However, the benefits of the BRT service to the traveler are evident on US 29 south of MD 198 where shorter BRT travel times make transit an attractive alternative. The benefits for the transportation system as a whole are illustrated by the increased person throughput along this roadway. The projected boardings on the US 29 route (total of both Counties) compares very favorably to successful BRT systems such as the Los Angeles Orange Line – which had daily boardings in 2010 of 21,902 – and the Pittsburgh East Busway, with 25,600 daily boardings as of 2011. The route even compares favorably to successful LRT lines such as the Dallas Red and Blue Lines which had over 60,000 daily boardings in 2011.

The Broken Land Parkway route should also be advanced for further study and analysis, as it has over 5,000 projected daily boardings and over 1,300 daily passenger load on the maximum load link, which is somewhat low, but with potential changes in land use under consideration along the Snowden River/ Gateway and US 1 areas, this ridership could increase to levels that are consistent with other existing BRT systems such as the Boston Silver line which had a Saturday daily station boardings of 9,285 in 2011. The daily boardings on the MD 32 and MD 216 routes are less than 7,000 combined, and less than 1,000 daily passenger loads on the maximum load link per route which indicate that these lines would not

1 – new linked transit trips are defined as new fare-paying riders

generate the passenger traffic to justify the investment in infrastructure, maintenance, and operations. **Figures 8-11** illustrate the station boardings for each line in the proposed BRT network. **Tables 7a-10a** summarize the AADT and travel times along the proposed BRT routes under existing conditions, no build conditions in 2035, and 2035 conditions with BRT service. The person throughput calculation adds the people traveling on each segment regardless of mode as a representation of overall capacity – this value is highlighted **boldface** in instances where BRT implementation allows for an increase in total person throughput. **Tables 7b-10b** summarize the station boardings and link loads.

Travel time savings are also significant along the Broken Land Parkway BRT route due to the routing along the railroad right-of-way, resulting in a more direct path between some of the stations. Conversely, service on the MD 32 and MD 216 BRT routes would not provide travel time advantages over driving.

The AM peak period level of service was examined for all segments along the four routes within Howard County. The purpose of this exercise was to determine if any segments that projected a failing level of service (E or F) under the 2035 No Build would improve to a non-failing level of service under the 2035 BRT scenario. The level of service is derived based on the facility type and peak period volume-to-capacity ratios, whereas a v/c ratio of 1.0 or greater equates to a LOS F for all freeway and multi-lane arterials, and a v/c ratio of 0.79 and higher equates to a LOS E for all freeway and multi-lane arterials. Of approximately 40 directional segments analyzed, only 1 segment had an LOS improvement due to the BRT implementation. All others remained a LOS E or F. Detailed LOS summary tables and plots are included in **Appendix C.**

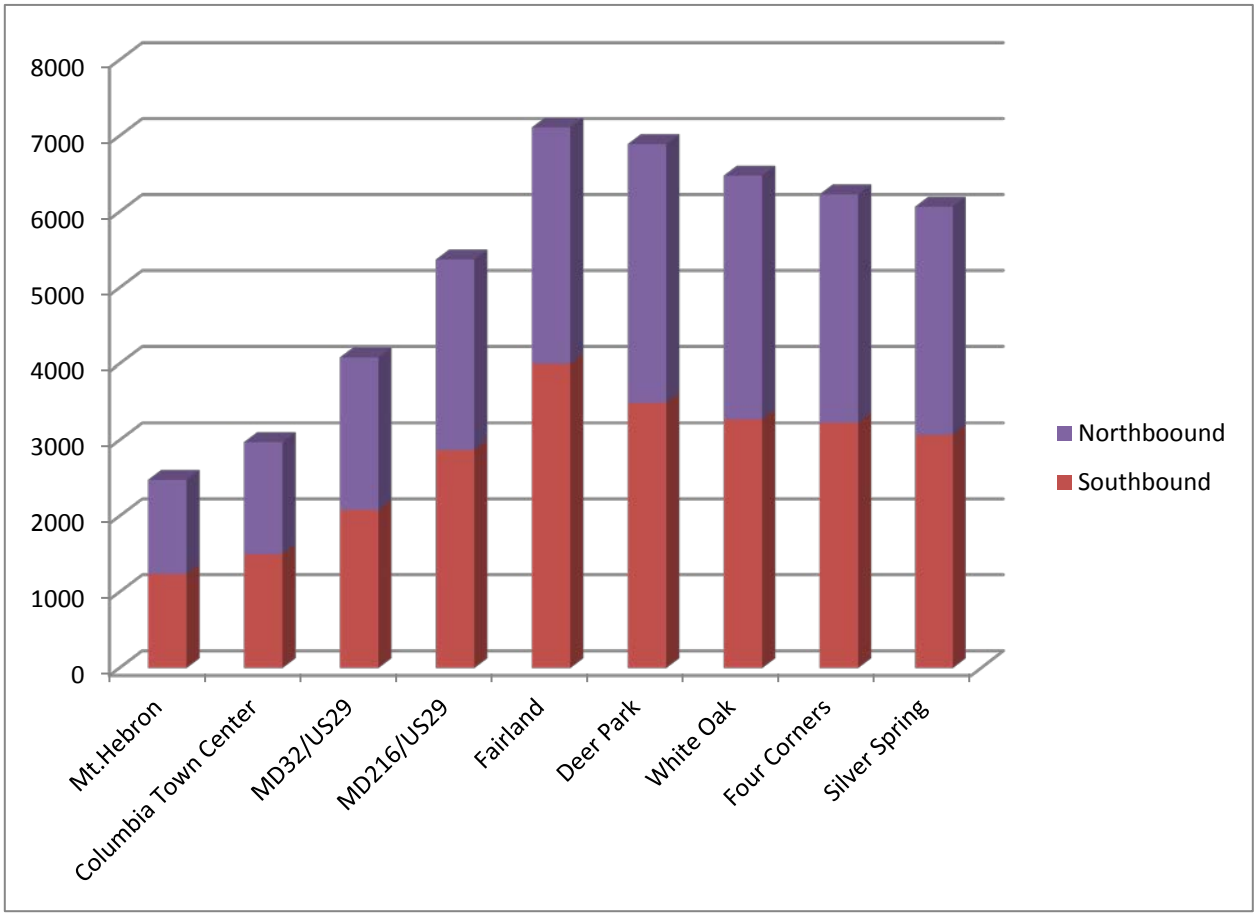


Figure 8. US 29 BRT Route Average Station Daily Boarding Forecasts.

	Existing				2035 No Build					2035 BRT								BRT Time	
	NB		SB		NB		SB			NB			SB						
Segment	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	Person Throughput Both Directions	AADT	AADT Change from No Build	Travel Time (minutes)	AADT	AADT Change from No Build	Travel Time (minutes)	Person Throughput Both Directions	Change in Person Throughput from 2035 No Build	NB	SB
Mt Hebron to MD 100	72285	4.34	71368	4.31	104903	4.07	100309	4.19	299610	99545	-5.10%	4.31	94270	-6.00%	4.43	285805	-13805	5.24	5.24
MD 100 to Col. Town Center Ramp	50914	4.13	53102	4.18	73150	3.9	72976	3.92	213344	70659	-3.40%	4.06	72081	-1.20%	4.04	211958	-1386	5.37	5.37
Col. Town Center Ramp to MD 32	41404	2	46278	1.94	77362	2.45	67603	2.38	211649	63273	-18.20%	2.31	66574	-1.50%	2.26	194758	-16891	4.02	4.02
MD 32 to MD 216	37076	3.77	44533	3.81	65046	3.4	68214	3.83	194560	63962	-1.70%	3.4	69143	1.40%	3.83	***200828***	6268	4.36	4.36
Subtotal Howard County		**14.24**		**14.24**		**13.82**		**14.32**	**919163**		**-7.10%**	**14.08**		**-1.83%**	**14.56**	**893349**	**-25814**	**18.99**	**18.99**
MD 216 to MD 198	32757	3.98	29591	4	55404	3.98	50437	4	154528	52503	-5.20%	3.98	48884	-3.10%	4	154520	-8	4.31	4.31
MD 198 to MD 200	30523	5.84	29266	5.84	59992	5.41	56289	5.41	169770	57384	-4.30%	5.41	54914	-2.40%	5.41	***170450***	680	4.57	4.57
MD 200 To MD 650	28495	5.08	27501	5.08	54472	4.97	53475	4.97	157603	52235	-4.10%	4.97	52437	-1.90%	4.97	***168220***	10617	3.02	3.02
MD 650 to MD 193	29043	4.59	27281	4.59	52680	4.5	50949	4.5	151298	51902	-1.50%	4.5	50066	-1.70%	4.53	***155807***	4509	4.18	4.18
MD 193 to MD 97	29698	5.04	27697	5.04	40986	6.08	39560	6.08	117597	39574	-3.40%	5.47	39099	-1.20%	5.47	***121532***	3935	3.09	3.09
Subtotal Montgomery County		**24.53**		**24.55**		**24.94**		**24.96**	750796		-3.70%	**24.33**		-2.06%	**24.38**	***770529***	***19733***	**19.17**	**19.17**
Totals		**38.77**		**38.79**		**38.76**		**39.28**	**1669959**			**38.41**			**38.94**	**1663878**	**-6081**	**38.16**	**38.16**

Table 7a. US 29 Existing and Forecasted AADT and Travel Times.

US 29 BRT Daily Boardings and Link Volumes							
	SB	NB			SB	NB	
Station	Boardings		Total NB & SB	Percent of Total Boardings	Link Load		Total NB & SB
Mt.Hebron	1239	1239	2478	5%	1239	0	1239
Columbia Town Center	1500	1475	2975	6%	2139	1239	3378
MD32/US29	2083	2000	4083	9%	2622	1788	4410
MD216/US29	2872	2500	5372	11%	3950	3388	7338
subtotal Howard County	**7694**	**7214**	**14908**	**31%**			
Fairland	4000	3112	7112	15%	5950	3488	9438
Deer Park	3493	3400	6893	14%	6057	4600	10657
White Oak	3277	3200	6477	14%	4780	6200	10980
Four Corners	3231	3000	6231	13%	3070	5000	8070
Silver Spring	3069	3000	6069	13%	0	3000	3000
subtotal Montgomery County	**17070**	**15712**	**32782**	**69%**			
Total	**24764**	**22926**	**47690**	**100%**			

Table 7b. US 29 Forecasted Station Boardings and Link Volumes.

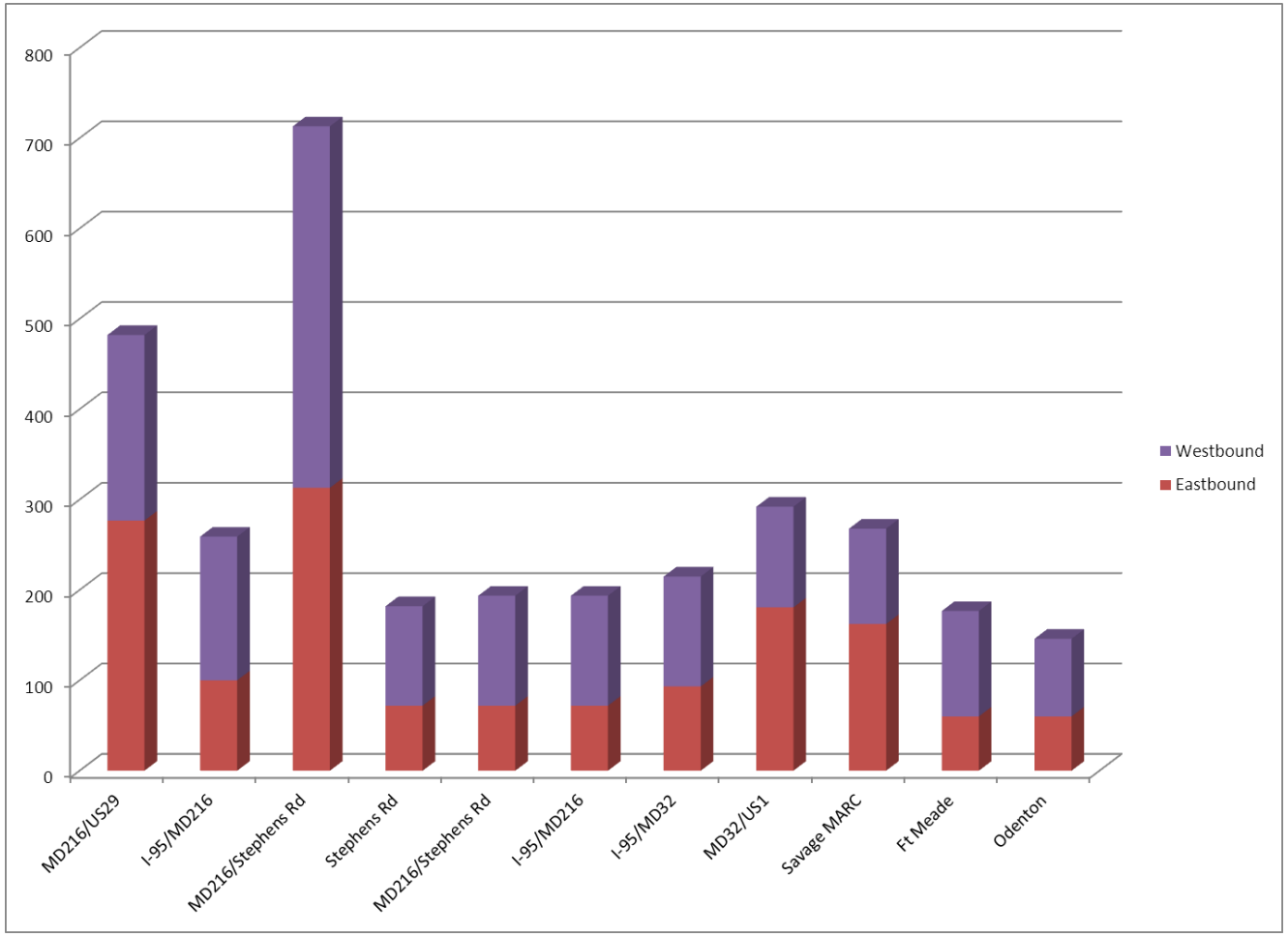


Figure 9. MD 216 BRT Route Average Station Daily Boarding Forecasts.

	Existing				2035 No Build					2035 BRT								BRT Time	
	WB		EB		WB		EB			WB			EB						
Segment	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	Person Throughput Both Directions	AADT	AADT Change from No Build	Travel Time (minutes)	AADT	AADT Change from No Build	Travel Time (minutes)	Person Throughput Both Directions	Change in Person Throughput from 2035 No Build	WB	EB
US 29 to Stephens Rd	12272	7.05	13243	6.91	19059	8.05	23154	8.13	61631	17423	-8.60%	8.03	19976	-13.70%	8.15	56432	-5199	3.84	3.84
I-95/MD 216 to I-95/MD 32	94699	3.29	99013	3.51	117034	3.32	118122	3.5	343328	115538	-1.30%	3.29	117830	-0.20%	3.53	341126	-2202	7.19	7.19
I-95/MD 32 to US 1	28261	1.78	26649	1.76	50453	1.78	50309	1.76	147113	51054	1.20%	1.78	49404	-1.80%	1.76	146961	-152	2.4	2.4
US 1 to I-295	33470	2.18	28736	2.29	54045	2.23	46685	2.29	147066	53080	-1.80%	2.23	45334	-2.90%	2.29	143952	-3114	2.79	2.79
Subtotal Howard County		**14.3**		**14.47**		**15.38**		**15.68**	**699138**			**15.33**			**15.73**	**688471**	**-10667**	**16.22**	**16.22**
I-295 to Odenton Station	33908	6.04	29682	6.04	52445	6.14	41775	6.14	137561	51033	-2.70%	6.14	40632	-2.70%	6.14	134154	-3407	8.45	8.45
Subtotal Anne Arundel County		**6.04**		**6.04**		**6.14**		**6.14**	**137561**			**6.14**			**6.14**	**134154**	**-3407**	**8.45**	**8.45**
Totals		**20.34**		**20.51**		**21.52**		**21.82**	**836699**			**21.47**			**21.87**	**822625**	**-14074**	**24.67**	**24.67**

Table 8a. MD 216 Existing and Forecasted AADT and Travel Times.

MD 216 BRT Daily Boardings and Link Volumes							
	EB	WB			EB	WB	
Station	Boardings		Total WB & EB	Percent of Total Boardings	Link Load		Total EB & WB
MD216/US29	277	205	482	15%	277	0	277
I-95/MD216	100	159	259	8%	317	205	522
MD216/Stephens Rd	313	400	713	23%	430	232	662
Stephens Rd	72	110	182	6%	362	172	534
MD216/Stephens Rd	72	122	194	6%	330	162	492
I-95/MD216	72	122	194	6%	378	122	500
I-95/MD32	93	122	215	7%	311	162	473
MD32/US1	181	111	292	9%	172	164	336
Savage MARC	162	106	268	9%	124	175	299
Subtotal Howard Co.	**1342**	**1457**	**2799**	**90%**			
Ft Meade	60	117	177	6%	61	189	250
Odenton	60	86	146	5%	0	86	86
Subtotal AA County	**120**	**203**	**323**	**10%**			
Total	**1462**	**1660**	**3122**	**100%**			

Table 8b. MD 216 Forecasted Station Boardings and Link Volumes

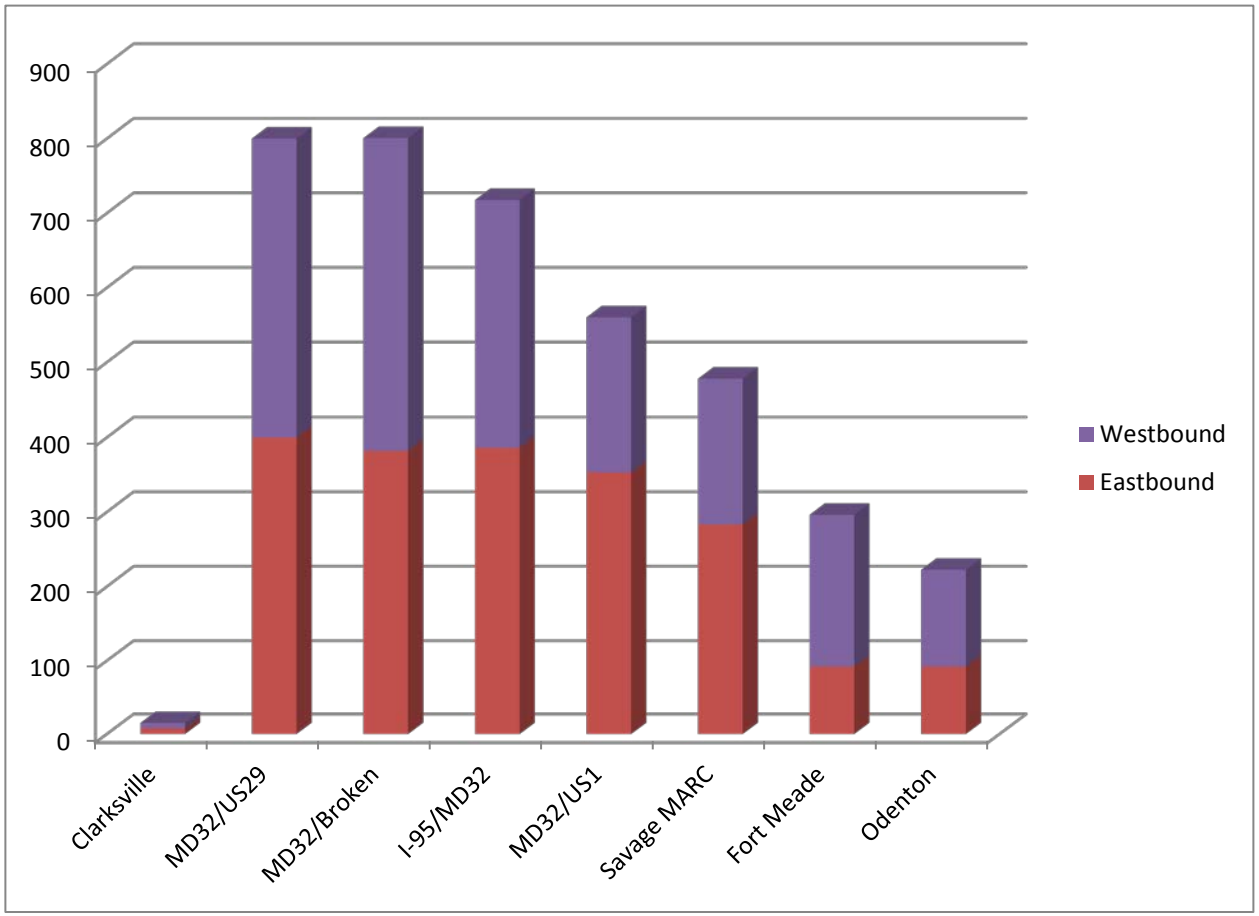


Figure 10. MD 32 BRT Route Average Station Daily Boarding Forecasts

	Existing				2035 No Build					2035 BRT								BRT Time	
	WB		EB		WB		EB			WB			EB						
Segment	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	Person Throughput Both Directions	AADT	AADT Change from No Build	Travel Time (minutes)	AADT	AADT Change from No Build	Travel Time (minutes)	Person Throughput Both Directions	Change in Person Throughput from 2035 No Build	WB	EB
MD 108 to US 29	32176	3.99	29426	3.95	44216	4.05	41227	3.95	124747	44625	0.90%	4.05	42910	4.10%	3.95	***128616***	3869	6.31	6.31
US 29 to I-95	41996	4.02	42239	3.87	59057	4.03	59288	3.91	172784	59203	0.20%	4.03	62874	6.00%	3.91	***179751***	6967	4.66	4.66
I-95 to US 1	28261	1.78	26649	1.76	50453	1.78	50309	1.76	147113	51054	1.20%	1.78	49404	-1.80%	1.76	***147229***	116	2.4	2.4
US 1 to I-295	33470	2.18	28736	2.29	54045	2.23	46685	2.29	147066	53080	-1.80%	2.23	45334	-2.90%	2.29	144162	-2904	2.79	2.79
Subtotal Howard County		**11.97**		**11.87**		**12.09**		**11.91**	**591710**			**12.09**			**11.91**	**599758**	**8048**	**16.16**	**16.16**
I-295 to Odenton Station	33908	6.04	29682	6.04	52445	6.14	41775	6.14	137561	51033	-2.70%	6.14	40632	-2.70%	6.14	134349	-3212	8.45	8.45
Subtotal Anne Arundel County		**6.04**		**6.04**		**6.14**		**6.14**	**137561**			**6.14**			**6.14**	**134349**	**-3212**	**8.45**	**8.45**
Totals		**18.01**		**17.91**		**18.23**		**18.05**	**729271**			**18.23**			**18.05**	**734107**	**4836**	**24.61**	**24.61**

Table 9a. MD 32 Existing and Forecasted AADT and Travel Times.

MD 32 BRT Daily Boardings and Link Volumes							
	EB	WB			EB	WB	
Station	Boardings		Total EB & WB	Percent of Total Boardings	Link Load		Total EB & WB
Clarksville	8	7	15	0%	8	0	8
MD32/US29	400	400	800	21%	396	7	403
MD32/Broken	382	419	801	21%	378	387	765
I-95/MD32	386	332	718	18%	364	560	924
MD32/US1	353	207	560	14%	317	548	865
Savage MARC	283	195	478	12%	184	481	665
subtotal Howard County	**1812**	**1560**	**3372**	**87%**			
Fort Meade	92	204	296	8%	92	326	418
Odenton	92	130	222	6%	0	130	130
subtotal AA County	**184**	**334**	**518**	**13%**			
Total	**1996**	**1894**	**3890**	**100%**			

Table 9b. MD 32 Forecasted Station Boardings and Link Volumes.

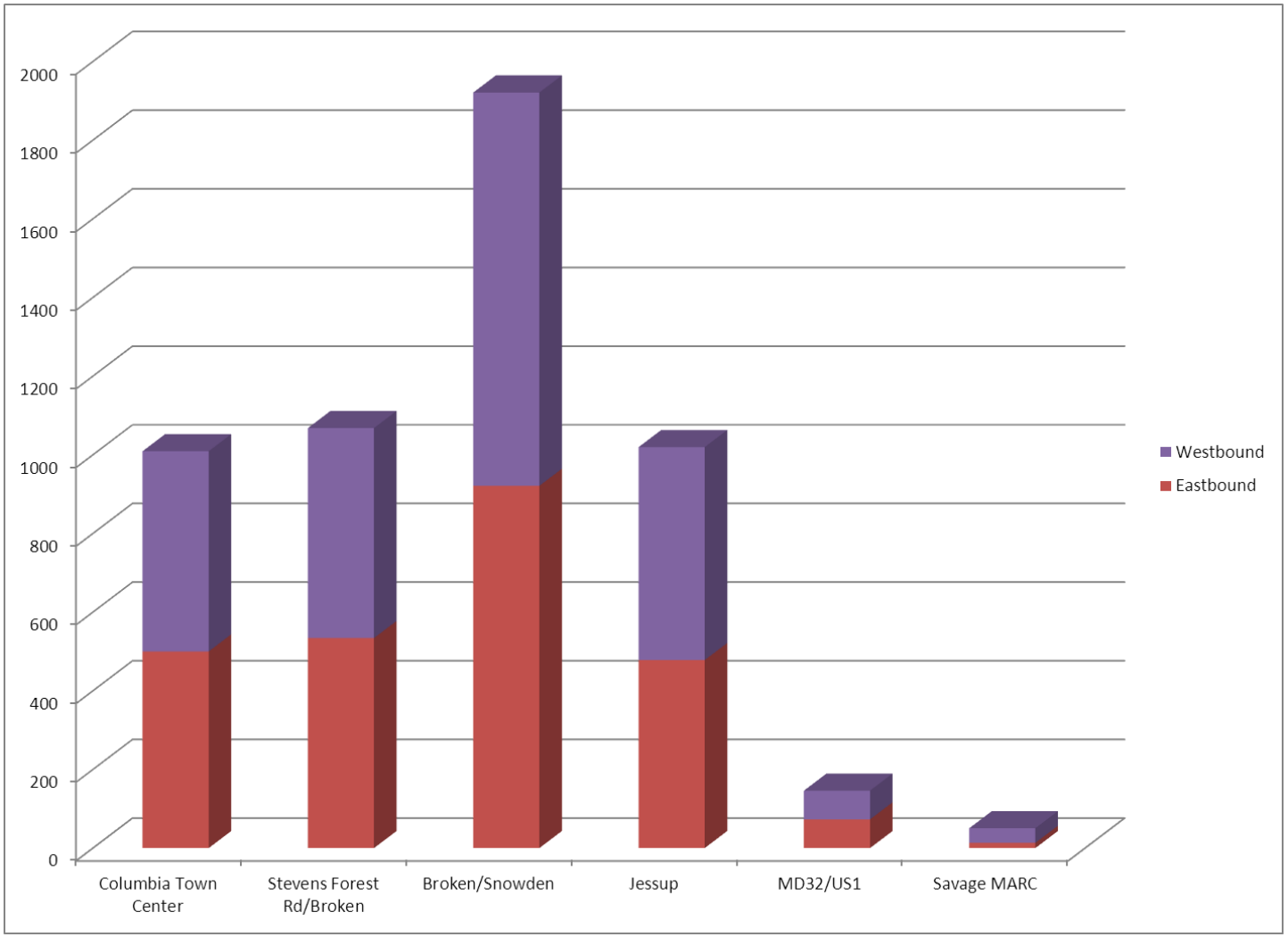


Figure 11. Broken Land Parkway BRT Route Average Station Daily Boarding Forecasts.

	Existing				2035 No Build					2035 BRT								BRT Time	
	WB		EB		WB		EB			WB			EB						
Segment	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time (minutes)	AADT	Travel Time	Person Throughput Both Directions	AADT	AADT Change from No Build	Travel Time (minutes)	AADT	AADT Change from No Build	Travel Time (minutes)	Person Throughput Both Directions	Change in Person Throughput from 2035 No Build	WB	EB
Columbia Town Center to US 29	11416	2.87	9173	3.12	24790	4.29	28020	3.88	77103	26442	6.70%	4.48	31401	12.10%	4.5	***85460***	8357	1.42	1.42
US 29 to I-95	18633	4.51	19247	4.69	23044	5.26	23489	5.42	67938	23477	1.90%	4.93	23113	-1.60%	4.74	***71010***	3072	1.65	1.65
US 1/Patuxent Range Road	25568	3.56	25372	3.45	44313	2.4	44692	2.51	129947	43964	-0.80%	2.36	43247	-3.20%	2.51	128348	-1599	1.84	1.84
US 1/MD32 to Annapolis Junction	22869	0.28	28736	0.5	39622	0.3	46269	0.5	125401	39979	0.90%	0.3	44908	-2.90%	0.5	124132	-1269	0.14	0.14
Subtotal Howard County		**11.22**		**11.76**		**12.25**		**12.31**	**400389**		**2.18%**	**12.07**		**1.10%**	**12.25**	**408950**	**8561**	**5.05**	**5.05**
Totals		**11.22**		**11.76**		**12.25**		**12.31**	**400389**			**12.07**			**12.25**	**408950**	**8561**	**5.05**	**5.05**

Table 10a. Broken Land Parkway Existing and Forecasted AADT and Travel Times.

Broken Land Parkway BRT Daily Boardings and Link Volumes							
	EB	WB			EB	WB	
Station	Boardings		Total WB & EB	Percent of Total Boardings	Link Load		Total EB & WB
Columbia Town Center	500	509	1009	19%	500	0	500
Stevens Forest Rd/Broken	534	534	1068	20%	566	511	1077
Broken/Snowden	921	1000	1921	37%	487	872	1359
Jessup	478	542	1020	20%	99	172	271
MD32/US1	73	73	146	3%	13	114	127
Savage MARC	13	37	50	1%	0	37	37
subtotal Howard County	**2519**	**2695**	**5214**	**100%**			
Total	**2519**	**2695**	**5214**	**100%**			

Table 10b. Broken Land Parkway Forecasted Station Boardings and Link Volumes

The Institute for Transportation and Development Policy (ITDP) has developed a rating system for BRT projects based on international best practices. Their scoring plan allocates points based on the BRT system's characteristics, awarding bronze, silver, and gold certifications. Through their research, they have developed standards and guidelines that adapt BRT treatments to address bus delays in different contexts. They stress the importance of implementing only the necessary BRT treatments needed to minimize specific delays along existing bus routes instead of building to a gold standard that may represent an excessive investment and result in an underused system. Some examples of BRT treatments that may not be necessary in all instances include:

- Dedicated lanes – Can be helpful in areas where congestion has a negative impact on travel times, but does not offer time savings where traffic travels at or near free flow speeds.
- Median running buses – Useful in urban areas where the curb lane experiences delay due to frequent vehicle stops and pedestrians impeding right turns, though they may not be necessary where pedestrians are not as numerous.
- Off-board fare collection – Typically most important where a large number of boardings and alightings slows down operations.

The ITDP reviewed the Montgomery County BRT plans and concluded that only select treatments should be pursued for most routes and a gold standard BRT system would be justified only along Rockville Pike as development brings about changes in land use. Ridership forecasts for Montgomery County's BRT system range from 200 to 800 passengers per hour per direction whereas successful international BRT systems average between 1,700 and 45,000 passengers per hour per direction. It should be noted that only five BRT projects in the United States have attained ITDP's bronze standard and none have reached silver or gold. The US 29 route is forecasted to carry 55,000 passengers a day; assuming a K-factor of 0.10 and a peak hour directional distribution, this could translate to almost 3,850 passengers per hour per direction – performing near the lower end of the international standard.

VII. Conclusion

The ridership forecast model suggests that two BRT routes, US 29 and Broken Land Parkway, are viable and should be targeted for further study and implementation. The characteristics along US 29 and on Broken Land Parkway would likely support a BRT system that would offer competitive travel options and attract significant ridership. The other corridors could benefit from some transit improvements even though they may not warrant the full investment to achieve the BRT standard.

US 29

The study results indicate that ***US 29 should be the priority corridor for Howard County***. The implementation of BRT along US 29 would result in:

- An average AADT reduction of 4.5% in Howard County and 3% in Montgomery County when compared to No Build year 2035 conditions.
- 2.5% more person-throughput in Montgomery County.

- Up to 23% faster travel time advantages between Burtonsville and Silver Spring
- A 500% increase in transit ridership when compared to current commuter bus ridership to and from Washington, DC.

Broken Land Parkway

Because the success of BRT along Broken land Parkway is dependent upon future changes (e.g. densification) in land use along this corridor, implementation of improvements must be considered in concert with transit oriented development near proposed stations. The main advantage of this service would be the reduced travel times between stations. Travel time for transit vehicles is forecasted to be less than half the travel time for personal vehicles. However, the study predicts a moderate increase in AADT, up to 12%, when compared to the no-build scenario on the west end of the corridor. A slight decrease in AADT, up to 3%, is expected along the rest of the route, east of US 1.

MD 32

The MD 32 BRT route is not likely to attract enough riders to justify the investment. Dedicated bus lanes are costly and are not necessary where general travel lanes operate at speeds higher than that of the proposed transit vehicles. In the case of MD 32, congestion is severe only in limited segments and may not be enough to warrant a dedicated guideway for bus travel the entire length of the corridor. Forecasted travel times for transit vehicles are 35% longer than driving, even though they would be traveling along a dedicated guideway. The study indicates relatively minor (less than 2% plus or minus) changes in AADT and person throughput on MD 32 when compared to the no build scenario. AADT would increase up to 6% between MD 108 and I-95 and decrease up to 3% east of US 1. Given the low forecasted ridership for this line, person throughput forecasts are strongly tied to the AADT predictions.

Transit service along MD 32 could be enhanced by exploring additional peak hour service for transit markets currently not served by the Baltimore and D.C. commuter lines. These new service routes could also become more attractive by providing more comfortable vehicles, upgraded bus stops, and real-time transit information. The travel demand model results show some demand for transit along this route, as does Anne Arundel County's *Corridor Growth Management Plan.* The implementation of subscription transit service could also be explored by the two counties with the option of establishing fixed route bus service further into the future as the need arises.

MD 216

Similarly, the MD 216 BRT route could be routed in mixed traffic. Although the segment between US 29 and Stephens Road would see significant travel time advantages, riding the overall route would take 15% longer than driving. While the implementation of BRT did show a correlation to reduction in vehicle AADT, the overall change in total person throughput forecasted to travel the corridor was minimal.

There is currently no transit service along the MD 216 route so improvements should be phased in gradually, beginning with subscription transit. The MD 216 BRT would be routed along MD 32 for much of its course so this service would benefit from any transit infrastructure improvements made to MD 32.

Next Steps

As the BRT system advances into further project planning, and preliminary engineering and detailed environmental analysis, coordination between the County, the Maryland State Highway Administration, and the Maryland Transit Administration is important to define costs, finalize alignment, right-of-way needs and station alignments, implementation timelines and funding for each corridor as well as operational and maintenance roles and considerations. Additionally, coordination with Montgomery County is crucial given that the US 29 BRT route is planned through both counties and is the best performing line in preliminary system-wide evaluations for both counties. Also, the possibility of BRT along the US 1 corridor should be explored given the proximity to rail stations and redevelopment potential.

Travel Demand Model and Validation

Regional Travel Demand Model

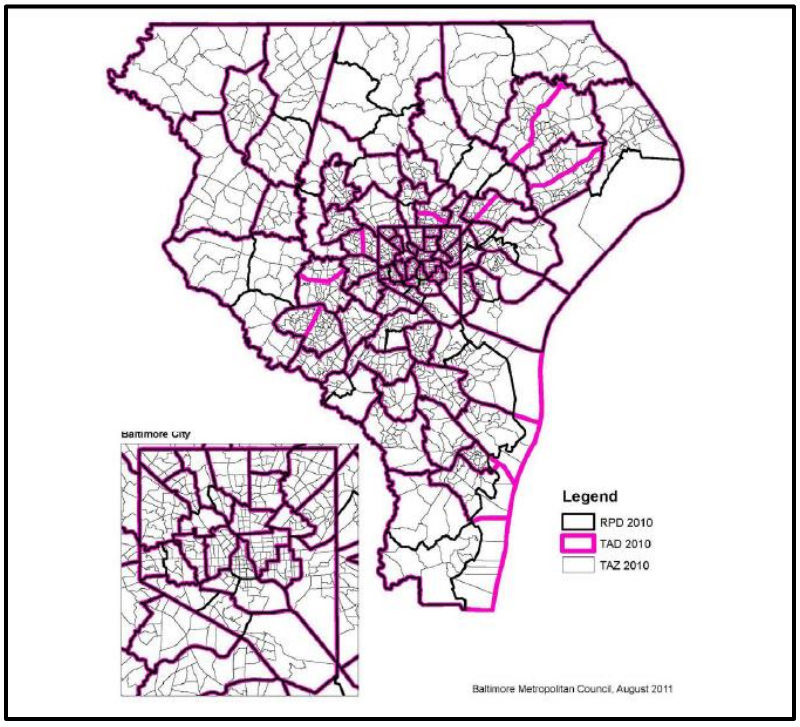
The Howard County Regional Travel Demand Model was developed using the Baltimore Metropolitan Council (BMC) version 4 regional Cube model. As part of the Census Bureau's 2010/2011 TAZ/TAD Delineation Program, BMC in cooperation with its member jurisdictions – Baltimore City and Anne Arundel, Baltimore, Carroll, Harford, and Howard counties – and the Maryland Department of Transportation (MDOT) developed a new TAZ structure in the travel demand modeling process to connect the Census' demographic and economic data to BMC's Travel Demand Model.

The TAZ/TAD Delineation Process resulted in:

- **1,387 Transportation Analysis Zones (TAZ) –** a net increase of 236 TAZs from the 2000 TAZ structure (various additions and mergers across the region).
- **93 Regional Planning Districts (RPD)** – one less than the 2000 RPD structure (the two Aberdeen Proving Grounds RPDs were consolidated).
- **72 Transportation Analysis Districts (TAD)** – created using the RPDs and Census tracts as a basis (consolidation of similar and adjacent RPDs less than 20,000 residents and splits of RPDs above 60,000 residents).

Presented in Figure 2, is the zonal configuration.

Figure 2, BMC Version 4 TAZ structure



General Validation Approach

The general approach to model validation of the Howard County travel demand model was one that was focused on improving highway assignments for the key corridors being studied as part of this project and as a part of future county planning efforts. The current model was developed from the BMC version 4 model, and modules such as Trip Generation, Distribution, and Mode-Choice all performed reasonably well for this project. Zone-splitting was considered as a strategy for improving network loadings, but was to be used on an as-needed basis. The BMC Tp+ script was revised to accommodate an additional 200 zones for the Howard County model. The core of the validation effort included evaluating each corridor individually in order to verify critical link attributes for accuracy. These attributes included number of lanes, facility type, roadway type, etc., in addition to other more qualitative features such as roadway geometry. Addition of collector roadways, repositioning of centroids, and adding additional centroid connectors were additional techniques used in validation. Also, certain original roadway links were eliminated from the analysis if they were considered redundant for the effort. These techniques have improved vehicular loadings such that the simulated volumes become a better match with the existing counts.

Prior to the corridor validation, several screenline validations were conducted to ensure the regional flows through the county and Columbia Town Center (CTC) were consistent with existing base year 2008 counts. The BMC model is simulating traffic flows between Baltimore and Washington within 2% of observed traffic counts at the screenline level. This flow is particularly important to model accurately given the magnitude of the flows between Baltimore and Washington and Howard County's location between both cities. However, initial model results indicated that US 1 was simulating at over 20% of observed counts, which is outside of the accepted FHWA threshold. In addition, the BMC model was validated using the screenline locations from the CTC to ensure consistency with the CTC validation. This initial validation indicated that the BMC model was not adequately replicating travel behavior in the CTC area, and that additional model adjustments were required. A detailed review of the Howard County network indicated that the BMC model was validating adequately at the regional level; however, the model was significantly under-estimating trips in the CTC area. The cause of this was determined to be an inadequate number of short trips being assigned between the Oakland Mills area to the east of US 29 and CTC. These short trips could be for any number of Home Based Shopping (HBS) and Home Based Other (HBO) trip purposes such as restaurants, movies, entertainment, pharmacy trips, etc. En lieu of spitting zones, which would have improved the validation, but not within the FHWA thresholds, the study team developed a fratar table, used to factor the trip table in the Oakland Mills/CTC area. The fratar procedure was implemented in the existing BMC model TP+ script, and this procedure significantly improved the validation results at the CTC screenlines. To improve the validation on US 1 and more accurately reflect the land use pattern in the Elkridge and Laurel areas, the functional class for US 1 was lowered from functional class 3 to functional class 4 and this improved the validation on US 1.

Each of the corridors analyzed used the existing year 2010/2011 counts. While the model validation year is 2008, given the recent recession, traffic counts have been stable or declining between the years 2007-2011; therefore, counts from this timeframe would be appropriate for model validation purposes. The base year conditions for validation represent the year 2008, with the socioeconomic inputs for the validation year also representing 2008 conditions.

Validation statistics that used include volume-to-count ratio, root mean squared error (RMSE), and Percent Deviation. All of these statistics and the validation goals were consistent with the current FHWA guidelines. The guidelines for volume-to-count ratios are as follows:

- Freeways/Expressways ±7%

- Principal Arterials ±10%
- Minor Arterials ±15%
- Collector Roadways ±25%

The subsequent pages provide a summary for the regional flows, CTC area, and each corridor that discusses the validation approach, challenges encountered, and final validation results. The results are presented in a "before validation" and "after validation" context in order to simplify the results of the validation techniques used. The charts are also color-coded such that segments that exceed the threshold appear with a **RED BACKGROUND**, while segments that are below the threshold are shown with a **GREEN BACKGROUND**. Segments that are within the validation goals are shown with a **YELLOW BACKGROUND**. The results of the final run also include the overall RMSE for the corridor.

Regional Flows

As mentioned previously, the regional flows between Baltimore and Washington are a key validation goal in the model development effort. The existing BMC model was adequately simulating travel on I-95 and US 29, the US 1 corridor was over simulating by as much as 46%. MD 295 was under simulating by 17%; however this facility has historically under simulated in the BMC model due to the unique characteristics of this parkway facility.

Table 1

BMC Version 4 Regional Validation

Howard County Model Regional Flows			
North			
Facility	Count	Simulation	% Difference
MD 295	103487	86235	-17%
US 1	32110	46768	46%
I 95	186781	195069	4%
US 29	59000	60584	3%
Total	381378	388656	2%
South			
Facility	Count	Simulation	% Difference
MD 295	81313	82348	1%
US 1	33062	37367	13%
I 95	204178	199455	-2%
Total	318553	319170	0%
East			
Facility	Count	Simulation	% Difference
MD 100	89530	88232	-1%
MD 175	28038	26083	-7%
MD 32	69565	58858	-15%
Total	187133	173173	-7%
West			
Facility	Count	Simulation	% Difference
MD 100	73000	61577	-16%
MD 175	49900	24922	-50%
MD 32	90650	82061	-9%
Total	213550	168560	-21%

The east screenline indicates that MD 32 is under simulating by 15% in the BMC model. This under simulation was addressed by Anne Arundel County in their past SAM 2 model development efforts by splitting zones and improving the loadings in the Fort Meade area; however that is outside of the scope of this current study. The BMC model significantly under simulated the MD 175 corridor leading into the CTC area. The fratar procedure improved the under simulation so that the counts on MD 175 were a much better match to model results. Adjusting the functional class on US 1 improved the validation within FHWA thresholds, and model adjustments improved the screenline validations for the east and west locations.

Table 2

Howard County Model Regional Validation

Howard County Model Regional Flows			
North			
Facility	Count	Simulation	% Difference
MD 295	103487	87564	-15%
US 1	32110	33122	3%
I 95	186781	197006	5%
US 29	59000	63437	8%
Total	381378	381129	0%
South			
Facility	Count	Simulation	% Difference
MD 295	81313	84172	4%
US 1	33062	31034	-6%
I 95	204178	201178	-1%
Total	318553	316384	-1%
East			
Facility	Count	Simulation	% Difference
MD 100	89530	92052	3%
MD 175	28038	26819	-4%
MD 32	69565	62079	-11%
Total	187133	180950	-3%
West			
Facility	Count	Simulation	% Difference
MD 100	73000	75977	4%
MD 175	49900	45936	-8%
MD 32	90650	82942	-9%
Total	213550	204855	-4%

Columbia Town Center

The Columbia Town Center is the focal point of the county and its plans for urban development. As such proper validation of the base year is critical. The previous CTC subarea model was used as a goal for the Howard County Model validation. The BMC model results indicated that this area was significantly under simulating. The CTC zone structure and highway network were implemented and this improved the results somewhat, however, further adjustments were required. The following table illustrates the BMC model validation for the CTC links with the green cells indicating acceptable model performance, yellow indicating adequate model performance (slightly over FHWA thresholds), and the red cells indicating links that are well outside of the FHWA thresholds. The table also illustrates the CTC control, which is the sum of the trips entering the Town Center from Broken Land Parkway (south) and Governor Warfield Parkway (north). The control locations show that the BMC model was simulating approximately half of the trips entering/exiting the Town Center.

Table 3

BMC Model CTC Validation

Count Location	Screenline	Observed	Simulated	Difference	FHWA Threshold	Screenline Difference
US 29 north of MD 108	1	111,175	99555	-10%	7%	-11%
Centennial Lane north of MD 108	1	13,100	9017	-31%	15%	
Homewood north of MD 108	1	8,800	6240	-29%	25%	
MD 32 west of MD 108	1	27,500	27,777	1%	10%	
Harpers Farm Road (CO 744) south of MD 108	2	13,000	6982	-46%	15%	-18%
Ten Mills Road (CO 886) south of MD 108	2	3,700	6366	72%	25%	
Columbia Road south of MD 108	2	10,350	8740	-16%	15%	
MD 32 east of US 29	3	90,650	82061	-9%	7%	-16%
MD 175 east of US 29	3	49,900	24922	-50%	10%	
MD 108 east of US 29	3	24,100	35805	49%	15%	
Broken Land Pkwy east of US 29	3	36,600	26168	-29%	10%	
MD 175 west of US 29	4	50,900	26881	-47%	10%	-51%
Broken Land Pkwy west of US 29	4	45,000	20112	-55%	10%	
Little Patuxent Pkwy north of Governor Warfield Pkwy	5	52,650	26683	-49%	10%	-10%
Little Patuxent Pkwy south of Governor Warfield Parkway	5	21,250	998	-95%	15%	
S. Entrance Road south of Little Patuxent Pkwy	5	4,350	10872	150%	25%	
Little Patuxent Pkwy (CO 794) west of Governor Warfield Pkwy	5	25,600	12750	-50%	15%	
Twin Rivers Road west of Governor Warfield Pkwy	5	15,100	9857	-35%	15%	
Ten Oaks Road west of MD 108	6	10,750	9,087	-15%	25%	15%
US 29 south of MD 32	6	59,000	71265	21%	10%	
Columbia Town Center Control		97,650	46,795	-52%		

As mentioned previously, a fratar procedure was implemented in Tp+ to adjust the trip tables in the CTC area prior to assignment, and this procedure significantly improved the model validation.

Table 4

Howard County Model CTC Validation

Count Location	Screenline	Observed	Simulated	Difference	FHWA Threshold	Screenline Difference
US 29 north of MD 108	1	111,175	105707	-5%	7%	-6%
Centennial Lane north of MD 108	1	13,100	10226	-22%	15%	
Homewood north of MD 108	1	8,800	7442	-15%	25%	
MD 32 west of MD 108	1	27,500	26,827	-2%	10%	
Harpers Farm Road (CO 744) south of MD 108	2	13,000	11491	-12%	15%	-14%
Ten Mills Road (CO 886) south of MD 108	2	3,700	3409	-8%	25%	
Columbia Road south of MD 108	2	10,350	8472	-18%	15%	
MD 32 east of US 29	3	90,650	82942	-9%	7%	-2%
MD 175 east of US 29	3	49,900	45936	-8%	10%	
MD 108 east of US 29	3	24,100	28371	18%	15%	
Broken Land Pkwy east of US 29	3	36,600	40472	11%	10%	
MD 175 west of US 29	4	50,900	58221	14%	10%	5%
Broken Land Pkwy west of US 29	4	45,000	42582	-5%	10%	
Little Patuxent Pkwy north of Governor Warfield Pkwy	5	52,650	60934	16%	10%	-10%
Little Patuxent Pkwy south of Governor Warfield Parkway	5	21,250	15718	-26%	15%	
S. Entrance Road south of Little Patuxent Pkwy	5	4,350	3684	-15%	25%	
Little Patuxent Pkwy (CO 794) west of Governor Warfield Pkwy	5	25,600	17931	-30%	15%	
Twin Rivers Road west of Governor Warfield Pkwy	5	15,100	12270	-19%	15%	
Ten Oaks Road west of MD 108	6	10,750	11,457	7%	25%	7%
US 29 south of MD 32	6	59,000	63437	8%	10%	
Columbia Town Center Control		97,650	103,516	6%		

Broken Land Parkway

Broken Land Parkway is a short but key corridor connecting MD 32 to Columbia Town Center. The initial model runs indicated that this corridor was over simulating between MD 32 and Snowden River Parkway and significantly under simulating for the rest of the corridor.

Graph 1

Broken Land Parkway BMC Validation

	MD 32	Snowden River Pkwy	US 29	Patuxent Pkwy		
2011 AADT		39,641	36,600	45,000	15,942	
Difference		26.17%	-28.50%	-55.31%	-24.47%	**Broken Land Parkway**
Simulated Volume		50016	26168	20112	12041	

While the fratar procedure did not fix the over simulation between MD 32 and Snowden River Parkway, it significantly improved the validation for the links leading to the Town Center. The links leading up to the mall are below and slightly above the FHWA threshold of 10%. It should be noted that the link north of Patuxent Parkway is used primarily for loading purposes, and therefore no further adjustments were made to the corridor.

Graph 2

Broken Land Parkway Howard County Model Validation

	MD 32	Snowden River Pkwy	US 29	Patuxent Pkwy		
2011 AADT		39,641	36,600	45,000	15,942	
Difference		27.08%	10.58%	-5.37%	44.89%	**Broken Land Parkway**
Simulated Volume		50375	40472	42582	23098	

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I-95

The I-95 corridor is the primary freeway facility between Baltimore and Washington and carries as many as 200,000 ADT, illustrating its importance in the region. The BMC model validated acceptably for all links in the county. The adjustments to US 1 shifted some additional demand to the I-95 corridor; however, all links still simulated below the FHWA threshold of 7%.

Graph 3

I-95 BMC Validation

	MD 100		MD 175	Patuxent Parkway MD 32		MD 216		
2011 AADT	193,062		195,334	188,862		187,692	186,972	
Difference	3.31%		5.13%	-0.74%		0.97%	4.33%	**I -95**
Simulated Volume	199455		205360	187457		189510	195069	

Graph 4

I-95 Howard County Model Validation

	MD 100		MD 175	Patuxent Parkway MD 32		MD 216		
2011 AADT	193,062		195,334	188,862		187,692	186,972	
Difference	4.20%		6.44%	1.34%		2.99%	5.37%	**I -95**
Simulated Volume	201178		207918	191400		193307	197006	

US 1 Corridor

This corridor extends from the Baltimore Beltway (I-695) to the Capital Beltway (I-495) and serves a parallel route to I-95. The BMC model has historically over simulated the US 1 corridor between the two beltways, and the current version of the BMC model over simulates by as much as 60% in the county.

Graph 5

US 1 BMC Validation

	MD 100	Patuxent Parkway MD 32		
2011 AADT	35,641	33,371	35661	
Difference	15.58%	47.25%	59.76%	**US 1**
Simulated Volume	41195	49140	56973	

The functional class for US 1 was reduced from primary arterial to minor arterial to reflect the speeds and land use in the Laurel and Elkridge areas. This adjustment between the two beltways significantly improved the base year validation for this corridor, with all links below the FHWA threshold of 10%.

Graph 6

US 1 Howard County Model Validation

	MD 100	Patuxent Parkway MD 32		
2011 AADT	35,641	33,371	35661	
Difference	5.26%	9.97%	9.39%	**US 1**
Simulated Volume	37515	36698	39009	

MD 216 Corridor

The MD 216 corridor extends from downtown Laurel to the Scaggsville area of the County. The corridor is generally parallel to the Gorman Road study area and MD 198.

Graph 7

MD 216 BMC Validation

	US 29	I 95		
2011 AADT	18,041	21,731	25,121	
Difference	-44.27%	8.32%	-0.52%	**MD 216**
Simulated Volume	10055	23538	24990	

Initial model runs indicated that the MD 216 corridor was simulating below the FHWA threshold of 15% with the exception of the link west of US 29. Moving centroids along the corridor closer to MD 216 improved the loadings in this area.

Graph 8

MD 216 Howard County Model Validation

	US 29	I 95		
2011 AADT	18,041	21,731	25,121	
Difference	-15.00%	12.71%	15.42%	**MD 216**
Simulated Volume	15334	24493	28995	

The link east of MD 216 slightly over simulates above the FHWA threshold; however, as the value of 15.42% barely exceeds the threshold of 15%, no further model adjustments were made.

MD 32 Corridor

The MD 32 corridor extends from the Anne Arundel County Line to I-70 in western Howard County. This corridor is a major east-west route through the County and provides access to much of the future growth in the County.

Graph 9

MD 32 BMC Validation

	Clarksville Pike	Columbia Pike	I -95	Washington Blvd		
2011 AADT	26,921	55,191	91,011	79,191	68,291	
Difference	3.18%	0.10%	-8.62%	-31.30%	-27.06%	**MD 32**
Simulated Volume	27777	55248	83163	54406	49814	

However, from a modeling perspective, this corridor was one of the most problematic regarding validation. The initial evaluation showed some segments of the corridor under-simulating by almost 25,000 ADT, which for that segment was 31% of the 2010 count volume. Similar to I-95 and US 29, this corridor functions very much like an interstate facility given the design, speeds, and limited access. Therefore, the entire corridor was re-coded as such.

Although there were slight improvements as a result of these refinements, the links approaching Fort Meade/NSA were still under simulating. To further improve the validation for these links would require modifying the Fort Meade/NSA TAZ structure to replicate the zone structure used in the Anne Arundel County SAM2 model. This adjustment included splitting zones and adjusting the loadings on the base and significantly improved the model validation for the SAM2 model. While this is outside of the current scope of the Howard County model development, the county may explore this option to improve the model performance in the future.

Table 10

MD 32 Howard County Model Validation

	Clarksville Pike	Columbia Pike	I -95	Washington Blvd		
2011 AADT	26,921	55,191	91,011	79,191	68,291	
Difference	-0.35%	3.47%	-10.09%	-26.51%	-21.71%	**MD 32**
Simulated Volume	26827	57107	81830	58199	53466	

When developing the traffic forecasts with this improved model, NCHRP 255 screenline techniques will be used to remedy the remaining inaccuracies for the model in this corridor.

MD 175 Corridor

The MD 175 corridor runs from the Columbia Town Center area to MD 3 in Anne Arundel County. This is a limited-access expressway is some sections west of I-95 and at grade for the remaining portions. MD 175 is a key corridor in the county serving the Jessup State Prison, Fort Meade, and NSA in addition to the Town Center. The initial BMC model runs indicated that this corridor was significantly under simulating in the Town Center area.

Table 11

MD 175 BMC Validation

	Columbia Pike		Snowden River Pkwy		I-95		Washington Blvd			
2011 AADT	50,990		49,990		69,060		47,280	17,590		
Difference	-47.28%		-50.15%		-8.56%		28.88%	1.92%		**MD 175**
Simulated Volume	26881		24922		63146		60933	17928		

The fratar procedure led to a slight over simulation on the link approaching the Town Center, but improved the validation percentage by 30%. The fratar process led to overall improved validation for the MD 175 corridor particularly near the Town Center, which is the focal point of the BRT study.

Graph 12

MD 175 Howard County Model Validation

	Columbia Pike		Snowden River Pkwy		I-95		Washington Blvd			
2011 AADT	50,990		49,990		69,060		47,280	17,590		
Difference	17.14%		-8.11%		-12.97%		4.08%	1.43%		**MD 175**
Simulated Volume	59732		45936		60100		49210	17841		

MD 100 Corridor

The MD 100 corridor extends from US 29 to the Anne Arundel County line and east to MD 2 and Pasadena. The corridor is a limited access facility throughout the county, meaning that it would not be sensitive to network changes such as centroid adjustments.

This initial BMC model run indicated that the corridor was simulating reasonably well with half of the links below the FHWA threshold, with the other links under simulating by 15-19%.

Graph 13

MD 100 BMC Validation

	Snowden River Pkwy	I-95	Washington Blvd		
2011 AADT	73,000	90,361	96,881	89,891	
Difference	-15.65%	-3.92%	-18.64%	-5.94%	**MD 100**
Simulated Volume	61577	86819	78827	84554	

The fratar procedure added some additional trips to the MD 100 corridor, and overall the corridor validation was improved with half of the links simulating below the FHWA threshold as in the initial BMC model run, but with the other links simulating just outside of the FHWA thresholds.

Graph 14

MD 100 Howard County Model Validation

	Snowden River Pkwy	I-95	Washington Blvd		
2011 AADT	73,000	90,361	96,881	89,891	
Difference	4.08%	9.98%	-9.15%	-1.16%	**MD 100**
Simulated Volume	75977	99383	88016	88850	

MD 108 Corridor

The MD 108 corridor is located north of the Columbia Town Center. It is two lanes for the majority of its length with some small 4 lane sections. The BMC model was simulating this corridor acceptably with all links below the FHWA threshold of 15%.

Graph 15

MD 108 BMC Validation

			Snowden River Pkwy	US 29	Patuxent Pkwy		
2011 AADT				24,080	27,890	15,942	
Difference				12.18%	-14.31%	11.70%	**MD 108**
Simulated Volume				27012	23898	17808	

The fratar procedure added additional trips to the study area network in the CTC area and as such led to the slight over simulation of the link west of US 29. As the remaining links remained below the FHWA threshold, the study team decided that no further adjustment were required for validation purposes.

Graph 16

MD 108 Howard County Model Validation

			Snowden River Pkwy	US 29	Patuxent Pkwy		
2011 AADT				24,080	27,890	15,942	
Difference				17.82%	-9.84%	14.75%	**MD 108**
Simulated Volume				28371	25145	18294	

US 29 Corridor

The US 29 corridor runs north-south from I-70 to the Capital Beltway (I-495). It is a prime candidate for the implementation of BRT service, as it connects densely developed portions of Montgomery County to the south with Columbia Town Center, it is a prime candidate for the implementation of BRT service. US 29 is a limited access facility that also serves a parallel route to I-95 through the county, particularly south of the Town Center.

The initial BMC model results indicated that US 29 was validating within the FHWA thresholds. The fratar procedure led to poorer simulation on the US 29 corridor in the CTC area, with several of the links simulating outside of the FHWA threshold. However, a more detailed review of the results indicated that the percentages do not exceed 10%, which means the corridor is simulating reasonably well. Some of the over simulation on US 29 also results from over simulation on I-70 which feeds US 29. A penalty

could be added to I-70 in the western portion of the county to reduce the number of trips entering the county from the west, though this would have to be accounted for in the forecasting process.

Graph 18

US 29 BMC Validation

	MD 100	MD 175	Patuxent Parkway MD 32	MD 216		
2011 AADT	145,361	105,421	80,061	69,550	57,661	
Difference	-2.47%	-4.04%	3.86%	2.47%	5.07%	**US 29**
Simulated Volume	141777	101164	83153	71265	60584	

Graph 19

US 29 Howard County Model Validation

	MD 100	MD 175	Patuxent Parkway MD 32	MD 216		
2011 AADT	145,361	105,421	80,061	69,550	57,661	
Difference	7.33%	0.96%	9.99%	-7.30%	10.02%	**US 29**
Simulated Volume	156016	106430	88058	64476	63437	

Summary of Results

The BMC Version 4 regional model validated reasonably well at the regional level; however under simulation of the CTC area led to the under simulation of regional flow in the east-west direction in the county.

The fratar procedure considerably improved the validation for the CTC area and led to the improvements in validation for a number of the key study corridors in the county. Providing reasonable, intuitive refinements to the highway network achieved further network validation. The only notable tradeoff in introducing the additional trips to the network, was the US 29 corridor which did not simulate as well after the procedure.

Overall, the model replicates travel behavior in the CTC area more accurately that in turn improves the countywide model validation.

The MD 32 corridor is the only key corridor in the study area that is still simulating well outside of the FHWA thresholds. As referenced previously, it is recommended that the county explore replicating the zone structure used in the SAM2 model for the Fort Meade/NSA area in the future. In the meantime, when developing the traffic forecasts with this improved model, NCHRP 255 screenline techniques will be used to remedy the remaining inaccuracies for the model in this corridor

Travel Model Files (Cube network, Socioeconomic Data, Script Files)

DVD 1

- Columbia Town Center subarea 2005 network with 2008 demographics

DVD 2

- Columbia Town Center subarea 2035 Forecasts with full build out Town Center trips

DVD 3

- Regional/Countywide base year model update with Route 1 Corridor Updates

DVD 4

- Regional/Countywide base year model updated with Town Center subarea updates

DVD 5

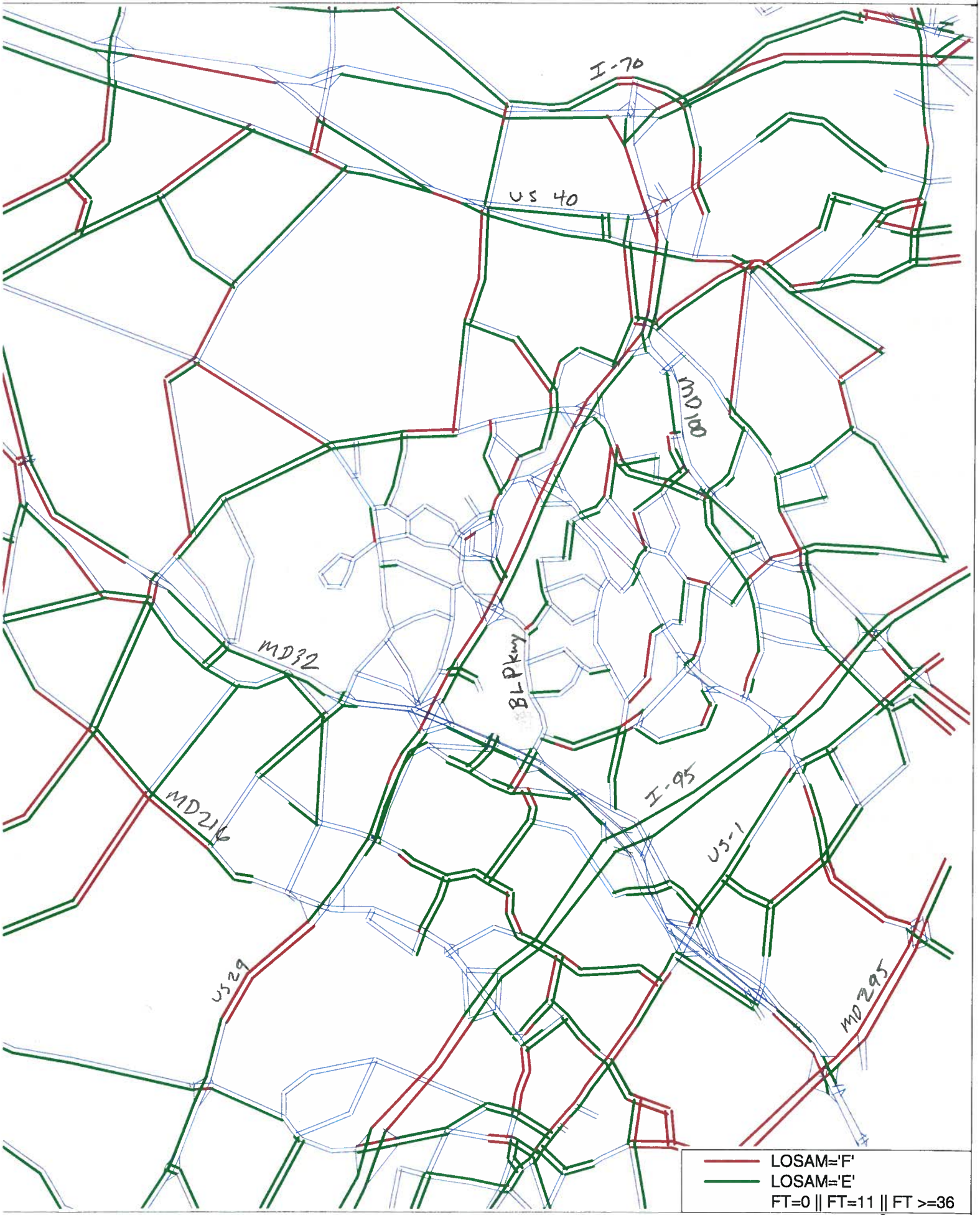
- Regional/Countywide year 2035 model updated with final BRT alignments/stations

BRT Impact for Link Level of Service

2035 AM Peak (6:30 AM - 9:30 AM) Highway Network Level of Service Summary

US 29		**Southbound**		**Northbound**	
From	**To**	**No Build**	**BRT**	**No Build**	**BRT**
US 40	MD 100	F	F	D/E	D/E
MD 100	MD 108	F	F	E	E
MD 108	MD 175	F	E/F	E	E
MD 175	Broken Land Pkwy	F	E/F	E	E
Broken Land Pkwy	MD 32	F	E/F	E	E
MD 32	MD216	E/F	E/F	D/E	E
MD216	Howard County Line	F	F	F	F
MD 32		**Eastbound**		**Westbound**	
From	**To**	**No Build**	**BRT**	**No Build**	**BRT**
MD 108	Great Star Drive	E	**D**	C	C
Great Star Dr	Cedar Lane	E	F	C	D
Cedar Lane	US 29	D	D	B	B
US 29	Broken Land Pkwy	E	E	C	C
Broken Land Pkwy	I-95	E	E	C	C
I-95	US 1	D	D	C	C
US 1	Dorsey Run Road	C	D	B	B
Dorsey Run Road	BW Pkwy	F	F	D	D
MD 216		**Eastbound**		**Westbound**	
From	**To**	**No Build**	**BRT**	**No Build**	**BRT**
US 29	I-95	C/D	D/E	B/C	B/C
I-95	Stephens RD	E	E	D	E
Broken Land Pkwy		**Eastbound**		**Westbound**	
From	**To**	**No Build**	**BRT**	**No Build**	**BRT**
Columbia Town Center	US 29	B/C/D	C/D/E	B/C	B/C
US 29	MD 32	A/B/C/D	B/C/E	B/D	B/D

2035 No Build Peak AM LOS



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2035 BRT Peak AM LOS