

# APPENDIX 3. METRICS & PERFORMANCE

## CONTENTS

List of Tables.....	2
List of Figures .....	3
Read This First – Anticipated Updates.....	4
Evaluation Approach.....	4
Organization of Appendix .....	5
Modeling Tools Used .....	5
General Modeling Approach .....	5
Travel/4 Travel Demand Modeling .....	5
Regional Dynamic Model .....	6
Economic and Financial Modeling.....	7
Performance and metrics Across Evaluation Dimensions.....	10
Strategic Dimension.....	10
Financial Dimension.....	14
Economic Dimension .....	16
Implementation Dimension.....	19
Options’ Service and Costing Assumptions .....	21
Enhanced MARC Rail .....	21
Red Line Extension .....	26
Corridor Cities Transitway .....	29
Purple Line Extension .....	32
New Rail Connection to Frederick .....	35
Managed Lanes Enhanced Commuter Bus .....	38
Land and Right of Way Needs .....	44
Operations and Maintenance Facilities.....	44
Right-of-Way and Property Impacts .....	46
Network Evaluation.....	48
Recommended Network Rationale .....	52
Network Packages without the Red Line .....	53

## LIST OF TABLES

Table 1. I-270 and I-495 Coding Assumptions .....	6
Table 2. Corridor Forward Goal .....	10
Table 3. Strategic Dimension Performance Outputs for 2045 Modeling.....	11
Table 4. Strategic Dimension Performance Outputs for Existing Conditions Modeling (Key Metrics Only).....	12
Table 5. Description of Strategic Dimension Metrics.....	12
Table 6. Financial Dimension Performance Outputs.....	14
Table 7. Financial Dimension Metrics.....	14
Table 8. Economic Dimension Performance Outputs.....	16
Table 9. Economic Analysis Assumptions .....	17
Table 10. Economic Analysis Unit Rate Sources .....	18
Table 11. Implementation Dimension Performance Outputs for 2045 Modeling.....	20
Table 12. Enhanced MARC Rail Assumptions Profile .....	21
Table 13. Enhanced MARC Rail Tested Service Patterns .....	23
Table 14. Enhanced MARC and Annual Revenue Miles and Tested Headways.....	24
Table 15. Hypothetical Morning Service Schedule (Supplied for Ease of Understanding) .....	25
Table 16. Red Line Extension Assumptions Profile .....	26
Table 17. Red Line Extension Miles Traveled and Headways .....	27
Table 18. Corridor Cities Transitway Assumptions Profile .....	29
Table 19. Corridor Cities Transitway Miles Traveled and Headways .....	31
Table 20. Purple Line Extension Assumptions Profile .....	32
Table 21. Purple Line Extension Miles Traveled and Headways.....	34
Table 22. New Rail Connection to Frederick Assumptions Profile .....	35
Table 23. New Rail Connection to Frederick Miles Traveled and Headways .....	37
Table 24. Managed Lanes Enhanced Commuter Bus Assumptions Profile.....	39
Table 25. Managed Lane Enhanced Commuter Bus Miles Traveled and Headways .....	41
Table 26. Managed Lanes Enhanced Commuter Bus Service Patterns and Headways.....	42
Table 27. Example Capital Cost Allocation within 2020 Capital Construction Database .....	44
Table 28. Operations and Maintenance Facility Land Need Assumptions and Costs.....	45
Table 29. Right-Of-Way and Property Impacts.....	47
Table 30. Total Planning Level Land Costs.....	48
Table 31. Anticipated Grade Crossings.....	48
Table 32. Description of Network Packages <sup>1,2,3</sup> .....	51
Table 33. Infrastructure and Service .....	52
Table 34. New Transit Trips with and without the Red Line Extension (2045).....	53
Table 35. VMT Reductions with and without the Red Line Extension (2045).....	53

## LIST OF FIGURES

Figure 1. Conceptual Overview of the Regional Dynamic Model (source: Steer Group) .....	7
Figure 2. Financial Profiling Process.....	8
Figure 3. Economic Profiling Process .....	9
Figure 4. Enhanced MARC Rail Alignment (Regional Scale).....	22
Figure 5. Red Line Extension Alignment (Regional Scale) .....	27
Figure 6. Red Line Extension Illustrative Service Diagram .....	28
Figure 7. Corridor Cities Transitway Alignment (Regional Scale).....	30
Figure 8. Corridor Cities Transitway Illustrative Service Diagram.....	31
Figure 9. Purple Line Extension Alignment (Regional Scale).....	33
Figure 10. Purple Line Extension Illustrative Service Diagram .....	34
Figure 11. New Rail Connection to Frederick Alignment (Regional Scale).....	36
Figure 12. New Rail Connection to Frederick Illustrative Service Diagram.....	37
Figure 13. Managed Lanes Enhanced Bus Alignment (Regional Scale).....	40
Figure 14. Managed Lanes Enhanced Commuter Bus Illustrative Service Diagram .....	43

## READ THIS FIRST – ANTICIPATED UPDATES

Corridor Forward analyzes transit options and networks across strategic, financial, economic, and implementation dimensions. Financial evaluations are built from unit rate assumptions developed from national benchmarks, but also locally comparable information. Following the project team’s analysis and evaluation, the Montgomery County Department of Transportation provided feedback to Montgomery Planning and has requested additional analysis be undertaken. Montgomery Planning has agreed to undertake this additional analysis and will release results in a forthcoming addendum to this appendix. All values reported in this report reflect initially employed benchmarks.

## EVALUATION APPROACH

Corridor Forward applies a business case analysis to assess the value of each of the six options retained following the pre-screening analysis described in Appendix 2. Business case analysis is defined as the collection of evidence assembled in a logical way to explain the contribution of a proposed investment, with the intent of determining if the investment is a good use of public funds. The business case process aids decision-making by developing evaluation dimensions that provide key variables of value to multiple stakeholder parties rather than solely the party running the analysis.

Typically, business case analysis is performed prior to engineering work and is used as a decision-making framework. In other words, it is a planning-level process that is not intended to account for every detail of an option’s ultimate benefits and costs, but to instead provide a clear and consumable picture of a transit option’s overall benefit, cost, and risk bundle. For Corridor Forward, the business case analysis results in high-level comparative analysis to further curate corridor-serving transit options, de-emphasizing those which had less merit. The business case analysis for the project included several steps:

- A. Generate dimensions of analysis and required evidence (metrics) for each dimension
- B. Generate evidence (metric outputs) for each transit option
- C. Summarize how each transit option performs against each dimension
- D. Assess consequences and trade-offs for each option

**The business case approach used by the effort is for comparative purposes. Regarding costs, its analysis is not reflective of bottom-up engineering. Regarding modeling, staff calibrated and Montgomery Planning’s standard travel demand model tool with the best known information at the time of modeling. The project team, which includes the project consultant Steer Group, undertook additional dynamic land use modeling and financial modeling. As the recommendations of Corridor Forward advance, additional studies will likely need to be completed, such as facility planning or alternatives analysis.**

Observing the isolated costs, benefits, and risks of isolated transit options allowed Montgomery Planning to sort and elevate transit options that may function well as a component of a larger network. Planning then tested potential networks, which in tandem with policy considerations, helped the staff arrive at its recommendations for near-term recommended dedicated bus lanes and the long-term, ambitious extension of the Red Line to Germantown.

## ORGANIZATION OF APPENDIX

This appendix walks through the modeling tools employed for analysis. It then discusses the performance of the Plan’s retained options and tested network packages by evaluation dimension. The project team developed four different performance dimensions: a strategic dimension, a financial dimension, an economic dimension, and an implementation dimension. Each dimension includes core questions, which the project team used to develop metrics to assess the performance of options and packages. The following sections detail the description, method of analysis, and performance of relevant metrics.

## MODELING TOOLS USED

### General Modeling Approach

Corridor Forward used a series of tools to inform metric outputs. Technical modeling included use of the Travel/4 travel demand model and a proprietary dynamic land use model referred to by the project consultant as the Regional Dynamic Model. The project also consultant-produced financial and economic spreadsheet models. The project team undertook benchmarking and input gathering to inform applications of modeling, as reported with the relevant sections of this appendix.

### Travel/4 Travel Demand Modeling

For travel demand modeling, Montgomery Planning’s consultant used the Department’s Travel/4 Model, a fine-grained iteration of the Metropolitan Washington Council of Government’s (MWCOC) regional travel demand model, to evaluate the retained services. The consultant modeled the six retained transit options using land use and network assumptions for two model years: 2015—a proxy for existing conditions—and 2045. The rationale for modeling the options using an existing conditions network was twofold. First, the existing conditions modeling outputs can be understood as probable “performance floors” for each option. Additionally, when comparing 2015 outputs to the 2045 outputs, Planning staff could better gauge how much of the option’s performance may be attributed to growth. In other words, modeling results that depict larger disparities between 2015 and 2045 suggest that the county and/or region would need to realize projected growth as it is spatially allocated per current forecasts in order attain the projected benefits. For land use, the 2045 model year uses cooperative forecast versions 9.1a for locations exterior to the county and 9.2 for locations interior to the county. When modeling commenced in December 2020, MWCOC had approved the county’s proposed 9.2 inputs, but the regional release and approval for 9.2 in its entirety remained forthcoming.

Staff retained all regionally-accepted CLRP items in the future year network, except for the following project-based decisions:

- Staff removed the Corridor Cities Transitway from the 2045 background network as this project was a retained option and was analyzed individually.
- Staff retained 2015 MARC transit coding assumptions for the 2045 background as this project was a retained option and was analyzed individually.
- Staff removed the North Bethesda Transitway from the background network as an extension of the project was included on initial transit options menu.
- Staff added the under-construction Purple Line to the 2015 background network, given that a Purple Line extension was evaluated as one of the six retained transit options.
- One adjustment was made to the I-270 highway network in 2045, as described in

Table 1 below to account for the State’s managed lanes project. Access locations related to the managed lanes project were integrated into the highway network based on the State’s Draft Environmental Impact Statement (DEIS); however, access locations may change following coordination with the selected bidder.

Table 1. I-270 and I-495 Coding Assumptions

Model Version	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
	I-270: Frederick to Clarksburg Rd	I-270: Clarksburg Rd to I-370	I-270: I-370 to Spur	I-495 (west side): Spur to ALB Bridge	I-495 (east side): Spur to WW Bridge
<b>MWCOG Model Version 2.3.78</b>	2 HOT lanes each direction	2 HOT lanes each direction + 1 HOV lane in PM peak (I-270 northbound only)	2 HOT lanes each direction + 1 HOV lane each direction (AM southbound; PM northbound)	2 HOT lanes each direction	2 HOT lanes each direction
<b>Corridor Forward Evaluation</b>	Same as above	Same as above	2 HOT lanes each direction (HOV lane is converted to one of the HOT lanes)	Same as above	Same as above

Notes: HOT = high-occupancy toll, HOV = high-occupancy vehicle

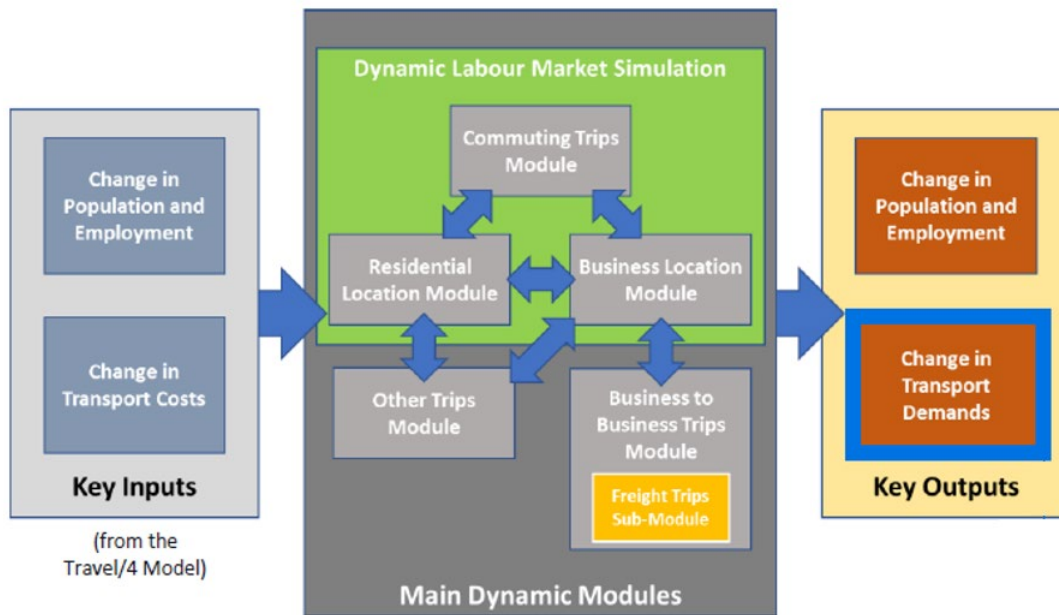
### Regional Dynamic Model

Beyond travel demand modeling, the project consultant provided Montgomery Planning access to a dynamic land use model referred to as the Regional Dynamic Model. The model applies system dynamics principles to simulate how changes to generalized travel times between geographic areas can influence both the level of real estate supply and where firms and people choose to locate. The project consultant used this proprietary model to assesses the potential for any studied option to change the distribution of jobs and population in response to attractiveness of the areas for households and businesses. To do this, the model:

- Establishes a 2015 baseline, calibrated with 2015 travel demand model skims from Travel/4 and existing conditions land use patterns;
- Creates a 2045 ceiling across all zones based on Travel/4 regional forecasts;
- Creates a 2045 business as usual scenario—without application of options—for comparison purposes, allowing the build out and allocation of population and employment over time;
- Runs 2045 option scenarios to test the provision of transit, programming an option’s opening in within years between the model’s run-time span; and
- Observes the comparison of the spatial allocation of jobs and employment between the options scenarios and business-as-usual scenario.

Figure 1 displays a high level overview of the inputs and modules associated with the regional dynamic model. Modeling limitations impact the tool’s value—particularly for bus options and for options that traverse larger analysis zones; however, the tool can suggest hypothetical trends that could potentially occur with the provision of a given option. Given that the magnitude of land use reallocation for tested options was minor, one can assume that the cooperative forecast’s land use assumptions are reasonable. The model’s outputs hint at the location and direction of trends that could be anticipated were an option(s) to be implemented.

Figure 1. Conceptual Overview of the Regional Dynamic Model (source: Steer Group)



### Economic and Financial Modeling

The consultant used a two-step approach to calculate financial metrics. First, the consultant developed unit rate cost inputs in coordination with Montgomery Planning. At base, capital costs included rails, guideways, and vehicles. Benchmarks are sourced from the Eno Center for Transportation’s Capital Construction Database, local sources like the Corridor Cities Transitway 2017 Environmental Assessment, the Maryland Department of Transportation’s 2020 *Monorail Feasibility Study*, and 2018 *MARC Rail Cornerstone Plan*. Operational costs are sourced from the 2019 National Transit Database, maintained by the Federal Transit Administration or local sources like the Corridor Cities Transitway EA. All costs are inflated to 2021 dollars.<sup>1</sup>

Next, the project consultant created financial profiles for each option informed by ridership and revenue inputs from the Travel/4 model, as well as assumptions about the discount rate, inflation rate, and appraisal horizon. Financial outputs include capital estimates, operating estimates, fare revenue, net present value, revenue to cost ratio, net financial impacts, and 2045 revenue to operating cost ratios. The total financial profiling process is shown in Figure 2. The economic dimension employs cost inputs from the financial analysis, with slight variation in discount rate (discussed in the relevant section below).

<sup>1</sup> The Montgomery County Department of Transportation (MCDOT) has requested Planning staff update its capital and operation benchmarking metrics for bus service (presenting costs in ranges) and capital cost benchmarking for Metrorail (using only the Silver Line Phase 1 rather than an average of similar projects, including the Silver Line). More information is provided in the Options’ Service and Costing Assumptions section.

Benefits from the Travel/4 travel demand model are monetized and run through a spreadsheet model assessing the value of capital and operating cost impacts over time accounting for societal benefits. The economic modeling process is shown in Figure 3.

Figure 2. Financial Profiling Process

**Two-part approach to calculating financial metrics**

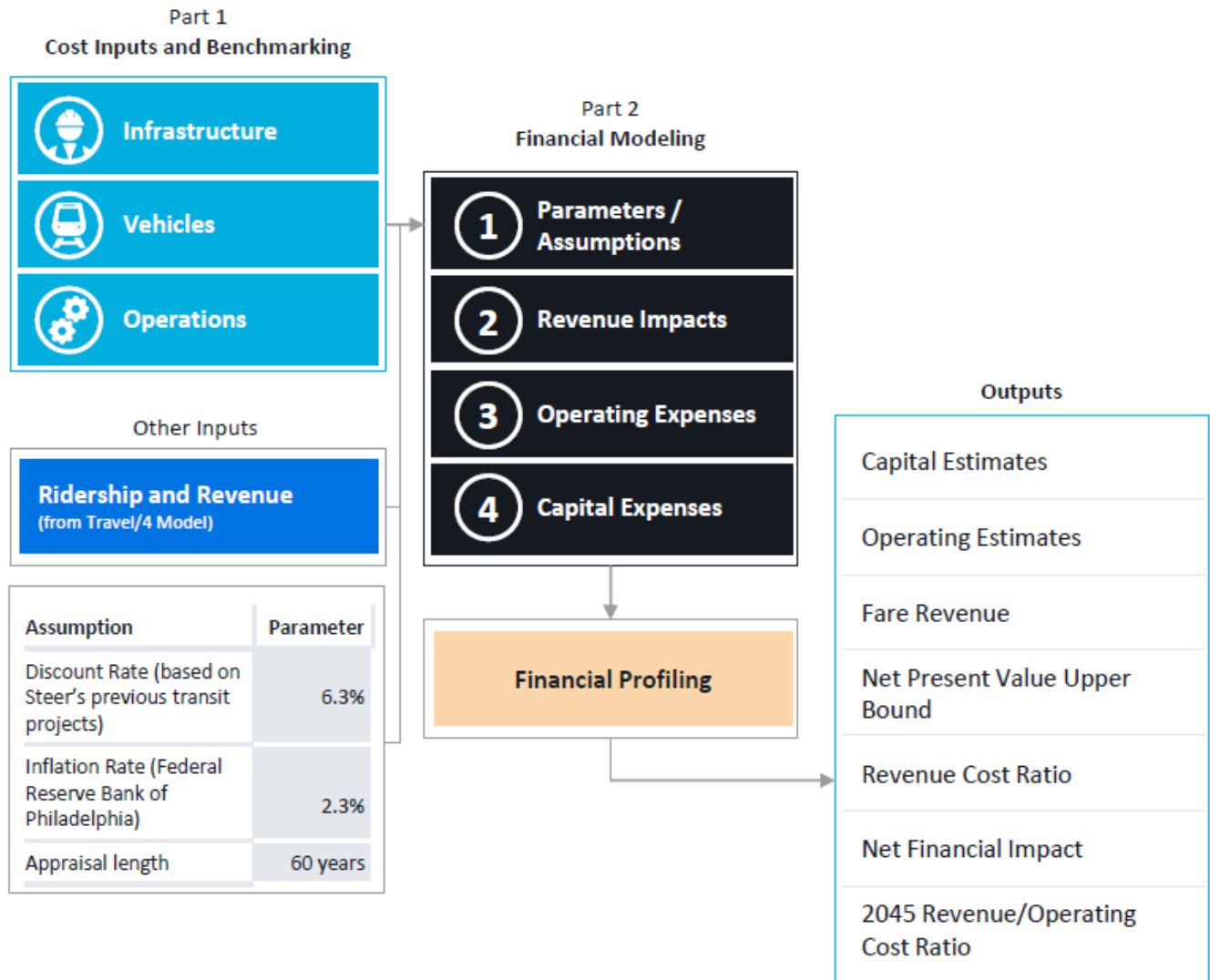




Figure 3. Economic Profiling Process

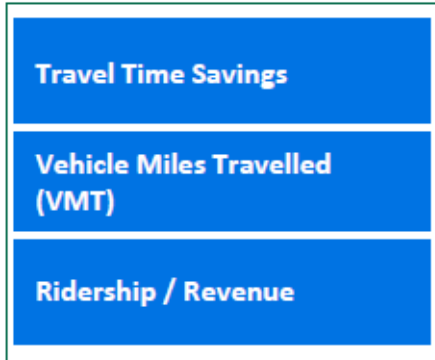
Two-part approach to calculating financial metrics

Part 1 – Cost and Benefits Inputs

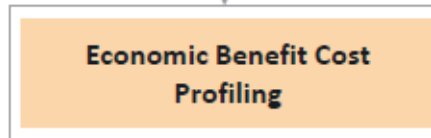
Cost Inputs



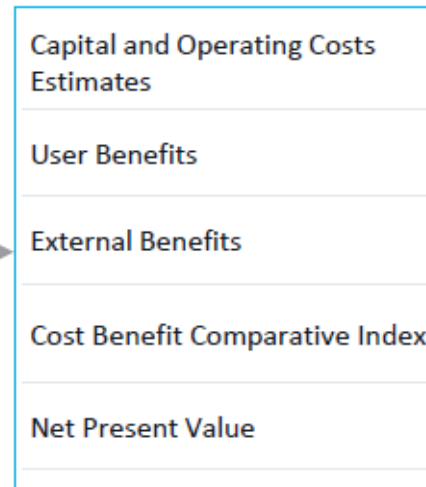
Benefits Inputs (from Travel/4 Model)



Part 2 -Economic Modeling



Outputs



## PERFORMANCE AND METRICS ACROSS EVALUATION DIMENSIONS

Results are reported for each dimension and network package. For more information about the individual options, please see Appendix 2. For more information about the development of network packages, please see the “Network Evaluation” section of this Appendix.

### STRATEGIC DIMENSION

The strategic dimension focuses on non-monetized performance and excludes practical constraints related to implementation. This dimension asks the core question, “**How does the option support county and regional policies, goals, and objectives?**” In this regard, this dimension addresses the Plan’s goal, which in turn is derived from three values of *Thrive Montgomery 2050* and a transit specific value added by the project team. The Plan’s goal is depicted in Table 2 below:

Table 2. Corridor Forward Goal

<b>Corridor Forward Goal:</b>		
Advance a transit network that:		
<b>Corridor Forward</b>	<b>Strategic Connections</b>	Serves high-demand origin and destination pairs, balancing the costs of implementation with projected benefits.
<b>Thrive Montgomery 2050</b>	<b>Economic Health</b>	Enables existing development and master planned communities to realize their potential as livable and economically vibrant places.
	<b>Community Equity</b>	Aligns with the county’s social equity goals and principles.
	<b>Environmental Resilience</b>	Operates sustainably and reduces negative environmental impacts.

The project team developed metrics within the strategic dimension that address the four values included in the Plan goal. Table 3 presents the results of the analysis for modeling in the forecast year. Table 4 reports key metrics for modeling in existing conditions (i.e. a 2015 land use and transportation network, demonstrating the assumed “performance floor” of each option). Table 5 describes metrics and the process used to source the outputs of the metrics.

Table 3. Strategic Dimension Performance Outputs for 2045 Modeling

Category	Metric	Business As Usual	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension	New Frederick Rail Connection	Managed Lanes Enhanced Commuter Bus	Network Package One	Network Package Two	Network Package Three
<b>Strategic Dimension</b>	Regional transit trips	1.7M	+0.23% (+3.8k)	+0.49% (+8.3k)	+0.44% (+7.4k)	+0.33% (+5.5k)	+0.49% (+8.3k)	+0.55% (+9.3k)	+1.26% (+21.4k)	+1.22% (+20.7k)	+1.02% (+17.3k)
	County Transit Trips	268.4K	+0.74% (+1.9k)	+1.90% (+5.1k)	+2.63% (+7.1k)	+0.57% (+1.5k)	+1.36% (+3.6k)	+2.19% (+5.9k)	+5.68% (+15.3k)	+5.42% (+14.6k)	+3.76% (+10.1k)
	Regional Transit Mode Share	7%	+0.02%	+0.03%	+0.03%	+0.02%	+0.03%	+0.04%	+0.09%	+0.08%	+0.07%
	Montgomery County Transit Mode Share	7%	+0.05%	+0.14%	+0.19%	+0.04%	+0.10%	+0.16%	+0.42%	+0.40%	+0.28%
	Reductions in Daily Vehicle Miles Traveled (VMT)	219M	-0.03% (-73.0k)	-0.07% (-157.4k)	-0.01% (-29.4k)	-0.02% (-44.5k)	-0.07% (-159.4k)	-0.05% (-110.0k)	-0.13% (-283.2k)	-0.13% (-285.0k)	-0.13% (-293.7k)
	Annual Reductions of Crashes Causing Fatalities based on Annual VMT Reductions	576	-0.2	-0.4	-0.08	-0.1	-0.4	-0.3	-0.75	-0.75	-0.77
	Annual Reductions of Crashes Causing Injuries based on Annual VMT Reductions	49.7k	-16.60	-35.78	-6.68	-10.11	-36.24	-25.01	-64.37	-64.78	-66.75
<b>Economic Health</b>	Jobs accessible within 45 minutes on transit	209,629	0.09%	4.62%	1.25%	0.74%	1.63%	2.11%	6.30%	6.19%	5.69%
	Jobs Filled	2,194,065	+0.018% (2,194,453)	+0.101% (2,196,272)	+0.006% (2,194,187)	+0.001% (2,194,086)	-0.004% (2,193,977)	-0.015% (2,193,728)	N/A <sup>1</sup>	N/A <sup>1</sup>	N/A <sup>1</sup>
	Population	3,512,563	+0.003% (3,512,673)	+0.007% (3,512,808)	+0.001% (3,512,592)	+0.001% (3,512,600)	+0.004% (3,512,689)	-0.001% (3,512,529)	N/A <sup>1</sup>	N/A <sup>1</sup>	N/A <sup>1</sup>
<b>Environmental Resilience</b>	CO <sub>2</sub> emissions (grams)	88.3B	-0.03% (-29.5M)	-0.07% (-63.6M)	-0.01% (-11.9M)	-0.02% (-18.0M)	-0.07% (-64.4M)	-0.05% (-44.4M)	-0.13% (-114.4k)	-0.13% (-115.1M)	-0.13% (-118.6k)
<b>Montgomery County Equity</b>	Jobs accessible by MCO Equity Focus Area (EFA) populations in 45 minutes on transit	224,687	0.23%	6.82%	0.95%	-0.53%	1.54%	1.63%	8.14%	8.86%	8.03%

<sup>1</sup>The Regional Dynamic Model was not run for the network packages

Table 4. Strategic Dimension Performance Outputs for Existing Conditions Modeling (Key Metrics Only)

Category	Metric	Business As Usual	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension	New Frederick Rail Connection	Managed Lanes Enhanced Commuter Bus
<b>Strategic Dimension</b>	Regional transit trips	1.16M	+0.27% (+3,145)	+0.69% (+8,049)	+0.33% (+3,862)	+0.31% (+3,634)	+0.40% (+4,611)	+0.48% (+5,599)
	County Transit Trips	183.8K	+0.89% (+1,643)	+2.65% (+4,871)	+2.08% (+3,825)	+0.73% (+1,346)	+1.01% (+1,857)	+1.86% (+3,423)
	Regional Transit Mode Share	6.00%	0.02%	0.04%	0.02%	0.02%	0.02%	0.03%
	Montgomery County Transit Mode Share	6.00%	0.05%	0.16%	0.13%	0.04%	0.06%	0.11%
	Reductions in Daily Vehicle Miles Traveled (VMT)	178M	-0.04%	-0.09%	-0.01%	-0.02%	-0.07%	-0.05%

Table 5. Description of Strategic Dimension Metrics

Value	Benefits	Metrics	Source	Estimation Approach
Strategic Connections	<ul style="list-style-type: none"> <li>Increased transit trips</li> </ul>	<ul style="list-style-type: none"> <li>Net new regional transit trips</li> <li>Net new Montgomery County transit trips</li> <li>Transit mode share change for Montgomery County</li> <li>Transit mode share change for region</li> </ul>	Travel/4 Model	<ul style="list-style-type: none"> <li>Trips extracted from Travel/4 based on in scope TAZs</li> <li>Mode share based on the proportion of total linked trips that use transit for some or all the trips divided by all trips in region</li> </ul>
	<ul style="list-style-type: none"> <li>Reduced congestion and automobile related externalities</li> </ul>	<ul style="list-style-type: none"> <li>Daily VMT</li> <li>Annualized VMT on number of crashes causing fatalities</li> <li>Annualized VMT on number of crashes causing injuries</li> </ul>	Travel/4 Model	<ul style="list-style-type: none"> <li>Extracted from Travel/4 based on trips that change from auto to transit</li> <li>VMT calculated by multiplying the number of trips by their lengths from their origins to destinations in each time period of a day, then summing all the VMT to a total in a geographical area (region, Montgomery County, and Montgomery County EFAs.</li> <li>VMTs are fully counted for trips with both origins and destinations in the study area. Only 50% of VMTs are counted if only one end of trip is within the study area.</li> <li>VMT multiplied by a unit factor for crashes per VMT; rates derived from the National Highway Traffic Safety Administration.</li> </ul>
Economic Health	<ul style="list-style-type: none"> <li>Increased employment served by investment</li> </ul>	<ul style="list-style-type: none"> <li>Change in average number of jobs accessible to travelers within 45 minutes on transit across all origin TAZs</li> </ul>	Travel/4 Model	<ul style="list-style-type: none"> <li>Extracted using M-NCPPC-owned script for average number of jobs accessible</li> </ul>
	<ul style="list-style-type: none"> <li>Support for regional growth</li> </ul>	<ul style="list-style-type: none"> <li>Change in population and employment (jobs filled) to account for growth that is reallocated and stimulated to zones adjacent to transit compared to the 2045 BAU</li> </ul>	Travel/4 Model, Regional Dynamic Model and GIS for visualization	<ul style="list-style-type: none"> <li>Use of Regional Dynamic Model</li> </ul>
Environmental Resilience	<ul style="list-style-type: none"> <li>Reduced transportation greenhouse gas emissions and environmental impacts</li> </ul>	<ul style="list-style-type: none"> <li>Change in VMT, reported as changes in greenhouse gas emissions and local pollutants (CO<sub>2</sub> emissions per mile, hydrocarbons, exhaust carbon monoxide, exhaust nitrogen oxides)</li> </ul>	Travel/4 Model	<ul style="list-style-type: none"> <li>Change in VMT extracted from Travel/4 is used to estimate reduction in pollution based on emission rates multiplied by the grams of emission/pollutant per VMT</li> </ul>
Montgomery County Equity	<ul style="list-style-type: none"> <li>Improved EFA access to jobs</li> </ul>	<ul style="list-style-type: none"> <li>Change in average number of jobs accessible to travelers within 45 minutes on transit from Equity Focus Areas</li> </ul>	Travel/4 Model	<ul style="list-style-type: none"> <li>Extracted using M-NCPPC-owned script for average number of jobs accessible</li> </ul>

## FINANCIAL DIMENSION

The financial dimension poses the core question, “**What are the financial impacts of each option?**” It focuses solely on the lifecycle cash flow impacts of delivering the project, which are discounted using a financial discount rate—in this case over a sixty-year horizon. The analysis employs a financial discount rate of 6.4 percent per year and an inflation rate of 2.3 percent per year.<sup>1</sup> The modeling employs the following process:

- The model estimates revenue in 2045 and scales it down to ‘opening day’ (which varies by option) based on a growth rate derived from the 2015 and 2045 business as usual model runs. Change in revenue is assumed to be equal to an average assumed fare multiplied by the change in a service’s ridership. Growth is capped after 15 years of operations (for example, if an option were to begin operation in 2025, its growth would be capped in 2055).
- Costs are estimated for each year of the 60-year operating lifecycle as well as an initial capital delivery phase. Renewal costs—costs incurred to replace expired components of the option throughout the analyses 60-year lifecycle—are also included. Table 6 depicts financial metric outputs per option and network. Table 7 provides a description of each metric and its derivation. Initial benchmarking costs (pre-analysis costs) are described in the “Options’ Service and Costing Assumptions” section of this appendix.

Table 6. Financial Dimension Performance Outputs

Metric	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension	New Frederick Rail Connection	Managed Lanes Enhanced Commuter Bus	Network Package One	Network Package Two	Network Package Three
Capital (millions) <sup>1</sup>	\$1,193	\$1,423	\$894	\$1,596	\$2,962	\$706	\$2,540	\$2,223	\$1,960
Renewals (millions) <sup>1</sup>	\$74	\$101	\$245	\$446	\$828	\$189	\$505	\$457	\$421
Operating (millions)	\$360	\$170	\$490	\$282	\$862	\$990	\$1,183	\$1,102	\$866
Fare Revenue (millions)	\$30	\$57	\$128	\$66	\$293	\$282	\$314	\$279	\$254
Net Present Value (millions)	\$-1,596	\$-1,637	\$-1,500	\$-2,257	\$-4,358	\$-1,604	\$-3,915	\$-3,502	\$-2,994
Revenue / Cost Ratio	0.08	0.33	0.26	0.24	0.34	0.28	0.27	0.25	0.29

<sup>1</sup>The economic and financial dimensions apply different discount rates, resulting in different cost values across the two dimensions

Table 7. Financial Dimension Metrics

Category	Consideration	Description	Source
Costs	Capital and renewal costs	Total costs to deliver option infrastructure and renew it over the 60-year evaluation period	Benchmarking – See Options’ Service and Costing Assumptions section of appendix
	Operating costs	Total costs incurred for day-to-day operations and maintenance	Benchmarking – See Options’ Service and Costing Assumptions section of appendix
Revenue	Fare revenue	Change in revenue due to the delivery of the new option	Travel/4 Model: change in ridership multiplied by average fare
Financial Indicators	Revenue / operating cost ratio	Illustrates the relative value of incremental revenue to incremental operating costs	Revenue / Operating Costs
	Net present value	Illustrates the value of an investment	Present value of cash inflows less the present value of cash outflows over the life the investment, in this case a sixty-year horizon.

**Both the financial and economic dimension analyses build upon capital and operating cost benchmarking. At the time of this writing, Planning staff are working with the Montgomery County Department of Transportation to update cost evaluations for bus and heavy rail. . The initial calculations are based on local and national benchmarks from the Eno Center for Transportation and are sufficiently reasonable for the purposes of the comparative analysis; however, updates will be presented following the initial release of the appendices on November 9, 2021, as an addendum, to provide further detail.**

## ECONOMIC DIMENSION

The economic dimension asks the core question, “**What are the overall financial impacts of the corridor in economic terms accounting for societal benefits?**” The dimension focuses on the lifecycle benefits and costs of each option over a 60 year period. Like the financial analysis, all benefits and costs are discounted; however, the economic dimension applies a social discount rate of 4.0 percent per year. Note that this discount rate differs from the discount rate applied in the financial analysis. Table 8 depicts economic metric outputs per option and network. Table 9 provides a description of each metric and its derivation.

Table 8. Economic Dimension Performance Outputs

Metric	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension	New Frederick Rail Connection <sup>3</sup>	Managed Lanes Enhanced Commuter Bus	Network Package One	Network Package Two	Network Package Three
Capital and Renewal Costs (millions) <sup>1</sup>	\$1,250	\$1,500	\$1,110	\$1,990	\$3,690	\$870	\$2,980	\$2,620	\$2,330
Operating Costs (millions)	\$330	\$160	\$460	\$260	\$800	\$930	\$1,110	\$1,030	\$810
Transit Travel Time Savings (millions)	\$180	\$590	\$330	\$200	\$470	\$560	\$1,300	\$1,250	\$1,140
Auto Travel User Impacts - Operating and Decongestion (millions)	\$190	\$410	\$90	\$110	\$410	\$340	\$840	\$850	\$870
GHG Reductions (millions)	\$10	\$20	\$4 <sup>2</sup>	\$5 <sup>2</sup>	\$20	\$10	\$30	\$30	\$30
Air Quality Improvements (millions)	\$20	\$40	\$10	\$10	\$40	\$30	\$80	\$80	\$90
Reduced Collisions (millions)	\$130	\$270	\$60	\$80	\$270	\$220	\$560	\$560	\$580
Improved Health (millions)	\$10	\$20	\$20	\$10	\$20	\$30	\$60	\$60	\$50
Cost to Benefit Comparative Indices	0.33	0.81	0.33	0.19	0.27	0.66	0.70	0.78	0.88
Net Present Value (millions)	-\$1,056	-\$320	-\$1,055	-\$1,828	-\$3,255	-\$608	-\$1,212	-\$814	-\$392

<sup>1</sup>The economic and financial dimensions apply different discount rates, resulting in different cost values across the two dimensions

<sup>2</sup>Values are rounded to the nearest million as benefits are less than \$10 million

<sup>3</sup>Economic assessment examines monorail as mode for New Frederick Rail Connection as it is assumed to be lower cost than light rail



Table 9. Economic Analysis Assumptions

Considerations	Assumption	Value
Start of appraisal	Start year of appraisal (usually current year)	2021
Appraisal length (in years)	Capital delivery and 60 years of operation	60
Start of operations	Start year of operations	Different for each alternative – See Options Assumptions beginning on page [x]
Length of growth cap period	A cap is usually applied to real inflation. This is length (in years) after start of appraisal.	15 years after opening day for operations
Year growth cap is achieved	Year that growth cap is implemented	2060
Social discount rate	A social discount rate	4.00%
Real inflation rate	Assumed price increase above inflation for cost-related items	1.00%
Ridership Growth rate	Assumed annual growth rate drawn from demand model	1.46%

The general process used to calculate the economic performance of each option follows:

1. Set out operating, capital, and renewal costs for each year of the appraisal, including an initial construction period followed by a 60-year operating period;
2. Extract change in travel time and automobile VMT from the Travel/4 Model for 2015 and 2045;
3. Estimate a growth rate (using VMT and travel time references) between the 2015 and 2045 model runs; apply the rate through to the cap year of 2060;
4. Estimate annual travel time savings and automobile VMT changes for each year in the appraisal period (60 years) using the growth rate assumptions;
5. Monetize change in travel time and VMT for each year using the unit rate factors included in Table 10;
6. Apply a social discount rate starting in 2022 to discount each annual benefit and cost to express each option's performance in real 2021 USD. Each year is discounted by multiplying a given year's performance by the following equation  $[1 / (1 + \text{social discount rate})^{(\text{year} - 2021)}]$ .

Table 10. Economic Analysis Unit Rate Sources

Parameter	Notes	Value in 2021	Unit
Value of Time (VOT)	Personal value of time. <a href="#">Source page 33/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a>	\$17.37	2021 USD per person hour
VOT Growth Rate	Source: <a href="#">page 14/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a>	0.00%	Percent change
Increased physical activity (walked)	<a href="#">page 125/199 of Metrolinx Business Case Manual Volume 2: Guidance</a>	\$1.93	2021 USD per mile walked
Auto operating cost savings	Source: <a href="#">page 34/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a> – used light duty vehicles	\$0.45	2021 USD per Mile
Reduced collisions (safety benefits) - injury	Source: <a href="#">page 32/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a> – cost of injury	\$2,991,57	2021 USD
Reduced collisions (safety benefits) - death	Source: <a href="#">page 32/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a> – cost of death	\$12,710,763	2021 USD
Deaths - Value per VMT		\$0.234	2021 USD per auto VMT reduction
Injury - Value per VMT		\$0.115	2021 USD per auto VMT reduction
GHG value (CO2)	source: <a href="#">page 35/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a>	\$0.021	2021 USD per auto VMT reduction
Direct PM 2.5	Source for emissions per VMT: <a href="#">Bureau of Transportation Statistics</a> , value per metric tonne drawn from <a href="#">page 35/42 of Benefit-Cost Analysis Guidance for Discretionary Grant Programs (US DOT)</a>	\$0.03	2021 USD per auto VMT reduction
NOx		\$0.02	2021 USD per auto VMT reduction
Decongestion	Metrolinx Manual Volume 2: Guidance. 2019	\$0.104	2021 USD per auto VMT reduction

**Regarding initial “Cost to Benefit Comparative Indices”:** Based on allocated resources for Corridor Forward, the Cost to Benefit Comparative Indices do not include all of the specific criteria and methodologies for cost-benefit analyses prescribed by the Federal Transit Administration (FTA). For example, the FTA analyses methodologies also suggest accounting for additional benefits beyond what is included in the subject planning level analysis, such as property tax revenue increase. These types of analyses are typically completed when a project is advanced further beyond master planning, such as during alternatives analyses or facility planning. Initially, previous staff reports prepared for Planning Board consideration referred to this metric as benefit-to-cost ratio (BCR), but to reduce confusion for those in the industry who expect this metric to include more sophisticated bottom-up engineering estimates and tax revenue growth analyses, this comparative metric is now referred to as a “cost to benefit comparative index.”

## IMPLEMENTATION DIMENSION

The implementation dimension poses the core question “**What constraints and challenges would need to be accounted for to successfully deliver and operate the transit option?**” This dimension focuses on exploring the overall feasibility of each option in a general high-level manner. While the other dimensions use quantitative inputs, the implementation dimension is primarily a qualitative analysis (with some support from geographic information systems [GIS] to inform understanding). As such, this is a planning-level assessment, that provides an understanding of—at a high-level—general constraints and challenges that could impact the delivery, operation, and success of an option. The implementation dimension considers five different domains. Each of these domains was assigned a low, medium-low, medium, medium-high, and high risk value. Then, based on these combined values, staff applied an overall risk assessment value to each transit option. The five domains are discussed below.

- 1. Roles and Responsibilities** – Who are the strategic stakeholders (and/or likely stakeholders) and what would their role be in advancing, delivering, or operating an option? Options with a greater number of stakeholders, fewer jurisdictions, and fewer private interests were deemed less complex and received more favorable score assignments.
- 2. Decision-Making** – What is the likely political decision-making process required to advance the project into subsequent stages of development? Options with more direct or well-understood paths of advancement through the political and funding processes were deemed less complex and thus received more favorable score assignments.
- 3. Feasibility Assessment** – Describe the infrastructure necessary to support an option. Options with more complex infrastructure needs, such as tunnels or targeted elevation, were deemed more complex and received less favorable score assignments. This domain considers grade crossings, operations and maintenance needs, and at a high-level, right-of-way needs—including air rights. This analysis was informed with a GIS desktop analysis.
- 4. Operating Model** – Who would most likely operate this facility? Do they have the capacity to manage operations? Would complex operating agreements be necessary? Options with existing operators and interjurisdictional MOUs and processes that secure support for operations were assigned more favorable scores. Options that do not exist today, or would require new inter-jurisdictional coordination, or potentially a private-sector operating arrangement scored less favorably.
- 5. Spatial/External Impacts** – At a high-level and based on spatial analysis, what are the historic, equity, environmental, and utility impacts associated with the project? A desktop GIS analysis informed the score assignments for this domain. Staff placed simple buffers around the options’ study alignments and summarized the number of potential impacts for each option.

Table 11 summarizes the implementation dimension’s score assignments across each domain. **Individual risk profiles created to inform score assignments and the spatial/external impacts summary will be provided as a forthcoming addendum to this appendix.**

Table 11. Implementation Dimension Performance Outputs for 2045 Modeling

<b>Metric</b>	<b>Enhanced MARC Rail</b>	<b>Red Line Extension</b>	<b>Corridor Cities Transitway</b>	<b>Purple Line Extension</b>	<b>New Frederick Rail Connection</b>	<b>Managed Lanes Enhanced Commuter Bus</b>
<b>Overall Risk Assessment</b>	<b>Moderate-High</b>	<b>Moderate-High</b>	<b>Low-Moderate</b>	<b>Moderate-High</b>	<b>Moderate</b>	<b>Low-Moderate</b>
Roles & Responsibilities Risk Level	High	High	Low-Moderate	High	Moderate	Moderate
Decision-Making Risk Level	High	High	Moderate	High	Moderate	Low-Moderate
Feasibility Assessment Risk Level	Moderate	High	Moderate	High	Moderate-High	Moderate
Operating Model Risk Level	Low	Low	Low	Moderate	Moderate	Low
Spatial/External Impacts Risk Level	High	Low-Moderate	Low-Moderate	Low-Moderate	Low-Moderate	Low

## OPTIONS' SERVICE AND COSTING ASSUMPTIONS

### ENHANCED MARC RAIL

Table 12. Enhanced MARC Rail Assumptions Profile

Assumed Opening Year in RDM and Financial Modeling <sup>1</sup>		Total End to End Run Time		
2035		<ul style="list-style-type: none"> <li>• Pattern A - Brunswick to Union Station, 96 Minutes</li> <li>• Pattern B – Frederick to Union Station Express Service, 105 minutes</li> <li>• Pattern C – Martinsburg to Union Station, 132 minutes</li> </ul>		
<b>Tested Alignment</b>	Retains existing alignment of Brunswick Line, with segments of additional mainline track in locations noted in MTA's 2018 <i>MARC Rail Cornerstone Plan</i> including segments between the District and Silver Spring, Garrett Park and the Monocacy River, and the entire Frederick Branch (approximately 45.8 miles). Tests three service patterns contemplated by MTA's 2018 <i>MARC Rail Cornerstone Plan</i> Adds two additional stations in at Shady Grove Metrorail and White Flint across all three programmed service patterns (shown in Table 13). See Figure 4 for depiction of alignment.			
<b>Frequencies</b>	15 minute peak hour headways for stations served by all three service patterns. See Table 14 and Table 15 for tested frequencies and a hypothetical morning service schedule (supplied to demonstrate how the service could be run).			
	Unit Rate(s)	Benchmark Source(s)	Unit Rate Application	Total Estimated Cost <sup>2</sup>
<b>Capital Costs: Guideway Related Infrastructure</b>	\$27.54 million per mile	2018 MTA <i>MARC Rail Cornerstone Plan</i> estimates for additional mainline track on Brunswick and Camden lines; 2020 Eno Center for Transportation Capital Construction Database reporting on Denver Regional Transportation District Gold G Line and San Francisco eBART Extension	45.8 miles of guideway and associated infrastructure	\$1.3 billion
<b>Capital Costs: Vehicles</b>	\$8.87 million per locomotive \$5.04 million per rail car	Locomotive: 2015 MTA MARC Rail and 2020 New Jersey Transit locomotive purchases Rail cars: 2011 MTA MARC Rail and 2019 New Jersey Transit rail car purchases.	9 diesel locomotives 39 rail cars	\$79.9 million
<b>Operational Costs</b>	\$24.87 per revenue mile	2019 National Transit Database, MTA MARC Reporting	856,076 miles of annual revenue service provided by the option	\$22.6 million annually

<sup>1</sup> Opening year assumptions do not reflect actual anticipated dates of opening but are required to capture impacts within the model horizon for the comparative assessment and financial modeling. Thus, 2035 is assumed as the opening year of more complex options to allow for ten years of impact, whereas 2030 is assumed as the opening year of bus options.

<sup>2</sup> All costs converted from source year into 2021 dollars. Total costs precede financial and economic dimension analyses, which account for discounting and inflation across a time-horizon.

Figure 4. Enhanced MARC Rail Alignment (Regional Scale)

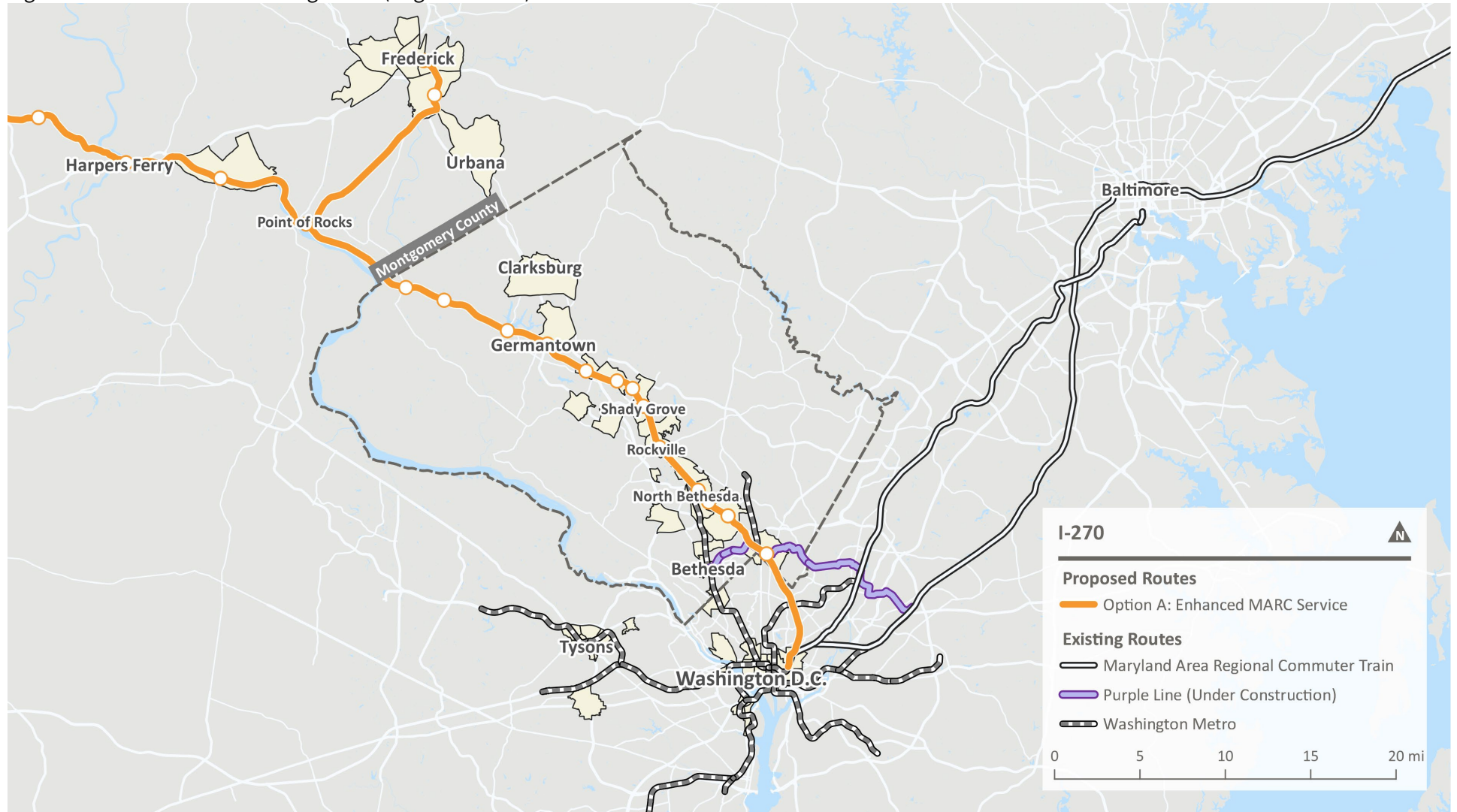


Table 13. Enhanced MARC Rail Tested Service Patterns

Station	Pattern A – Local Service	Pattern B – Frederick Express	Pattern C – Martinsburg Express
Martinsburg			C
Duffields			C
Harpers Ferry			C
Brunswick	A		C
Frederick		B	
Monocacy		B	
Point of Rocks	A	B <sup>1</sup>	C
Dickerson	A		
Barnesville	A		
Boys	A		
Germantown	A	B	C
Metropolitan Grove	A	B	C
Gaithersburg	A	B	C
Washington Grove	A		
Shady Grove <sup>2</sup>	A	B	C
Rockville	A	B	C
White Flint <sup>2</sup>	A	B	C
Garrett Park	A		
Kensington	A		
Silver Spring	A	B	C
Union Station	A	B	C

<sup>1</sup> Today, the Frederick spur from the Metropolitan Branch Subdivision is south of Point of Rocks. Currently, MARC Brunswick Line service to Frederick cannot serve Point of Rocks; however, per the service patterns shown on MTA’s 2018 *MARC Rail Cornerstone Plan*, a connection is envisioned. This Plan assumes this connection is possible for testing purposes.

<sup>2</sup> New stations are assumed at Shady Grove and White Flint for testing purposes as these stations are master-planned today. This Plan assumes that if the state were to make wholesale improvements to MARC mainline track, the investment would be grounds to allow the provision of new stations at master-planned locations, which today is contradictory to CSX Transportation policy.

Table 14. Enhanced MARC and Annual Revenue Miles and Tested Headways

Day	Service Pattern	1-way (miles)	Trips/day <sup>1</sup>	Days / year	Miles / year	Early AM (5-7am)	AM Peak (7-930am)	Mid-day (930-3pm)	PM Peak (3-7pm)	Evening (7-11pm)	Late Night (11pm-1am)
Mon-Fri	A - Brunswick to Union Station [inbound]	49.6	11	251	136,946	30	30	180	180	-	-
	B - Frederick to Union Station [inbound]	56.6	7	251	99,446	60	60	180	180	-	-
	C - Martinsburg to Union Station [inbound]	74.0	7	251	130,018	60	60	180	180	-	-
	A - Union Station to Brunswick [outbound]	49.6	11	251	136,946	180	180	180	30	-	-
	B - Union Station to Frederick [outbound]	56.6	7	251	99,446	180	180	180	60	-	-
	C - Union Station to Martinsburg [outbound]	74.0	7	251	130,018	180	180	180	60	-	-
Sat	A - Brunswick to Union Station [inbound]	49.6	3	52	7,738	-	-	180	180	-	-
	B - Frederick to Union Station [inbound]	56.6	3	52	8,830	-	-	180	180	-	-
	C - Martinsburg to Union Station [inbound]	74.0	3	52	11,544	-	-	180	180	-	-
	A - Union Station to Brunswick [outbound]	49.6	3	52	7,738	-	-	180	180	-	-
	B - Union Station to Frederick [outbound]	56.6	3	52	8,830	-	-	180	180	-	-
	C - Union Station to Martinsburg [outbound]	74.0	3	52	11,544	-	-	180	180	-	-
Sun & Holiday	A - Brunswick to Union Station [inbound]	49.6	3	62	9,226	-	-	180	180	-	-
	B - Frederick to Union Station [inbound]	56.6	3	62	10,528	-	-	180	180	-	-
	C - Martinsburg to Union Station [inbound]	74.0	3	62	13,764	-	-	180	180	-	-
	A - Union Station to Brunswick [outbound]	49.6	3	62	9,226	-	-	180	180	-	-
	B - Union Station to Frederick [outbound]	56.6	3	62	10,528	-	-	180	180	-	-
	C - Union Station to Martinsburg [outbound]	74.0	3	62	13,764	-	-	180	180	-	-
<b>Totals</b>				365	856,076						

<sup>1</sup>Trips per day are based on the frequencies shown on the right side of the table.



Table 15. Hypothetical Morning Service Schedule (Supplied for Ease of Understanding)

<b>Eastbound (5:00AM – 9:00AM)</b>	<b>Pattern A</b>	<b>Pattern B</b>	<b>Pattern A</b>	<b>Pattern C</b>	<b>Pattern A</b>	<b>Pattern B</b>	<b>Pattern A</b>	<b>Pattern C</b>	<b>Pattern A</b>	<b>Pattern B</b>	<b>Pattern A</b>	<b>Pattern C</b>	<b>Pattern A</b>	<b>Pattern B</b>
Martinsburg				4:55				5:55				6:55		
Duffields				5:11				6:11				7:11		
Harpers Ferry				5:20				6:20				7:20		
Brunswick	4:50		5:20	5:35	5:50		6:20	6:35	6:50		7:20	7:35	7:50	
Frederick		5:00				6:00				7:00				8:00
Monocacy		5:06				6:06				7:06				8:06
Point of Rocks	5:00	5:21	5:30	5:45	6:00	6:21	6:30	6:45	7:00	7:21	7:30	7:45	8:00	8:21
Dickerson	5:06		5:36		6:06		6:36		7:06		7:36		8:06	
Barnesville	5:11		5:41		6:11		6:41		7:11		7:41		8:11	
Boys	5:16		5:46		6:16		6:46		7:16		7:46		8:16	
Germantown	5:23	5:42	5:53	6:04	6:23	6:42	6:53	7:04	7:23	7:42	7:53	8:04	8:23	8:42
Metropolitan Grove	5:28	5:47	5:58	6:09	6:28	6:47	6:58	7:09	7:28	7:47	7:58	8:09	8:28	8:47
Gaithersburg	5:34	5:53	6:04	6:15	6:34	6:53	7:04	7:15	7:34	7:53	8:04	8:15	8:34	8:53
Washington Grove	5:37		6:07		6:37		7:07		7:37		8:07		8:37	
Shady Grove	5:39	5:57	6:09	6:19	6:39	6:57	7:09	7:19	7:39	7:57	8:09	8:19	8:39	8:57
Rockville	5:45	6:03	6:15	6:25	6:45	7:03	7:15	7:25	7:45	8:03	8:15	8:25	8:45	9:03
White Flint	5:50	6:08	6:20	6:30	6:50	7:08	7:20	7:30	7:50	8:08	8:20	8:30	8:50	9:08
Garrett Park	5:52		6:22		6:52		7:22		7:52		8:22		8:52	
Kensington	5:56		6:26		6:56		7:26		7:56		8:26		8:56	
Silver Spring	6:07	6:26	6:37	6:48	7:07	7:26	7:37	7:48	8:07	8:26	8:37	8:48	9:07	9:26
Union Station	6:26	6:45	6:56	7:07	7:26	7:45	7:56	8:07	8:26	8:45	8:56	9:07	9:26	9:45

Note: This is representative of what the above service could hypothetically look like in reality and is for informational/demonstration purposes only.

## RED LINE EXTENSION

Table 16. Red Line Extension Assumptions Profile

Assumed Opening Year in RDM and Financial Modeling <sup>1</sup>		Total End to End Run Time		
2035		15 minutes between Germantown Town Center and Shady Grove		
<b>Tested Alignment</b>	From its existing terminus in Shady Grove, the tested Red Line Extension option continues at-grade north adjacent to the CSX Transportation-owned Brunswick Line right-of-way, diverting into elevation at MD 118 in Germantown Town Center. The tested extension included stops at Olde Towne Gaithersburg, MD 124/Fairgrounds and Germantown Town Center. Figure 5 depicts the alignment at a regional scale.			
<b>Frequencies</b>	The option retains WMATA Metrorail existing pre-COVID frequencies for testing, as shown in Table 17 below.			
	Unit Rate(s)	Benchmark Source(s)	Unit Rate Application	Total Estimated Cost <sup>2</sup>
<b>Capital Costs: Guideway Related Infrastructure<sup>3</sup></b>	At-Grade: \$220.1 million per mile Elevated: \$223.3 million per mile	Benchmarks sourced from Eno Center for Transportation's 2020 Capital Construction Database. At-Grade: Average of three projects including WMATA Silver Line, Phase 1, WMATA Silver Line, Phase 2, and Bay Area Rapid Transit Warm Springs Extension. Elevated: Miami Dade Airport Link Metrorail Extension and Bay Area Transportation Coliseum Oakland Airport Line.	7 miles of at-grade service and .08 miles of elevated service	\$1.7 billion
<b>Capital Costs: Vehicles</b>	\$2.75 million per 8000 series railcar	2021 WMATA release on contract purchase of Hitachi 8000 series railcars	42 additional rail cars	\$115.5 million
<b>Operational Costs</b>	\$13.07 per revenue mile	2019 National Transit Database, WMATA Metrorail Reporting	770,297 annual revenue miles	\$10.7 million annually

<sup>1</sup> Opening year assumptions do not reflect actual anticipated dates of opening but are required to capture impacts within the model horizon for the comparative assessment and financial modeling. Thus, 2035 is assumed as the opening year of more complex options to allow for ten years of impact, whereas 2030 is assumed as the opening year of bus options.

<sup>2</sup> All costs converted from source year into 2021 dollars. Total costs precede financial and economic dimension analyses, which account for discounting and inflation across a time-horizon.

<sup>3</sup> Following the development of assumptions and cost-modeling, the Montgomery County Department of Transportation has requested Planning staff use only Silver Line Phase 1 as the Red Line Extension's capital cost benchmark with the rationale that it is both an elevated and at-grade running service constructed in local market conditions. While this is true, the Eno Center for Transportation's capital cost database includes costs that cover various inputs, including right-of-way acquisition, grade-crossings, operations and maintenance needs, etc. Increasing the number of benchmarks generalizes the differences of each capital project and works toward the law of averages. Despite this, staff agreed to update the analysis with the requested figure. This Appendix uses the initial reported benchmarks to build cost analyses in the financial and economic dimensions. An addendum to the appendix is forthcoming, which anticipates refinements to the Red Line's capital costs.

Figure 5. Red Line Extension Alignment (Regional Scale)

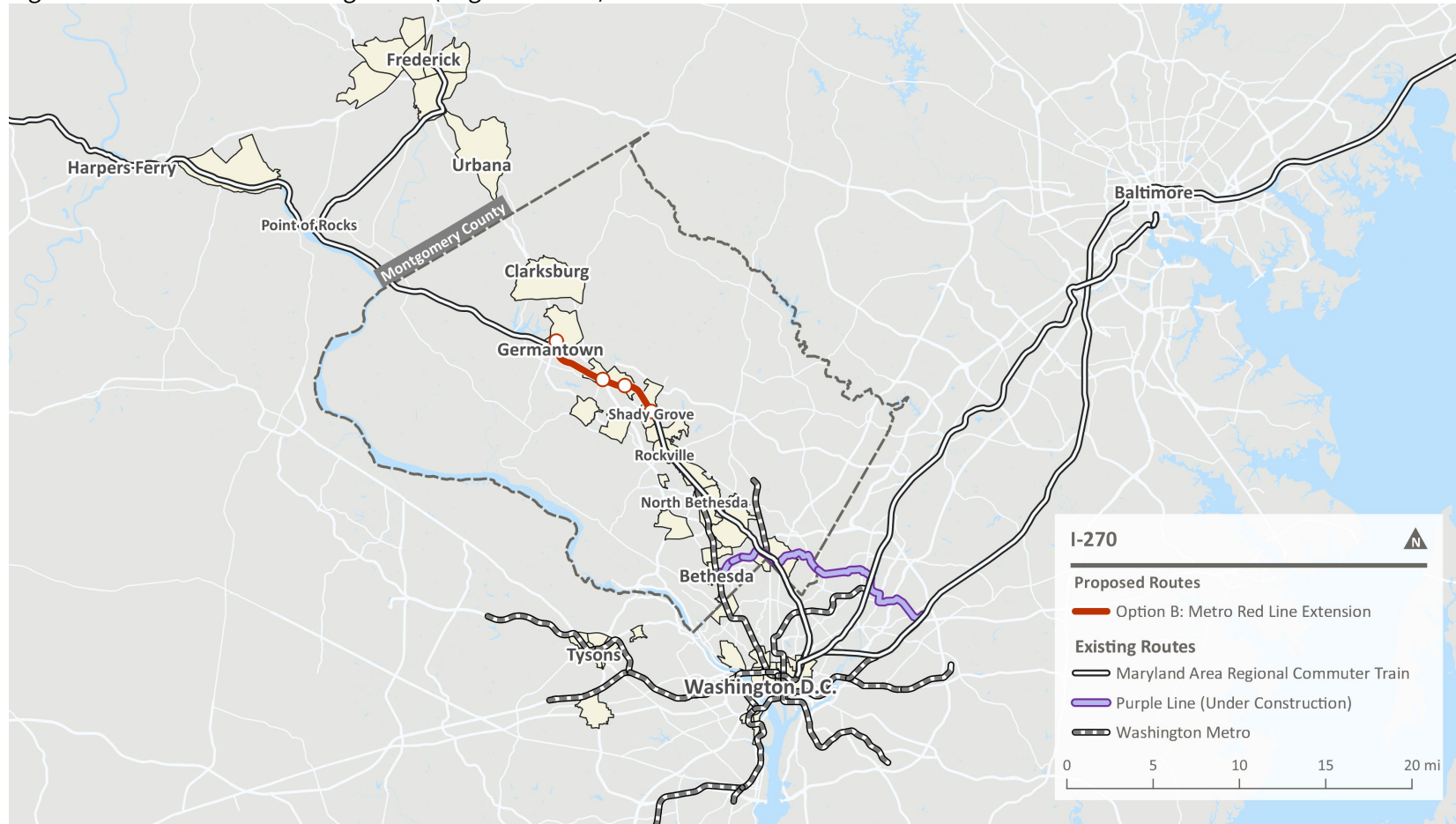
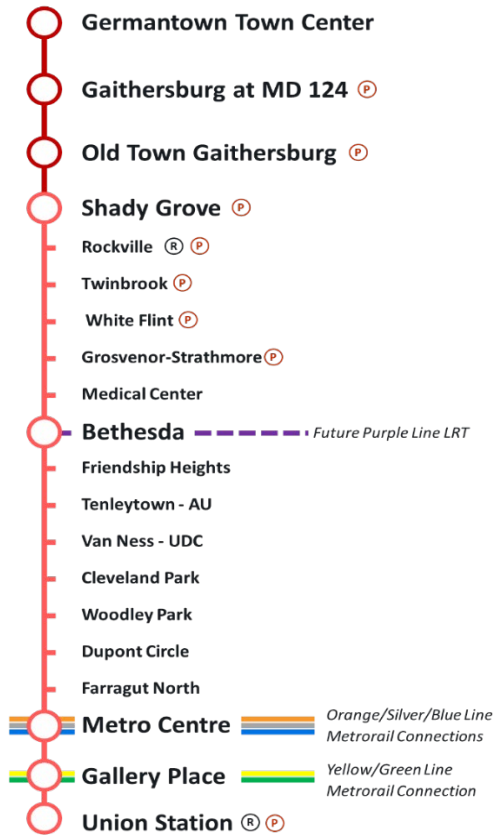


Table 17. Red Line Extension Miles Traveled and Headways

Day	2-way (mile)	Trips /day <sup>1</sup>	Days/year	Miles/year	Early AM (5-7am)	AM Peak (7-930am)	Mid-day (930-3pm)	PM Peak (3-7pm)	Evening (7-11pm)	Late Night (11pm-1am)
Mon - Thurs	15.6	160	201	501,696	6	6	6	6	15	-
Fri	15.6	164	50	127,920	6	6	6	6	15	15
Sat	15.6	84	52	68,141	-	12	12	12	15	15
Sun/Holiday	15.6	75	62	72,540	-	12	12	12	15	-
<b>Total</b>			<b>365</b>	<b>770,297</b>						

<sup>1</sup>Trips per day are based on the frequencies shown on the right side of the table.

Figure 6. Red Line Extension Illustrative Service Diagram



**Legend**

- Red Line Metro Extension (R) **MARC / AMTRAK Connection**
- Existing Red Line Metro (P) **Denotes Parking at Station**

## CORRIDOR CITIES TRANSITWAY

Table 18. Corridor Cities Transitway Assumptions Profile

Assumed Opening Year in RDM and Financial Modeling <sup>1</sup>		Total End to End Run Time		
2030		69 minutes between Shady Grove and COMSAT		
<b>Tested Alignment</b>	Assumes the 2017 Maryland Transit Administration Environmental Assessment alignment with both phases, including 17 stops between Shady Grove Metrorail and the COMSAT site in Clarksburg.			
<b>Frequencies</b>	Consistent with the 2017 Maryland Transit Administration's Environmental Assessment frequencies at five-minute peak hour headways. See Table 19 for full description of assumed frequencies.			
	<b>Unit Rate(s)</b>	<b>Benchmark Source(s)</b>	<b>Unit Rate Application</b>	<b>Total Estimated Cost<sup>2</sup></b>
<b>Capital Costs: Guideway Related Infrastructure<sup>3</sup></b>	\$62.26 million per mile	Average of two high-quality BRT services, including Cleveland Ohio's Healthline (less expensive) as reported in the Eno Center for Transportation's 2020 Capital Construction Database and the MTA's 2017 CCT Environmental Assessment (more expensive)	17 miles of at-grade service	\$1.1 billion
<b>Capital Costs: Vehicles</b>	\$1.08 million per high quality articulated bus	Average of the unit cost from two real purchases made by New Jersey Transit and Metrolink (Toronto) as well as the estimated total cost from the 2017 CCT Environmental Assessment divided by the assumed need of 35 buses.	35 high-quality articulated buses	\$37.9 million
<b>Operational Costs<sup>3</sup></b>	High: \$13.93 per revenue mile Low: \$6.70 per revenue mile	High: a national average of BRT operation costs reported to the 2019 National Transit Database  Low: MCDOT requested operations figure based on the US-29 combined mixed traffic/dedicated bus lane BRT service.	1,692,520 annual revenue miles	High: \$25.0 million annually Low: \$11.3 million annually

<sup>1</sup> Opening year assumptions do not reflect actual anticipated dates of opening but are required to capture impacts within the model horizon for the comparative assessment and financial modeling. Thus, 2035 is assumed as the opening year of more complex options to allow for ten years of impact, whereas 2030 is assumed as the opening year of bus options.

<sup>2</sup> All costs converted from source year into 2021 dollars. Total costs precede financial and economic dimension analyses, which account for discounting and inflation across a time-horizon.

<sup>3</sup> Following the development of assumptions and cost-modeling, the Montgomery County Department of Transportation has requested Planning staff use lower rates for bus rapid transit capital costs and operations. Staff agreed to update costs for the Managed Lanes Enhanced Commuter Bus option; however, because the CCT has been substantially studied by MTA, the initial rates are retained. Staff notes that if *only* the 2017 EA capital cost rate were used rather than the average of the CCT and the Healthline—staff's approved benchmark—the costs of the CCT would be greater. On the operations side, MCDOT requested the use of \$6.70 per revenue mile unit rate (2021 dollars) rather than the 2019 NTD based figure of \$13.93 per revenue mile. The requested \$6.70 figure is only \$0.58 greater than typical local bus service reported to the 2019 NTD. Based on the frequencies assumed by MTA for the CCT and tested for this effort, Planning staff feel the \$13.93 rate may be more appropriate but has agreed to provide a range. Note that in 2019, Montgomery County RideOn reported a \$9.20 per mile unit rate for local bus operations to the NTD for local bus service suggesting the \$6.70 figure may be optimistic. The current Appendix builds its financial analyses off of the high costs as these were the initial reference benchmarks for the project. An addendum to the appendix is forthcoming.



Figure 7. Corridor Cities Transitway Alignment (Regional Scale)

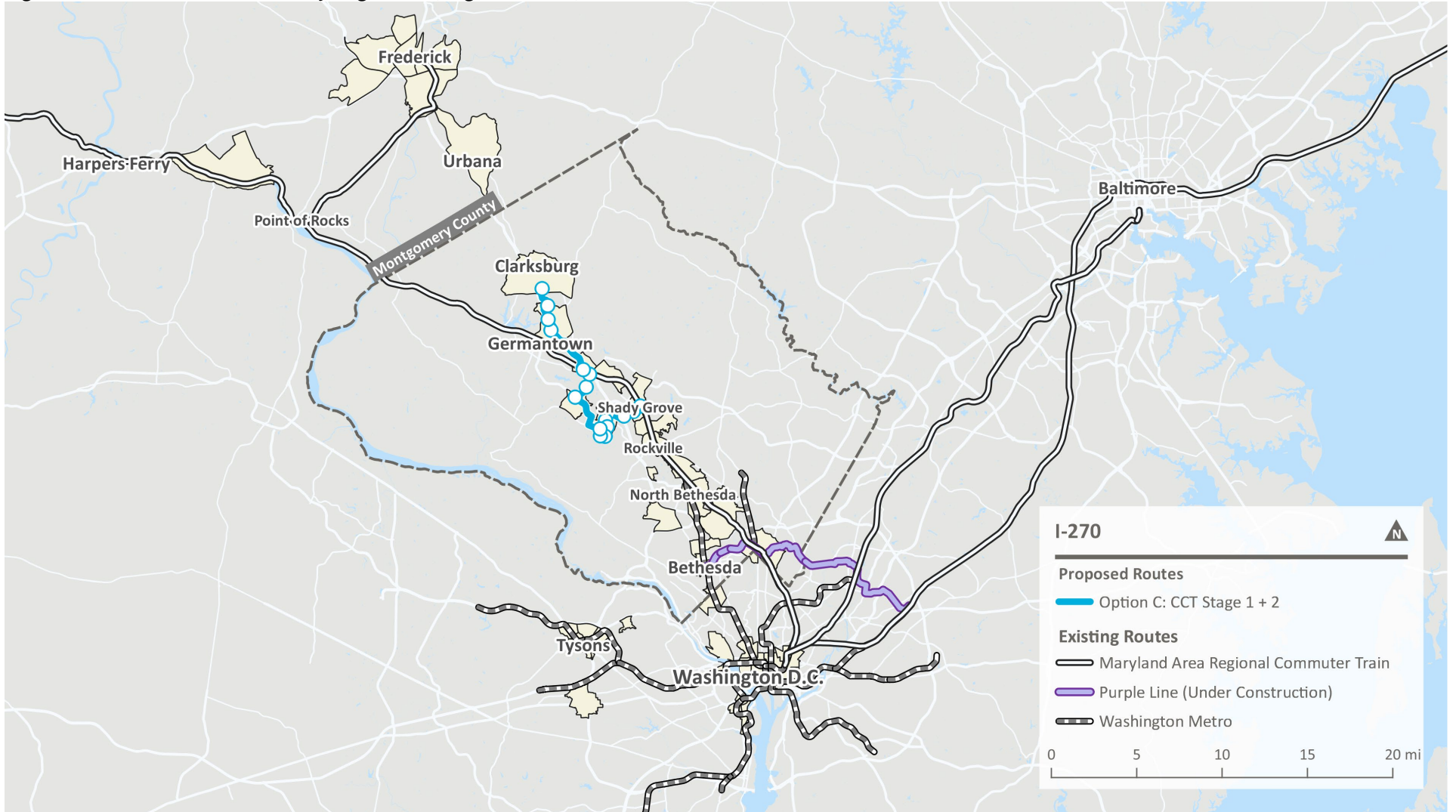
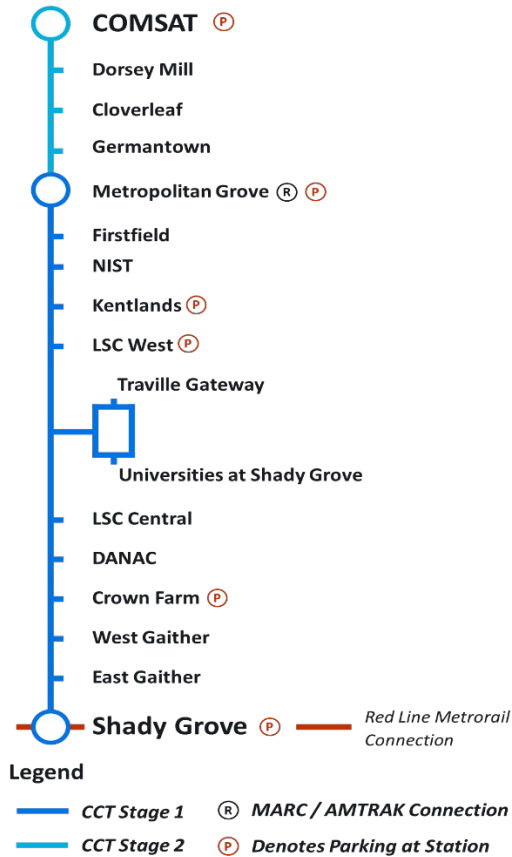


Table 19. Corridor Cities Transitway Miles Traveled and Headways

Day	2-way (mile)	Trips /day <sup>1</sup>	Day /year	Miles/year	Early AM (5-7am)	AM Peak (7-930am)	Mid-day (930-3pm)	PM Peak (3-7pm)	Evening (7-11pm)	Late Night (11pm-1am)
Mon - Thurs	34	156	201	1,066,104	10	5	10	5	10	10
Fri	34	162	50	275,400	10	5	10	5	10	10
Sat	34	96	52	169,728	-	10	10	10	15	15
Sun/Holiday	34	86	62	181,288	-	10	10	10	15	-
Total			365	<b>1,692,520</b>						

<sup>1</sup>Trips per day are based on the frequencies shown on the right side of the table.

Figure 8. Corridor Cities Transitway Illustrative Service Diagram



## PURPLE LINE EXTENSION

Table 20. Purple Line Extension Assumptions Profile

Assumed Opening Year in RDM and Financial Modeling <sup>1</sup>		Total End to End Run Time		
2035		33 minutes between Bethesda and Tysons		
<b>Tested Alignment</b>	In the westbound direction, the alignment follows the Capital Crescent Trail through Bethesda down to River Road below grade, then elevates to run at-grade along River Road until reaching the highway. Along the highway and into Tysons, the light rail is assumed to be elevated. There are four conceptual stops included in the model of the extension, located at River Road/Little Falls Parkway, River Road and MD-188, McLean Metrorail Station, and Tysons Metrorail Station.			
<b>Frequencies</b>	Assumed to be the same as the under-construction Purple Line. See Table 21 for a description of assumed frequencies.			
	<b>Unit Rate(s)</b>	<b>Benchmark Source(s)</b>	<b>Unit Rate Application</b>	<b>Total Estimated Cost<sup>2</sup></b>
<b>Capital Costs: Guideway Related Infrastructure</b>	At-grade: \$92.35 million per mile  Elevated: \$202.02 million per mile  Tunneled: \$410.40 million per mile	An average of systems by grade reported in the Eno Center for Transportation's 2020 Capital Construction Database.  At-grade: Link (Sound Transit, WA) Angle Lake Extension, Translink (British Columbia) Millenium Line Sky Train, Montreal REM Phase 1  Elevated: Phoenix (AZ) Valley Metro Gillbert Road Extension, Charlotte, NC Lynx Blue Line Extension, Sacramento Blue Line LRT Extension Ph 2, Minneapolis Metro Green Line LRT  Tunneled: Sound Transit U-Link (WA), Milan Line 5 Phase 2 (Milan, Italy)	11.6 miles total: 4.3 at-grade 7.0 elevated 0.3 tunneled	\$1.9 billion
<b>Capital Costs: Vehicles</b>	\$9.09 million per five-section light rail vehicle	Average of MTA LRV purchase (Purple Line) and Sound Transit Light Rail purchase	14 five-section light rail vehicles	\$127.2 million
<b>Operational Costs</b>	\$20.71 per revenue mile	National average reported to the 2019 National Transit Database, excluding outliers above the 90 <sup>th</sup> percentile and below the 10 <sup>th</sup> percentile.	805,829 annual revenue miles	\$17.7 million annually

<sup>1</sup> Opening year assumptions do not reflect actual anticipated dates of opening but are required to capture impacts within the model horizon for the comparative assessment and financial modeling. Thus, 2035 is assumed as the opening year of more complex options to allow for ten years of impact, whereas 2030 is assumed as the opening year of bus options.

<sup>2</sup> All costs converted from source year into 2021 dollars. Total costs precede financial and economic dimension analyses, which account for discounting and inflation across a time-horizon.



Figure 9. Purple Line Extension Alignment (Regional Scale)

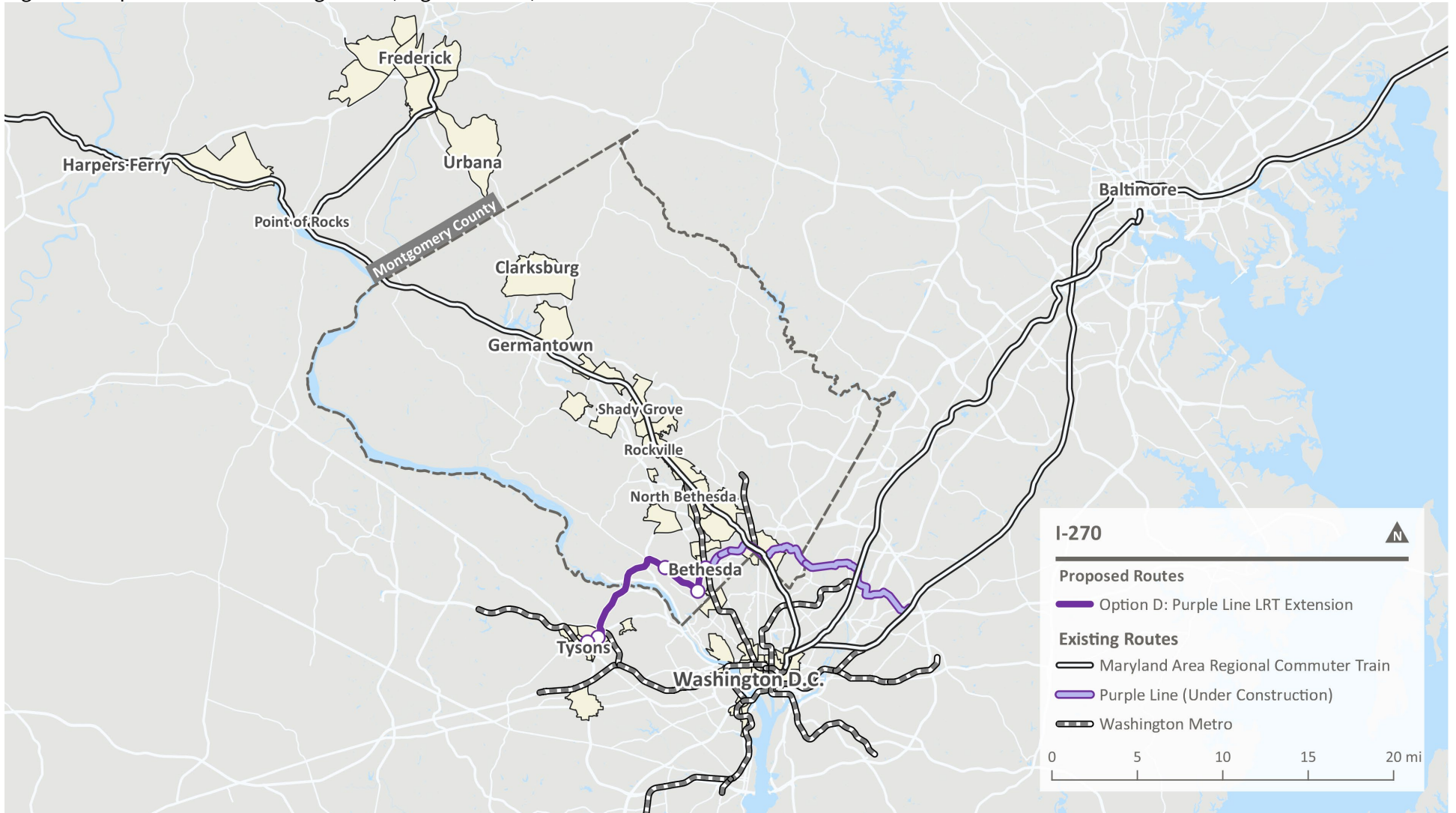
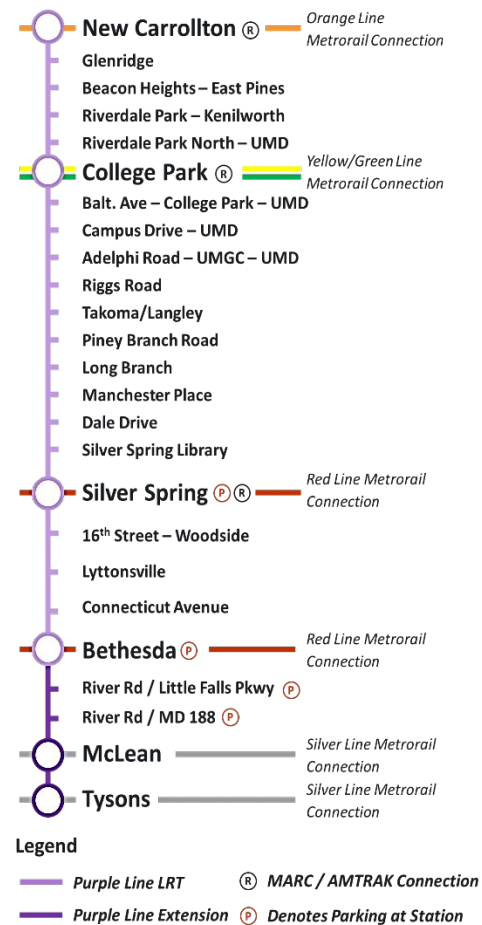


Table 21. Purple Line Extension Miles Traveled and Headways

Day	2-way (mile)	Trips /day <sup>1</sup>	Day /year	Miles /year	Early AM (5-7am)	AM Peak (7-930am)	Mid-day (930-3pm)	PM Peak (3-7pm)	Evening (7-11pm)	Late Night (11pm-1am)
Mon - Thurs	23.2	102	251	593,966	12	6	12	6	12	12
Fri	23.2	85	52	102,544	-	12	12	12	15	15
Sat	23.2	76	62	109,318	-	12	12	12	15	-
Sun/Holiday	23.2	102	251	593,966	12	6	12	6	12	12
<b>Total</b>			<b>365</b>	<b>805,829</b>						

<sup>1</sup>Trips per day are based on the frequencies shown on the right side of the table.

Figure 10. Purple Line Extension Illustrative Service Diagram



## NEW RAIL CONNECTION TO FREDERICK

Table 22. New Rail Connection to Frederick Assumptions Profile

Assumed Opening Year in RDM and Financial Modeling <sup>14</sup>		Total End to End Run Time		
2035		47 minutes between Downtown Frederick and Shady Grove, as consistent with MDOT's 2020 Monorail Feasibility Study+		
<b>Tested Alignment</b>	The tested alignment is the same as what MDOT assumed in its 2020 Monorail Feasibility Study, which generally follows the alignment of the highway with some service parallel to the CSX Brunswick Line. Stops include Urbana, COMSAT, Germantown, Metropolitan Grove and Shady Grove.			
<b>Frequencies</b>	Frequencies are also consistent with MDOT's 2020 Monorail Feasibility Study. See Table 23 for a full description of frequencies.			
	Unit Rate(s)	Benchmark Source(s)	Unit Rate Application	Total Estimated Cost <sup>15</sup>
<b>Capital Costs: Guideway Related Infrastructure</b>	Monorail, elevated: \$130.74 million per mile  Light Rail, elevated: \$202.02 million per mile	Monorail, elevated: MDOT Monorail Feasibility Study Capital Cost Estimate (excludes vehicles)  Light Rail, elevated: Phoenix (AZ) Valley Metro Gillbert Road Extension, Charlotte, NC Lynx Blue Line Extension, Sacramento Blue Line LRT Extension Ph 2, Minneapolis Metro Green Line LRT	27.4 miles (Elevated)	Monorail: \$3.5 billion  Light Rail: \$5.5 billion
<b>Capital Costs: Vehicles</b>	Monorail: \$6.40 million per three-section vehicle  Light Rail: \$9.09 million per five-section light rail vehicle	Monorail: MDOT Monorail Feasibility Study Capital Cost Estimate  Light Rail: Average of MTA LRV purchase (Purple Line) and Sound Transit Light Rail purchase	Monorail: 37 three-section vehicles  Light Rail: 20 five section vehicles	Monorail: \$236.9 million  Light Rail: \$181.73 million
<b>Operational Costs</b>	Monorail: \$18.85 per revenue mile  Light Rail: \$20.71 per revenue mile	Monorail: Average of two systems that report to 2019 National Transit Database (Seattle and Las Vegas)  Light Rail: National average reported to the 2019 National Transit Database, excluding outliers above the 90 <sup>th</sup> percentile and below the 10 <sup>th</sup> percentile.	2,705,914 annual revenue miles	Monorail: \$54.1 million  Light Rail: \$59.4 million

<sup>14</sup> Opening year assumptions do not reflect actual anticipated dates of opening but are required to capture impacts within the model horizon for the comparative assessment and financial modeling. Thus, 2035 is assumed as the opening year of more complex options to allow for ten years of impact, whereas 2030 is assumed as the opening year of bus options.

<sup>15</sup> All costs converted from source year into 2021 dollars. Total costs precede financial and economic dimension analyses, which account for discounting and inflation across a time-horizon.

Figure 11. New Rail Connection to Frederick Alignment (Regional Scale)

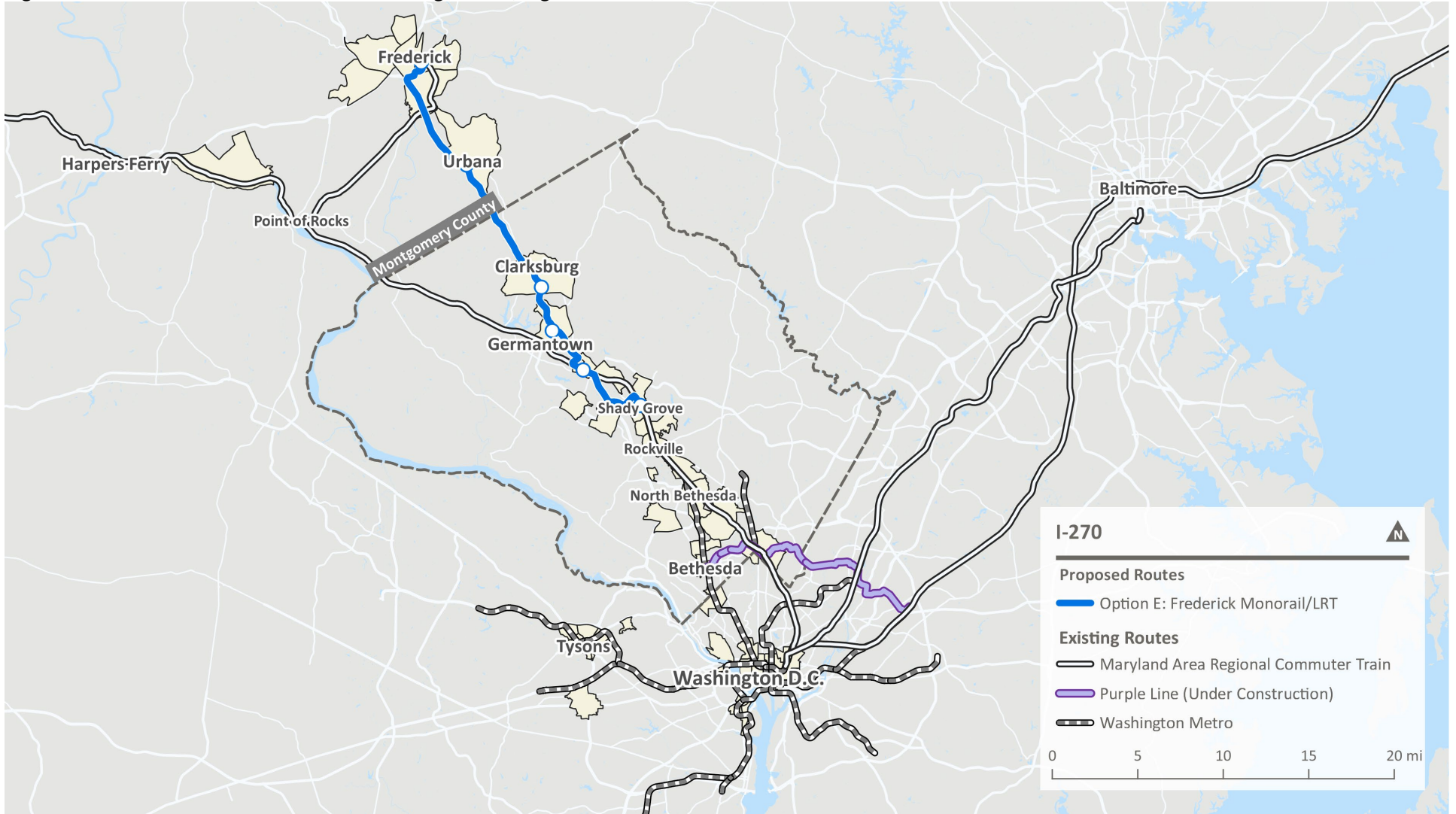
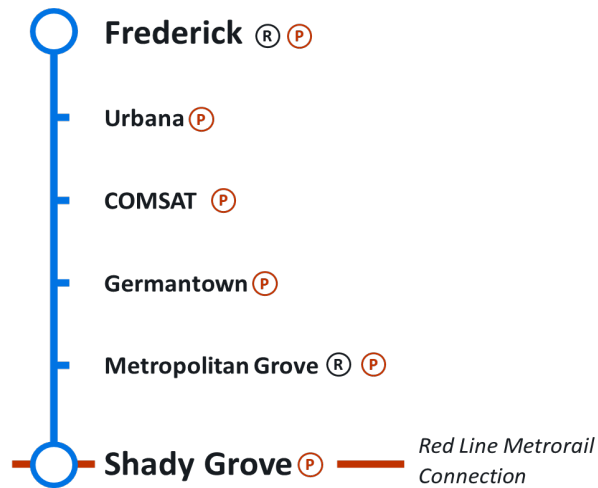


Table 23. New Rail Connection to Frederick Miles Traveled and Headways

Day	2-way (mile)	Trips /day <sup>1</sup>	Day /year	Miles/year	Early AM (5-7am)	AM Peak (7-930am)	Mid-day (930-3pm)	PM Peak (3-7pm)	Evening (7-11pm)	Late Night (11pm-1am)
Mon - Thurs	54.8	160	201	1,762,368	6	6	10	6	10	-
Fri	54.8	164	50	449,360	6	6	10	6	10	15
Sat	54.8	84	52	239,366	-	12	12	12	15	15
Sun/Holiday	54.8	75	62	254,820	-	12	12	12	15	-
Total			365	2,705,914						

<sup>1</sup>Trips per day are based on the frequencies shown on the right side of the table.

Figure 12. New Rail Connection to Frederick Illustrative Service Diagram



**Legend**

- Frederick Monorail / LRT
- R MARC / AMTRAK Connection
- P Denotes Parking at Station



## MANAGED LANES ENHANCED COMMUTER BUS

**Overview:** The Enhanced Commuter Bus Option (initially called “Corridor BRT” and sometimes referred to as “Option F”) was envisioned to support four different service patterns. The bus primarily runs in the planned managed lanes on I-270 with diversions onto local roads at key locations. A simple diagram of the four tested service patterns follows below in Figure 13. Staff was directed by the Planning Board during briefing #2 to address the needs of the CCT, (which were identified as serving the LSC and connecting Clarksburg and Germantown to the larger transit network) while also accommodating regional needs. This direction was the origin of this option.

The intent of service pattern A is to connect Frederick with the Life Sciences Center. In order to serve communities originally envisioned for CCT service and connect them more efficiently into the LSC, the bus diverts from the highway at Clarksburg Road and travels south on Observation Drive following the master-planned CCT route, including the highway bridge over Dorsey Mill. The bus returns to the highway at Middlebrook Road and diverts off the highway again at Gude Drive to reach the Life Sciences Center.

Service pattern B originates in Germantown at Montgomery College. The bus uses envisioned dedicated bus lanes on MD 118 to connect to the transit center before returning to the highway via the same route. It diverts again at MD 124 to serve Metropolitan Grove, returns to the highway, and then uses I-370 to reach the east side of the Shady Grove Road Metrorail station. The bus then remains off-highway, serving Montgomery College Rockville, Rockville Town Center, and Mt. Vernon Place, and is envisioned to use MD 355 BRT infrastructure to serve these locations. The bus turns into mixed traffic on Wootton Parkway to travel to Park Potomac before re-entering the highway at an assumed interchange on Wootton Parkway. The bus travels south, diverting from the highway to serve Rock Spring and a conceptual stop location at River Road (included for testing purposes only), before traveling into Northern Virginia. Staff solicited input from Fairfax County DOT on ongoing BRT plans, which helped inform routing in Tysons. Service pattern C follows the same routing as B, except that it originates in Montgomery Village, using envisioned dedicated lanes on MD 124. Some doubling back on MD 124 is assumed so connections could be provided to Metropolitan Grove.

Service pattern D is an express service originating in Downtown Frederick with stops at Urbana, Germantown Town Center (with off highway diversions into dedicated lanes on MD 118), Shady Grove Metrorail (via I-370 to the east side of the Metrorail), Rock Spring, a conceptual station at River Road (included for testing purposes only), and Tysons.

Because the option included dedicated bus lanes on Observation Drive as a component of service pattern A, staff altered the MD 355 BRT in the model to have two terminal legs in Clarksburg. Because service pattern A also allowed for a connection between MD 355 and the Life Sciences Center, staff extended the Montgomery College Rockville Veirs Mill BRT CLRP service pattern into the LSC. These decisions were made to maximize the potential of targeted infrastructure.

Following briefing #2, the Planning Board requested that staff de-emphasize this option as master plans typically do not include operational recommendations for things like commuter bus. However, the ultimately proposed network of dedicated bus lanes supports regional commuter bus service by including key connectors at MD 118, MD 124, and Gude Drive/MD 128. These connectors are intended to support local rapid transit service as well.

Table 24. Managed Lanes Enhanced Commuter Bus Assumptions Profile

Assumed Opening Year in RDM and Financial Modeling <sup>16</sup>		Total End to End Run Time		
2030		Pattern A – Downtown Frederick to the Life Sciences Center: 70 minutes Pattern B – Montgomery College to Tysons: 79 minutes Pattern C – Montgomery Village to Tysons: 75 minutes Pattern D – Downtown Frederick to Tysons Express: 115 minutes		
<b>Tested Alignment</b>	See overview above.			
<b>Frequencies</b>	6-7.5 minute headways during peak hours for locations served by multiple service patterns. See Table 25 and Table 26 for descriptions of frequencies and headways.			
	Unit Rate(s)	Benchmark Source(s)	Unit Rate Application	Total Estimated Cost <sup>17</sup>
<b>Capital Costs: Guideway Related Infrastructure<sup>18</sup></b>	High: \$62.26 million per mile <sup>5</sup> Medium: \$40.00 million per mile Low: \$6.00 million per mile	High: Average of two high-quality BRT services, including Cleveland Ohio’s Healthline (less expensive) as reported in the Eno Center for Transportation’s 2020 Capital Construction Database and the MTA’s 2017 CCT Environmental Assessment (more expensive) Medium: MCDOT supplied figure for median running BRT Low: MCDOT supplied figure for enhanced local bus	13.2 miles for off-highway infrastructure, excluding costs associated with the managed lanes <sup>19</sup>	High: \$819.2 million Medium: \$526.3 million Low: \$78.9 million
<b>Capital Costs: Vehicles</b>	\$1.08 million per high quality articulated bus	Average of the unit cost from two real purchases made by New Jersey Transit and Metrolink (Toronto) as well as the estimated total cost from the 2017 CCT Environmental Assessment divided by the assumed need of 35 buses.	43 high-quality articulated buses	\$46.6 million
<b>Operational Costs<sup>3</sup></b>	High: \$13.93 per revenue mile Low: \$6.70 per revenue mile	High: a national average of BRT operation costs reported to the 2019 National Transit Database Low: MCDOT requested operations figure based on the US-29 combined mixed traffic/dedicated bus lane BRT service.	3,421,992 annual revenue miles	High: \$50.6 million annually Low: \$22.9 million annually

<sup>16</sup> Opening year assumptions do not reflect actual anticipated dates of opening but are required to capture impacts within the model horizon for the comparative assessment and financial modeling. Thus, 2035 is assumed as the opening year of more complex options to allow for ten years of impact, whereas 2030 is assumed as the opening year of bus options.

<sup>17</sup> All costs converted from source year into 2021 dollars. Total costs precede financial and economic dimension analyses, which account for discounting and inflation across a time-horizon.

<sup>18</sup> Following the development of assumptions and cost-modeling, the Montgomery County Department of Transportation has requested Planning staff re-evaluate the rates used, and an addendum to this appendix is forthcoming.

<sup>19</sup> 13.2 miles include Snowden Farm Parkway/Stringtown Road; Observation Drive, Seneca Meadows, MD 118, MD 124, and a connection between MD 355 and the Life Sciences Center. Mileage from the original MD 355 BRT alignment on MD 355 is subtracted as the cost is reallocated to Snowden Farm.

Figure 13. Managed Lanes Enhanced Bus Alignment (Regional Scale)

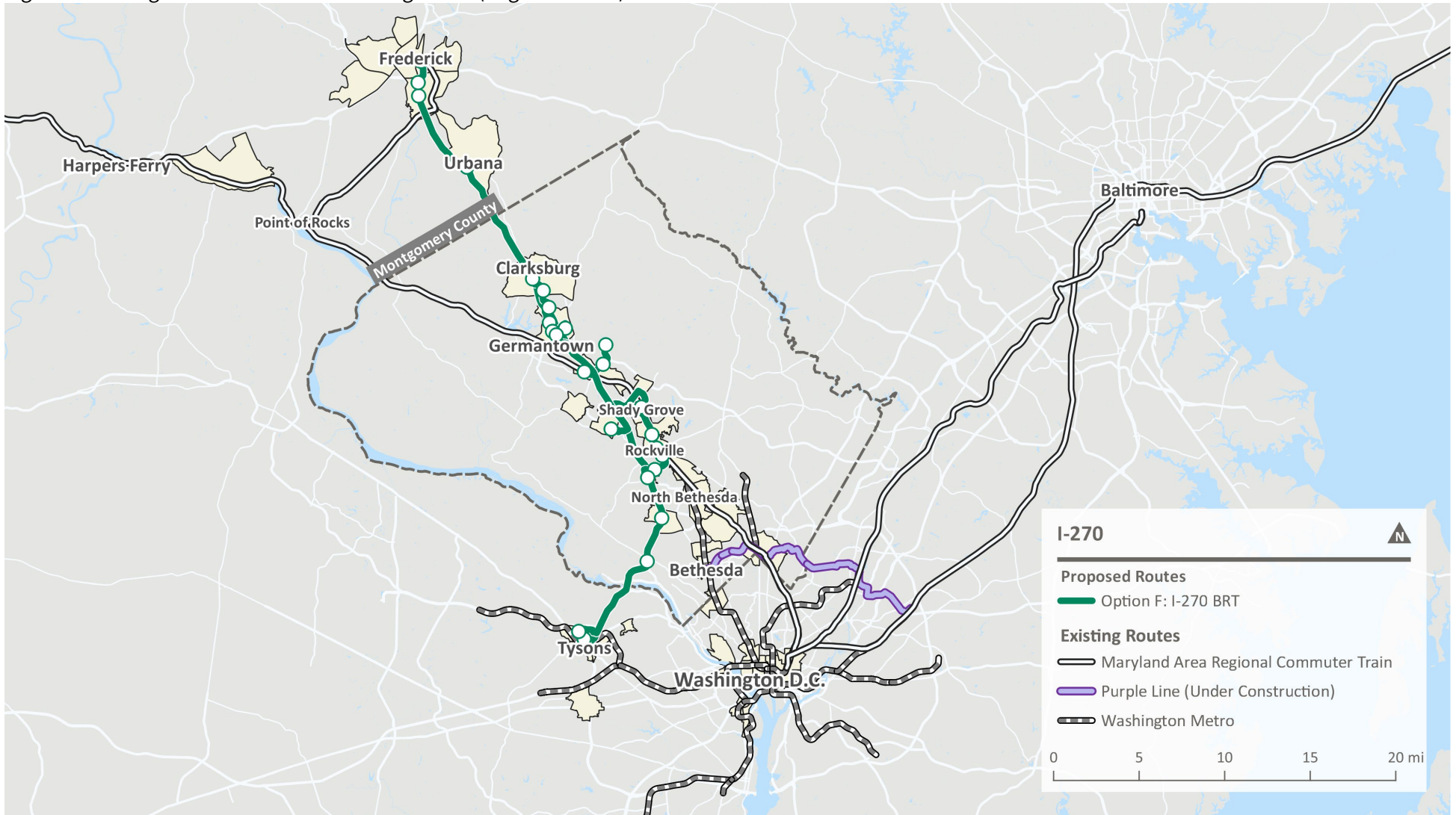




Table 25. Managed Lane Enhanced Commuter Bus Miles Traveled and Headways

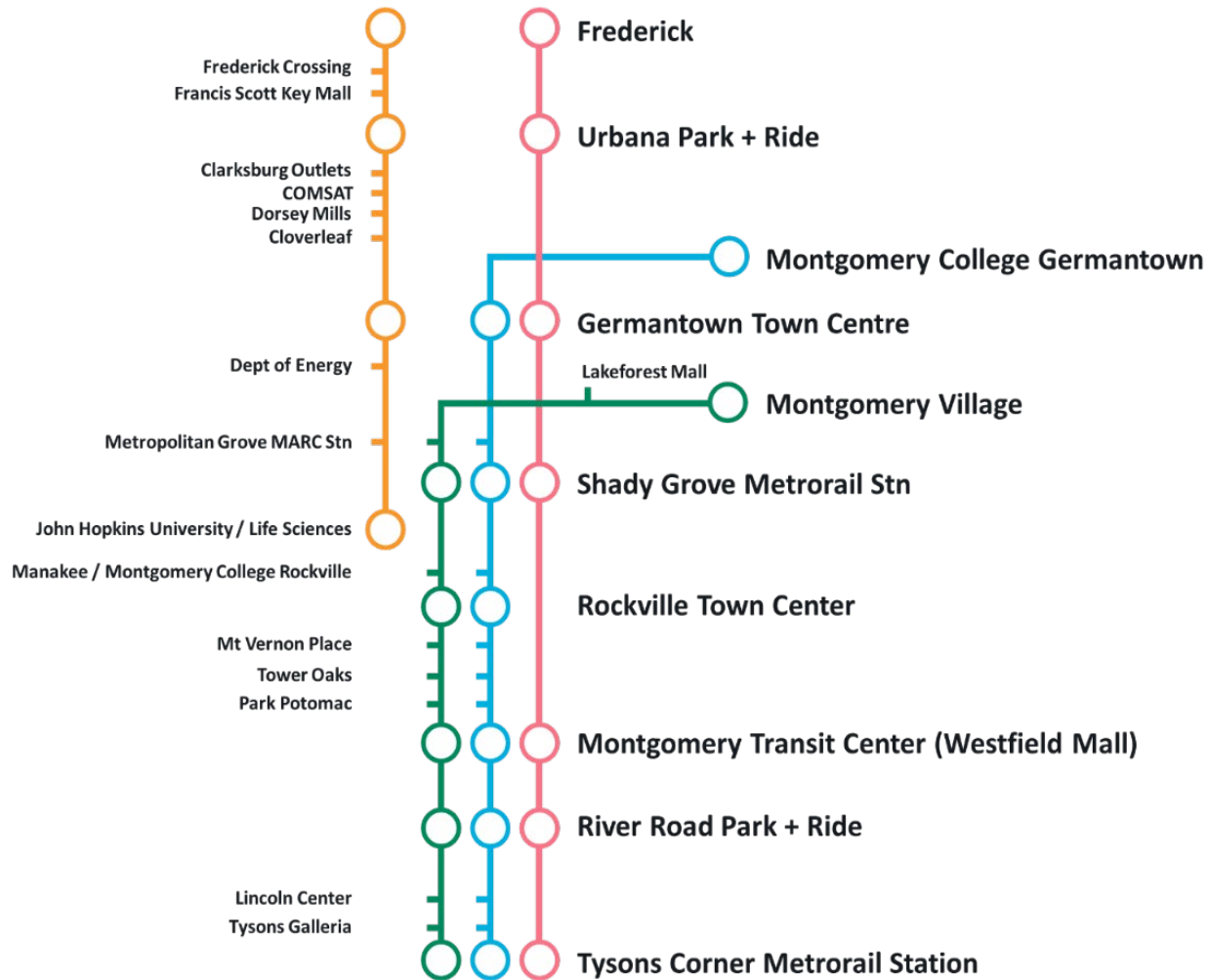
Day	Service Pattern	2-way (mile)	Trips /day <sup>1</sup>	Days /year	Miles/ year	Early AM (5-7am)	AM Peak (7-930am)	Mid-day (930-3pm)	PM Peak (3-7pm)	Evening (7-11pm)	Late Night (11pm-1am)
Mon - Thurs	A - Frederick to Life Sciences Center	57.2	26	201	298,927	60	30	60	30	60	60
	B - Mont. College Germantown to Tysons	64.0	52	201	668,928	30	15	30	15	30	30
	C - Montgomery Village to Tysons	57.8	52	201	604,126	30	15	30	15	30	30
	D - Frederick to Tysons Express	97.8	26	201	511,103	60	30	60	30	60	60
Fri	A - Frederick to Life Sciences Center	57.2	27	50	77,220	60	30	60	30	60	60
	B - Mont. College Germantown to Tysons	64.0	54	50	172,800	30	15	30	15	30	30
	C - Montgomery Village to Tysons	57.8	54	50	156,060	30	15	30	15	30	30
	D - Frederick to Tysons Express	97.8	27	50	132,030	60	30	60	30	60	60
Sat	A - Frederick to Life Sciences Center	57.2	18	52	53,539	-	60	60	60	60	60
	B - Mont. College Germantown to Tysons	64.0	30	52	99,840	-	30	30	30	60	60
	C - Montgomery Village to Tysons	57.8	30	52	90,168	-	30	30	30	60	60
	D - Frederick to Tysons Express	97.8	18	52	91,541	-	60	60	60	60	60
Sun/ Holiday	A - Frederick to Life Sciences Center	57.2	16	62	56,742	-	60	60	60	60	-
	B - Mont. College Germantown to Tysons	64.0	27	62	107,136	-	30	30	30	60	-
	C - Montgomery Village to Tysons	57.8	27	62	96,757	-	30	30	30	60	-
	D - Frederick to Tysons Express	97.8	16	62	97,018	-	60	60	60	60	-
	<b>Total</b>			365	<b>3,421,992</b>						

<sup>1</sup>Trips per day are based on the frequencies shown on the right side of the table.

Table 26. Managed Lanes Enhanced Commuter Bus Service Patterns and Headways

Station	Pattern A: Downtown Frederick to Life Sciences Center	Pattern B: Montgomery College Germantown to Tysons	Pattern B: Montgomery Village to Tysons	Pattern D: Frederick to Tysons Express	AM Headway (min)	AM Trips / Hr	PM Headway (min)	PM Trips / Hr
Downtown Frederick	A			D	15	4	30	2
Frederick Crossing	A				30	2	60	1
Francis Scott Key Mall	A				30	2	60	1
Urbana Park and Ride	A			D	15	4	30	2
Clarksburg Outlets	A				30	2	60	1
COMSAT	A				30	2	60	1
Dorsey Mills	A				30	2	60	1
Cloverleaf	A				30	2	60	1
Montgomery College Germantown		B			15	4	30	2
Germantown Town Center	A	B		D	7.5	8	15	4
Dept of Energy	A				30	2	60	1
Montgomery Village			C		15	4	30	2
Lakeforest Mall			C		15	4	30	2
Metropolitan Grove Station	A	B	C		6	10	12	5
Shady Grove Metrorail Station		B	C	D	6	10	12	5
Life Science Centre / JHU	A				30	2	60	1
Manakee/Montgomery College Rockville		B	C		7.5	8	15	4
Rockville Town Center		B	C		7.5	8	15	4
Mt Vernon Place		B	C		7.5	8	15	4
Tower Oaks		B	C		7.5	8	15	4
Park Potomac		B	C		7.5	8	15	4
Montgomery Transit Centre (Westfield Mall)		B	C	D	6	10	12	5
River Road Park + Ride		B	C	D	6	10	12	5
Lincoln Centre		B	C		7.5	8	15	4
Tysons Galleria		B	C		7.5	8	15	4
Tysons Metrorail Station		B	C	D	6	10	12	5

Figure 14. Managed Lanes Enhanced Commuter Bus Illustrative Service Diagram



## LAND AND RIGHT OF WAY NEEDS

The project team primarily used the Eno Center for Transportation’s 2020 Capital Construction Database to source benchmarks for capital construction costs. In some cases, these are supplemented by local resources including Maryland Transit Administration’s (MTA) 2018 *MARC Rail Cornerstone Plan*, MTA’s 2017 Environmental Assessment for the Corridor Cities Transitway, and the Maryland Department of Transportation’s (MDOT) 2020 Monorail Feasibility Study. In many cases, these sources account for right-of-way acquisition, operations and maintenance facilities, as well other capital needs. For example, the Silver Line Phase 1 and 2 benchmarks from Eno, which were used in the initial analysis, include the breakdowns shown in Table 27.

Table 27. Example Capital Cost Allocation within 2020 Capital Construction Database

	Guideway	Stations	Support Facilities	Sitework	Systems	ROW & Land Acquisition	Vehicles	Prof. Services	Contingency/ Finance Charge/ Other
<b>Silver Line Phase 1</b>	23%	13%	3%	9%	11%	2%	7%	31%	0%
<b>Silver Line Phase 2</b>	7%	9%	9%	27%	8%	2%	7%	24%	7%

While the benchmarks used help develop order of magnitude costs for evaluated options, the project team has received questions about right-of-way needs and acquisition costs. The team acknowledges that national benchmarks do not account for variation in land costs and that each benchmark project has its own contextual land acquisition needs. The project team also acknowledges that, per correspondence with the Montgomery County Department of Transportation, the County’s own Fiscal Impact Analysis associated with master plans does not account for right-of-way acquisition.

**The project team undertook a desktop analysis to develop a high-level assessment of additional land/right-of-way costs associated with the individual options and the Plan’s recommended network. The team anticipates updating capital costs identified in with these additional add-ons. Following revisions, this appendix will be updated with new values that account for these costs. As stated above, adding these costs may result in a conservative figure where benchmarks already partially or fully account for land needs.**

## OPERATIONS AND MAINTENANCE FACILITIES

For the purposes of the Plan’s high-level comparative analysis, staff first identified operations and maintenance facility (OMF) needs for each option. The project team acknowledges that there is no clean way of estimating OMF facility needs and that true bottom-up engineering costs would be determined if an option were to advance into facility planning. The project team developed planning-level costs by obtaining tax assessment data from the Maryland State Department of Assessments and Taxation (SDAT), Fairfax County, and using CoStar to assess recent property sales, where relevant and applicable. Table 28 provides the planning-level assumptions and costs associated with OMF facility needs.

Table 28. Operations and Maintenance Facility Land Need Assumptions and Costs

	<b>Enhanced MARC Rail</b>	<b>Red Line Extension</b>	<b>Corridor Cities Transitway</b>	<b>Purple Line Extension</b>	<b>New Frederick Rail Connection</b>	<b>Managed Lanes Enhanced Commuter Bus</b>	<b>Recommended Network</b>
<b>Assumed Land Needs</b>	23 Acres	70 acres	22 acres	9 acres	22 acres	26 acres	Red Line Extension: 70 acres  Near-Term Dedicated Bus Lanes: 26 acres
<b>Location</b>	Frederick and Brunswick - Expansion of Existing Yards	Germantown	Gaithersburg - Metropolitan Grove Vicinity	Tysons (Old Courthouse Road/Boone Boulevard Vicinity)	Gaithersburg - Great Seneca Creek Vicinity	Gaithersburg - Metropolitan Grove Vicinity	Red Line Extension: Germantown  Near Term Dedicated Bus Lanes: Metropolitan Grove Vicinity
<b>Assumption/ Source</b>	Location: Expansion locations noted in 2018 MARC Rail Cornerstone Plan  Size determined by creating a ratio of exiting trainsets to existing OMF acreage and applying the ratio to the new additional vehicle needs	Location: Likely would need to be Dept. of Energy or Montgomery College based on space requirements and existing subdivision patterns  Size determined by taking an average of the new Silver Line OMF (95 acres) and the existing Shady Grove OMF (45 acres). Assumes Shady Grove OMF remains operational.	Location and size: 2017 Corridor Cities Transitway EA. Size estimated based on 30 percent drawings and measurement in GIS.	Location determined via high level coordination with partner jurisdiction  Size determined by creating a ratio of procured trainsets to under-construction OMF acreage and applying the ratio to the new additional vehicle needs	Location: selected the more expensive of the two options called in 2020 MDOT Monorail Feasibility Study.  Size estimated in GIS based on MDOT graphic.	Location: Slight Expansion of 2017 Corridor Cities Transitway EA Location to support additional required vehicles	Combination of both Red Line Extension OMF needs and Managed Lanes Enhanced Commuter Bus Needs
<b>Planning-Level Land Costs for OMF<sup>1</sup></b>	\$19,000,000	\$105,000,000	\$33,000,000	\$36,000,000	\$23,000,000	\$39,000,000	\$144,000,000
<b>Assessment Notes</b>	Assumed agriculture parcel values in Brunswick; in Frederick, adjacent land is a mix of	No recent sales of similar properties. Each hypothetical property is owned by a government	Analysis considered assessed value of land and improvements on all vacant/empty	Multiple sales of properties in this area per CoStar. No property is 9 acres and as such,	All property in proposed location is parkland. No nearby sales of properties	Analysis considered assessed value of land and improvements on all vacant/empty	See notes for Red Line Extension and Managed Lanes Enhanced Commuter Bus.

	industrial and commercial properties. Near to Frederick and on highway.	institution. Assessed value is complicated	properties in location, DOT maintenance facilities, and Montgomery Abandoned Motor Unit property. Due to need to replace facilities, land value increased from \$1 million per acre to \$1.5 million per acre to be conservative.	consolidation would be required.	render assessed value complicated.	properties in location, DOT maintenance facilities, and Montgomery Abandoned Motor Unit property. Due to need to replace facilities, land value increased from \$1 million per acre to \$1.5 million per acre to be conservative.	
--	---	--	---	----------------------------------	------------------------------------	---	--

<sup>1</sup>All costs rounded to the nearest million

### **RIGHT-OF-WAY AND PROPERTY IMPACTS**

Staff undertook an additional analysis to assess land needs associated with the footprint of each option and the recommended network using geographic information systems (GIS), structure imagery, tax data from the State of Maryland and Fairfax County, and CoStar. For bus options, staff created roadway centerlines and created impact areas based on the footprint of options. For at-grade rail options (MARC and the Red Line), staff assumed buffers from the northbound and southbound Brunswick Line tracks—not the property line—based on sourced WMATA engineering specifications. The Red Line impact area assumes 62 additional feet of right-of-way are necessary, as measured from the southbound tracks. The MARC Rail impact area assumes 25 additional feet of right-of-way are necessary, as measured from the northbound track. It is important to note that the existing tracks’ distance from CSX Transportation’s property line varies (i.e. the tracks are not always completely centered within the private right-of-way).

Table 29. Right-Of-Way and Property Impacts

	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension	New Frederick Rail Connection <sup>5</sup>	Managed Lanes Enhanced Commuter Bus <sup>1</sup>	Recommended Network
Structures within impact Area, including structures of value and auxiliary, shed, and garage structures	91 structures	42 structures	33 structures	6 structures	0 structures	24-46 structures <sup>1</sup>	Red Line Extension: 42 structures  Recommended Dedicated Bus Lanes: 46 structures <sup>2</sup>
Total Properties Impacted (with and without structure impacts)	300	96	245	82	15	185	Red Line Extension: 96 properties  Recommended Dedicated Bus Lanes: 260 properties
Appx. Total of Additional Right-of-Way	20 acres beyond current CSX ROW <sup>3</sup>	21 acres beyond current CSX ROW <sup>3</sup>	114 acres <sup>4</sup>	4 acres, accounting for elevation and tunneling	Appx. 12 acres of air rights on private land; additional easement for columns	48 acres	Red Line Extension: 20 acres beyond current CSX ROW <sup>3</sup>  Recommended Dedicated Bus Lanes: 64 acres
Assessed Cost for Additional Right-of-Way and Property/Structure Impacts	\$160,000,000	\$140,000,000	\$39,000,000	\$72,000,000	\$1,000,000	\$16,000,000	\$215,000,000

<sup>1</sup>Assumes monorail spacing needs.

<sup>2</sup>For the Enhanced Bus Managed Lanes and Recommended Dedicated Bus Lanes, ranges are reported to account for flexibility in ROW alignment, repurposing, the ability to acquire right-of-way entirely from one side of the road vs. the opposite, etc.

<sup>3</sup>For the MARC option, a 25-foot wide buffer was applied to the northbound track. For WMATA a 62-foot wide buffer from the southbound track; both options assumes use of CSX Transportation’s property, which is not accounted for due to the complexity of existing operating agreements between CSX, MTA, and WMATA. This analysis includes land costs only, and use of private ROW is not included as a capital cost.

<sup>4</sup>Includes right-of-way needs for Observation Drive, Observation Drive Extension past Clarksburg Road to Frederick Road per Master Plans, Medical Center Drive Extended (not yet dedicated), ROW through MD Department of Natural Resources Great Seneca Creek area, segments adjacent to the CSX track, and Belward Leg (among other anticipated sliver takings).

<sup>5</sup>Analysis assumes monorail rather than light rail.

Table 30. Total Planning Level Land Costs

Costs	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension	New Frederick Rail Connection <sup>5</sup>	Managed Lanes Enhanced Commuter Bus <sup>1</sup>	Recommended Network
Planning-Level Land Costs for OMF	\$19,000,000	\$105,000,000	\$33,000,000	\$36,000,000	\$23,000,000	\$39,000,000	\$144,000,000
Assessed Cost for Additional Right-of-Way and Property/Structure Impacts	\$160,000,000	\$140,000,000	\$39,000,000	\$72,000,000	\$1,000,000	\$16,000,000	\$215,000,000
<b>Total</b>	<b>\$179,000,000</b>	<b>\$245,000,000</b>	<b>\$72,000,000</b>	<b>\$108,000,000</b>	<b>\$24,000,000</b>	<b>\$55,000,000</b>	<b>\$359,000,000</b>

Based on the various aspects of capital cost accounted for in utilized benchmarks, the analysis assumes that grade crossings are accounted for in all options (both bus and rail). Of note, the high capital cost benchmark for the CCT—which was included in the initial BRT unit rate developed for the project—includes two grade crossings. Averaging this with a national benchmark—the Cleveland Healthline—reduced the capital cost estimate of the CCT. In other words, this option’s capital cost for infrastructure is likely low rather than conservative. Table 31 lists the number of anticipated grade crossings associated with each option, including roadways, environmental features like Seneca Creek, and assumed pedestrian overpasses/underpasses.

Table 31. Anticipated Grade Crossings

	Enhanced MARC Rail	Red Line Extension	Corridor Cities Transitway	Purple Line Extension <sup>1</sup>	New Frederick Rail Connection <sup>1</sup>	Managed Lanes Enhanced Commuter Bus	Recommended Network
<b>Approximate Number Grade Crossings</b>	78	16	2	N/A <sup>1</sup>	Assumed to be entirely elevated	N/A <sup>1</sup>	Red Line Extension: 16  Recommended Dedicated Bus Lanes: 0

<sup>1</sup>Aside from the Purple Line Extension’s at-grade segment assumed along River Road, the Purple Line and New Frederick Rail Connections generally run in elevation or are tunneled and are excluded from this table.

## NETWORK EVALUATION

Following options analysis, the project team developed a series of network packages for Travel/4 travel demand modeling to better understand how selected transit options—or components of selected transit options—would perform as a larger network. Selected options were retained for inclusion in the network packages based on performance and policy direction.

- Enhanced MARC Rail:** This option was not advanced into the network package evaluation. While MARC Rail’s Brunswick Line service provides an important service, the additional resources necessary to obtain the additional main line track were not warranted based on performance, as compared with other options. Additionally, Montgomery Planning has only modest plans to grow densities near existing stations beyond mid-county. The Plan recommends continuing to absorb right-of-way for MARC expansion if and when possible, but de-emphasizes this option.



- **Red Line Extension:** While up-front costs are resource intensive and the option is challenging to implement, the Red Line Extension option performed well—relative to other options—at increasing regional and county trips. It also performed well at reducing VMT and is forecast to remove more VMT from roadways than the under-construction Purple Line between Bethesda and New Carrollton. The option is also forecast to increase the average number of jobs accessible for EFAs by over six percent and would be one of the less expensive options to operate. The option was retained for further evaluation.
- **Corridor Cities Transitway:** The Corridor Cities Transitway has been promised to Mid-county and Upcounty communities for decades. The transitway performed well in the 2045 forecast year and, relative to other options, is projected to add the greatest number of county transit trips (although regional benefits are more limited). However, its performance is dependent on the high frequency service programmed into the model. Existing conditions modeling work projected more limited gains were this option to be implemented today, which suggests the option’s future performance in 2045 is dependent on realizing forecasted growth. Per the project’s dynamic land use modeling, this appears reasonable. While the option is not without risk and had a relatively poor benefit to cost comparative index value, it was retained for further evaluation in the network package scenarios.
- **Purple Line Extension:** Based on cost, performance, and the sheer number of alignment alternatives that could be considered for a Purple Line Extension (beyond what was studied by Corridor Forward), the Purple Line was not retained for further evaluation in the network package scenarios. The Plan recommends that further study of travel demand is necessary to determine if and to where an extension may be warranted.
- **New Rail Connection to Frederick:** There is significant merit to developing a more direct rail connection between Downtown Frederick and Montgomery County’s rapid transit network. The option reduced the greatest number of daily VMT, edging out the Red Line, but the majority of the daily reduced VMT are from trips that originate in Frederick. While the Red Line and the New Rail Connection to Frederick generate approximately the same number of new regional transit trips, the Red Line Extension generated a greater share of Montgomery County transit trips. Considering initial costs were excessive despite minimal right-of-way acquisition costs (assuming a monorail mode), the option was not advanced. The Plan recommends county support of a more direct transit connection with Frederick, but suggests that it would be more appropriate for other jurisdictions to champion such a project.
- **Managed Lanes Enhanced Commuter Bus:** This option performed well, generating the greatest number of regional and county transit trips across all options—likely because of the long geographic span of service and high service frequencies assumed. However, VMT reductions lag behind the Red Line Extension and the New Rail Connection to Frederick. Based on the implementation analysis, it is likely easier to implement this option—assuming the managed lanes project advances. This option had the second highest cost benefit comparative index value, following the Red Line Extension.

Beyond the evaluation, policy also shaped the network packages. The Planning Board directed staff to consider the value of and alternatives to the CCT following the second board briefing on December 12, 2020. Following a public meeting in the summer of 2021, Council sent a memorandum, dated July 23, 2021, to Montgomery County Department of Transportation Director Chris Conklin requesting MCDOT work to consider how new transit routes can take

advantage of the managed lanes. The memorandum requests MCDOT to directly coordinate with Montgomery Planning on Option F (now referred to in the Plan and appendices as the “Managed Lanes Enhanced Commuter Bus” option).

In summary, based on performance and policy, staff retained the Red Line Extension and components of the CCT and Managed Lanes Enhanced Commuter Bus options in all network packages for further evaluation. Because staff anticipated questions about the feasibility of the Red Line Extension, each network package was also modeled *without* the Red Line Extension. Results, detailed under the “Recommended Package Without the Red Line” section demonstrate why pursuit of the Red Line Extension remains crucial despite implementation challenges.

Table 32 below describes the evaluated network packages. These packages fulfill both local and regional needs. The Red Line Extension and Managed Lanes Enhanced Commuter Bus option both generated regional and county transit trips. Both options connect to more locally-oriented rapid transit infrastructure, either the master-planned CCT or refined variants:

- Network package one includes the master-planned CCT.
- Network package two re-envisioned service to CCT communities by connecting Observation Drive with the MD 355 BRT, programming it and Snowden Farm Parkway in the model as alternating terminal service legs of the MD 355 BRT, and realigning Phase 1 of the CCT to Gude Drive in the south and Montgomery Village in the north. Staff reprogrammed the Veirs Mill BRT in the model, pulling it up along MD 355 and through to the Life Sciences Center on Gude Drive. The modeled service ultimately traverses around the Great Seneca vicinity—serving stop locations proximate to locations originally envisioned for CCT service—and terminates in Montgomery Village.
- Network Package Three provides more modest local rapid transit enhancements. The Life Sciences Center is served by extending the Veirs Mill Transitway via MD 355 BRT infrastructure and additional infrastructure on Gude Drive and connecting roadways. Observation Drive is added as an additional terminal leg of the MD 355 BRT. Because local transit infrastructure is reduced, this network scenario added an additional commuter bus line (service pattern A) between Frederick and the Life Sciences Center beyond the two service patterns provided in network packages one and two.

All packages consolidate Red Line Extension Service, MARC Rail service (formerly at Metropolitan Grove), and rapid transit stops into one node at MD 124/Fairgrounds.

Table 32. Description of Network Packages<sup>1, 2, 3</sup>

Description	Network Package 1	Network Package 2	Network Package 3
Red Line Extension to Germantown	Included	Included	Included
Corridor Cities Tranistway/Mid-County and Upcounty BRT Transit	Includes with the CCT’s Master-Planned Alignment	Phase II of the Master-Planned CCT removed; Observation Drive added as a terminal leg of the MD 355 BRT; Phase I of the Master-Planned CCT realigned to connect to Veirs Mill BRT and Montgomery Village. Both grade crossings are eliminated.	Observation Drive added as a terminal leg of the MD 355 BRT; dedicated bus lanes also added to connect the Life Sciences Center to Rockville and the Veirs Mill BRT.
Managed Lanes Enhanced Commuter Bus	Frederick – Tysons Express Service Pattern (D) Montgomery Village – Tysons Service Pattern (C)	Frederick – Tysons Express Service Pattern (D) Montgomery Village – Tysons Service Pattern (C)	Frederick – Tysons Express Service Pattern (D) Montgomery Village – Tysons Service Pattern (C) Frederick – Life Sciences Service Pattern (A)

<sup>1</sup>The Network Package analysis removes the originally tested stop at River Road.

<sup>2</sup>The Network Package analysis does not include an evaluation of the Manekin West Connector, which is ultimately included in recommended network package.

<sup>3</sup>The Network Package analysis was undertaken for the forecast year only—existing conditions modeling outputs are not available for the network packages.

Results of network package modeling can be found in the description of each performance dimension, see Table 3 Table 6 and Table 8.

Network package performance is generally comparable across network packages 1 and 2, with package 1 performing well generally, and package 2 providing greater benefits to equity focus communities. While the network packages were not modeled in existing conditions, results from the initial analysis suggests that the performance of the CCT in 2045 is predicated on the county achieving is forecasted land use growth, whereas network package 2 better integrates service to existing communities in addition to serving CCT communities. From a cost perspective, network package three offered the best value for resources expended based its cost benefit comparative index, with network package two offering the second best comparative index. From an implementation perspective neither network package 2 nor 3 require new interchanges over the I-270 at Dorsey Mill Road and Fields Road/King Farm Boulevard. These two networks also use MD 355 infrastructure as a north-south spine rather than create a north-south parallel roadway on the west side of the highway that is not programmed with stops. Network package two makes use of the CCT’s original concept design drawings (30-35 percent drawings) by retaining infrastructure along some segments of the originally planned CCT alignment. Network package 2 best served equity focus communities by improving local and regional transit access to Montgomery Village, and by creating the potential for a one-seat ride between the Life Sciences Center and EFAs like Wheaton and Twinbrook via Rockville Town Center.

## RECOMMENDED NETWORK RATIONALE

The recommended network is not fully reflective of any of the modeled options or packages; however, its infrastructure most closely aligns with Network Package 2. During its July briefing, the Planning Board directed staff to de-emphasize highway running bus service. In order to comply with this direction and still support the potential for efficient off-highway diversions to points of demand as well as support the primary purpose of enhancing local connectivity, the Plan recommends a series of dedicated bus lanes infrastructure, referred to in the Plan as Corridor Connectors, that can be programmed with a number of different service patterns. Table 33 details the difference between service and infrastructure.

Table 33. Infrastructure and Service

Dedicated Transit Lane Infrastructure	Transit Service Patterns
<ul style="list-style-type: none"> <li><b>Definition:</b> The physical components of a transit system, including dedicated or separated bus lanes, express bus lanes, and queue jumps.</li> <li><b>Responsible Agency:</b> Montgomery Planning master-plans right-of-way widths to ensure infrastructure accommodates transit, as well as other modes.</li> <li><b>How it is Planned:</b> Montgomery Planning considers existing and planned population and employment density, equity needs, the potential to stimulate economic development, and environmental benefits. Montgomery Planning plans infrastructure to support existing and future quality of life.</li> </ul>	<ul style="list-style-type: none"> <li><b>Definition:</b> How buses are routed and scheduled to use provided infrastructure.</li> <li><b>Responsible Agencies:</b> MCDOT and/or MTA develop and implement service patterns</li> <li><b>How it is Planned:</b> The agencies above develop service patterns that account for anticipated demand at the time of implementation, operational costs of services, and the opportunities and constraints of existing infrastructure.</li> </ul>

The Germantown, Lakeforest & Montgomery Village, and Life Sciences connectors proposed in the Plan each support commuter bus service and local rapid transit service. Enhanced commuter bus service running in the managed lanes can divert from the highway into dedicated lanes on these connectors to reach points of local demand. When paired with additional north-south connectors (Manekin West Connector, Milestone/COMSAT East Clarksburg Connector, and Great Seneca Connector) the numerous service patterns could be considered, including but not limited to:

- An extension of the Veirs Mill BRT into the Life Sciences Center
- MD 355 BRT service patterns with differing northern termini in the vicinities of Manekin, COMSAT, and the outlets via Snowden Farm
- An extension of the Veirs Mill BRT to Kentlands
- A one-seat ride connection between the Life Sciences Center and Montgomery Village
- A one-seat ride connection between the Clarksburg Outlets and the Life Sciences Center

The proposed infrastructure network offers the greatest potential to reduce implementation costs for service to CCT communities by removing grade separated interchanges, offers better value for money as compared to the original CCT by proposing dedicated bus lane infrastructure that can serve multiple purposes, and offers the strongest transit links to EFAs by better integrating Montgomery Village into the larger rapid transit network and by creating the potential for a one seat ride to the Life Sciences Center from points south in Twinbrook and Wheaton.

## NETWORK PACKAGES WITHOUT THE RED LINE

Through the individual option analysis, the Red Line extension demonstrated high benefits relative to the other options, but also high costs. As the Red Line extension was incorporated into the network package analysis, questions remained both about its feasibility and the potential benefits of the proposed transit network should the Red Line extension not be implemented. As a result, a complementary analysis was conducted to evaluate the benefits of the network packages without inclusion of the Red Line extension. The proposed transit network is a combination of Network Package 2 and Network Package 3, with minor additions based on policy direction.

The number of new transit trips in the region is a key metric applied to evaluate the individual transit options and network packages. In 2045, total network packages would generate between approximately 17,000 and 21,000 new daily transit trips. The supplemental analysis reveals that a significant portion of the new daily transit trips are dependent on the Red Line extension. Without the Red Line extension, the number of new transit riders would fall from by 43% (Network Package 1) to 59% (Network Package 3).

Table 34. New Transit Trips with and without the Red Line Extension (2045)

<b>New Transit Trips</b>	<b>Network Package 1</b>	<b>Network Package 2</b>	<b>Network Package 3</b>
Total Network Package	21,362	20,656	17,283
Network Package without the Red Line	12,131	11,350	7,109
Difference	9,231	9,306	10,174

Like new transit trips, vehicle miles traveled (VMT) is a metric used to evaluate the individual transit options and network packages. In 2045, the total network packages would reduce daily VMT by approximately 283,000 to 294,000 miles. The supplemental analysis reveals that a significant portion of the VMT reduction is dependent on the Red Line extension. Without the Red Line extension, the daily VMT reduction would fall by 65% (Network Packages 1 and 2) to 70% (Network Package 3).

Table 35. VMT Reductions with and without the Red Line Extension (2045)

<b>VMT Reductions</b>	<b>Network Package 1</b>	<b>Network Package 2</b>	<b>Network Package 3</b>
Total Network Package	283,196	284,997	293,670
Network Package without the Red Line	98,328	100,398	88,748
Difference	184,868	184,599	204,922

Context may aid understanding. Per the Final Environmental Impact statement for the Purple Line Light Rail project (currently under construction), the Purple Line is anticipated to reduce daily VMT by 129,828 miles. When modeled independently in the first phase of the project, the Red Line Extension was modeled to reduce regional VMT by approximately 157,400 daily miles. Because the Red Line accounts for approximately 65-70 percent of each network package's respective daily VMT reduction, and because it removes more miles from the roadway compared to existing under construction projects, it remains a compelling ambitious project.