Chapter 6. Evaluation of Alternatives

6.1. Approach

This chapter draws on the information and analyses presented in the previous chapters and features an evaluation framework involving the following:

- Effectiveness – the extent to which an alternative accomplishes the purposes that the transportation improvements are intended to address
- Cost-Effectiveness – the extent to which an alternative provides a level of benefits that is commensurate with its costs (and relative to other alternatives)
- Financial Feasibility – the extent to which sufficient funding is available or can be developed to support the construction, operation, and maintenance of an alternative
- Equity – the extent to which each alternative provides fair distribution of costs and benefits across various communities in the corridor

This evaluation framework is designed to support decision-making for the Washington metropolitan area, the State of Maryland, and the Federal Transit Administration (FTA), as it is expected that federal funding would be sought if one of the Build alternatives is selected for implementation. It has been followed in the belief that it provides both the quantitative and qualitative material needed for decision-making by a variety of groups in a manner that will successfully build a consensus among all concerned with selection and implementation of a Locally Preferred Alternative.

As presented in Chapter 1, improvements to the transportation system in the corridor need to address the following transportation challenges:

- Increasing congestion on the roadway system
- Slow and unreliable transit travel times on this congested roadway system
- Limited travel mode options for east-west travel
- Degraded mobility and accessibility between major activity centers and residential areas
- Degraded transit accessibility to the larger metropolitan region due to inferior connections to radial Metrorail lines and to other rail and bus services

Through extensive community and stakeholder outreach and the AA/DEIS technical analyses, a set of objectives and evaluation measures were developed for use in selecting the preferred transit investment in the corridor. These efforts identified that the consideration of transit improvements in the corridor was driven by factors beyond just mobility, accessibility, and transit operating efficiencies to include support of economic and community development, environmental quality and optimizing public investment. These can be summarized as follows:

- Increase mobility and improve accessibility
- Improve transit operations efficiencies
- Enhance environmental quality
- Optimize public investment
- Support local plans for economic and community development
- Support attainment of regional air quality standards

6.1.1. Federal New Starts Criteria Considerations

As discussed in Chapter 5, it is expected that FTA funds would be sought if one of the Build alternatives is selected for implementation. The study goals and objectives in part reflect the evaluation criteria established by the FTA for potential projects eligible for funding under the New Starts process. This is a competitive process whereby communities across the country compete for federal funding in starting new transit projects. The federal criteria and measures related to justifying the project are listed in Table 6-1.

In addition to the criteria above, the FTA considers the community's capacity to finance the proposed project. FTA has established a number of measures that help to assess financial capacity, including the following:

- Stability and reliability of capital financing plan
- Stability and reliability of operating financing plan
- Local share of proposed costs

The issue of financial capacity is not directly applicable to the evaluation of the merits of the specific alternatives and ranking one alternative above another; however, it can affect the decision on the overall affordability of an alternative if the cost of construction or operations and maintenance exceed likely available financial resources. It underscores the importance, as expressed in the project justification criteria related to operating efficiency and cost-effectiveness, of minimizing the costs of the alternatives relative to the transportation benefits they provide to the region.

6.2. Attainment of Goals and Objectives

A series of objectives were developed to support the goals described in Chapter 1 and summarized in Section 6.1. The objectives were based on FTA New Starts guidelines and recommendations from local agencies, stakeholders, and members of the public. The means of assessing how well the various alternatives do (or do not) meet the goals include a mix of quantitative measures of effectiveness and cost effectiveness, and qualitative

Table 6-1: FTA Project Justification Criteria and Measures

New Starts Criteria	Measures
Mobility Improvements	Travel Time Savings Transit Dependent Households Served
Environmental Benefits	EPA Air Quality Designation
Operating Efficiencies	Operating Cost per Passenger Mile
Cost-Effectiveness	Incremental Cost per Hour of Transportation System User Benefits Incremental Cost per New Rider
Transit-Supportive Land Use and Future Patterns	Existing Land Use Transit-Supportive Corridor Policies Performance and Impacts of Land Use Policies
Other Factors	Project Benefits not Reflected by Other New Starts Criteria

Source: New Starts: An Introduction to FTA's Capital Investment Program. US Department of Transportation, Federal Transit Administration.

assessments. The sources for these measures were MDOT/MTA, FTA New Starts Criteria, county and local jurisdictions and agencies, and corridor-specific needs and issues. The key measures, especially those that contribute substantially to differentiating among alternatives, are summarized in Table 6-2. This table presents information presented in the previous chapters. Some quantitative information presented in previous chapters is rounded here in order to simplify the presentation. In the sections that follow this information is discussed in regard to effectiveness, cost effectiveness, financial feasibility, and equity.

Table 6-2: Summary of Key Evaluation Measures for Alternatives

Objective	Evaluation Measure		No Build	TSM	Low Investment BRT	Med Investment BRT	High Investment BRT	Low Investment LRT	Med Investment LRT	High Investment LRT
Increase Mobility and Improve Accessibility										
• Improve accessibility to existing and planned economic development areas in the corridor • Improve access to jobs in corridor • Increase employers' access to labor pool	• User Benefits by Alternatives, 2030 (daily minutes)		--	401,200	623,700	851,200	994,200	1,033,700	1,098,200	1,211,8000
	• Percent over TSM		--	--	56%	112%	148%	158%	174%	202%
	• User Benefits with Mode-Specific Attributes by Alternatives, 2030 (daily minutes)		--	401,200	702,300	1,022,200	1,258,000	1,180,600	1,303,800	1,489,600
	• Percent over TSM		--	--	75%	155%	214%	194%	225%	271%
	• Accessibility of residents to employment: jobs within ¼ to ½ mile of stations		All alternatives have very similar alignments and station locations. Therefore, these accessibility measures are not a differentiating factor among the alternatives.							
	• Accessibility of employers to workers: households within ¼ to ½ mile of stations									
• Reduce travel time between activity centers:	• Peak transit travel times for alternatives in 2030 (minutes)	Current								
o Bethesda – Silver Spring		20	35	33	25	19	19	12	9	9
o Bethesda – Takoma/Langley Park		38	65	61	51	38	33	29	26	23
o Bethesda – UM Campus Center		49	81	76	66	49	40	38	34	30
o Silver Spring – Takoma/Langley		19	31	29	26	19	14	18	17	14
o Silver Spring – Riverdale Park		44	67	62	59	43	33	39	38	32
o Silver Spring – UM Campus Center		29	47	44	41	30	22	26	25	21
o Silver Spring-College Park Metro		36	56	53	52	36	28	32	31	27
o Takoma/Langley – Riverdale Park		25	36	34	33	24	19	22	22	19
o East Silver Spring – Silver Spring		5	8	8	8	7	5	7	7	4
o East Silver Spring – Takoma Langley		14	23	21	19	13	10	11	11	10
o New Carrollton – Riverdale Park		11	15	12	13	13	10	13	13	10
o New Carrollton – University of Maryland		25	35	30	31	25	21	25	25	21
o New Carrollton – Silver Spring		54	81	73	72	55	43	51	50	42
• Improve mobility for transit-dependent households	• Number of zero-car households within ¼ mile of stations		All alternatives have very similar alignments and station locations. Therefore, these accessibility measures are not a differentiating factor among the alternatives.							

Table 6-2: Summary of Key Evaluation Measures for Alternatives

Objective	Evaluation Measure	No Build	TSM	Low Investment BRT	Med Investment BRT	High Investment BRT	Low Investment LRT	Med Investment LRT	High Investment LRT
Improve Transit Operations Efficiencies									
• Increase interconnectivity of transit system, including bus-to-bus and bus-to-rail transfers	• Number of routes connecting at major transfer points	All alternatives have very similar station locations and connectivity to other transit services. Therefore, this connectivity measure is not a differentiating factor among the alternatives.							
• Integrate radial Metrorail and MARC lines for better transit system connectivity (also see below under Increase regional transit usage)	• Transfer walk time • Number of transfers required to access major activity centers	All alternatives have very similar service plans and station locations. Therefore, these transfer measures are not a differentiating factor among the alternatives, except that the BRT alternatives provide better connectivity with the existing bus facility at the Bethesda Metro Station.							
• Increase reliability of transit service	• Comparison of running way characteristics (miles):								
	o Dedicated	All shared	All shared 15.97	0.67	7.4	7.71	8.62	9.18	8.88
	o Exclusive			1.97	4.85	9.37	5.73	5.74	8.81
	o Shared (with traffic)			14.43	4.68	0.15	1.76	1.33	0.16
	• Comparison of vertical alignment type (miles):								
	o Aerial	All surface running	All surface 15.97	--	1.26	1.63	1.06	1.06	1.73
	o Surface			17.07	15.66	12.99	14.39	14.5	12.9
	o Tunnel			--	0.01	2.61	0.66	0.69	3.22
• Increase regional transit usage • Integrate radial Metrorail and MARC lines for better transit system connectivity	• Transit ridership (daily boardings)								
	o Purple Line	--	14,800	22,200	29,300	33,800	32,500	33,900	36,100
	o Purple Line via Metrorail	--	2,100	16,700	21,100	23,700	25,300	27,200	30,500
	o Purple Line via MARC	--	--	1,100	1,400	1,400	1,500	1,500	1,500
	Total	--	16,900	40,000	51,800	58,900	59,300	62,600	68,100
	New transit trips relative to No Build	--	8,200	11,400	15,300	17,700	18,200	19,200	20,500
	Percent new trips relative to No Build	--	--	14%	25%	29%	31%	32%	35%
• Reduce transit travel times in the corridor	• Change in operating speeds of transit service	--	9	10	13	16	15	16	19
	• Change in travel time between major activity centers	See objective “reduce travel time between activity centers” above.							
	• End-to-end peak period running times Bethesda to New Carrollton (minutes)	--	108	96	73	59	62	59	50
• Serve transit-oriented populations	• Number of zero-car households within ¼ and ½ mile of stations	All alternatives have very similar alignments and station locations. Therefore, these accessibility measures are not a differentiating factor between alternatives.							

Table 6-2: Summary of Key Evaluation Measures for Alternatives

Objective	Evaluation Measure	No Build	TSM	Low Investment BRT	Med Investment BRT	High Investment BRT	Low Investment LRT	Med Investment LRT	High Investment LRT
Enhance Environmental Quality									
• Minimize and mitigate impacts to the natural and human environment in the corridor • Provide a safe and attractive transit service that is compatible with local community character	• Direct impacts to natural resources	• All alternatives have very similar alignments and station locations, and as a result, the natural environment impacts are not appreciably different between alternatives. The Build alternatives would impact between 1 and 1.4 acres of wetland, 13.5 to 15.1 acres of floodplains, and 3,892 to 5,719 linear feet of stream.							
	• Direct impacts to parklands	• Up to 11 parks, five open space areas (schools) and five trails, could potentially to be impacted by a Build Alternative. • Individual park impacts are all less than an acre. Total impacts from the Build alternatives range from 1.98 acres for Low Investment LRT to 3.02 acres for Medium Investment BRT. • Individual open space (public school) impacts range from 0.05 acre to 1.65 acres except for impacts to the University of Maryland, which range from 7.02 acres to 13.91 areas. Total impacts to open space from the Build alternatives range from 7.38 acres for Medium Investment BRT Preinkert/Chapel Drive design option to 14.46 acres for Low Investment BRT. • Individual trail impacts range from 0.02 acre to 1.67 acres. Total impacts from the Build alternatives range from 1.29 acres for High Investment BRT Silver Spring/Thayer Avenue design option to1.85 acres for Medium Investment LRT.							
	• Direct impacts to historic properties	• All BRT and LRT alternatives except Low Investment BRT could impact one historic standing structure resources, the Falkland Apartments.							
	• Visual effects.	• All alternatives have nearly identical alignments and station locations and result is similar visual effects, with the most substantial visual effects being along the Georgetown Branch right-of-way. The Preinkert/Chapel Drive and Silver Spring/Thayer Avenue design options would present additional substantial visual effects.							
	• Direct residential property impacts (number of displacements)	• All of the Build alternatives require residential displacements. • Low Investment BRT has the fewest displacements (three single-family homes) while the High Investment BRT and LRT alternatives have the most residential displacements (ten single-family houses, several units from three buildings of two apartment complexes, and one duplex).							
Optimize Public Investment									
• Demonstrate that the overall benefits of the transit improvements warrant their capital and operating costs	• Total capital cost ($2007 in million)	--	$82	$386	$580	$1,088	$1,206	$1,220	$1,635
	• Annual operating and maintenance costs ($2007 in millions)	--	$14.6	$17.3	$17.3	$15.8	$26.4	$25.0	$22.8
	• Annual increase in operating subsidy ($2007 in millions)	--	$12.2	$14.0	$12.8	$10.6	$21.1	$19.4	$16.0
	• FTA cost-effectiveness measures (cost per hour of User Benefit)	--	--	$18.24	$14.01	$19.34	$26.51	$22.82	$23.71
	• Annualized cost per new rider relative to No Build	--	$8.98	$14.49	$14.29	$19.76	$22.96	$21.72	$24.57

Table 6-2: Summary of Key Evaluation Measures for Alternatives

Objective	Evaluation Measure	No Build	TSM	Low Investment BRT	Med Investment BRT	High Investment BRT	Low Investment LRT	Med Investment LRT	High Investment LRT
Support Local Plans for Economic and Community Development									
• Support local, regional, and state policies and adopted master plans	• Consistency with local, regional, and state policies and adopted master plans	• Only the LRT alternatives support the Montgomery County Master Plan, which calls for LRT between Bethesda and Silver Spring, with a trail along the Georgetown Branch right-of-way. All Build alternatives would support the Montgomery County Master Plan by constructing the permanent Capital Crescent Trail, although the Low Investment BRT alternative would not build the permanent trail west of Jones Mill Road. The Prince George's County Master Plan supports the Purple Line in general, but does not identify a specific alignment. Both Montgomery and Prince George's Counties are in the process of developing functional master plans for the Purple Line.							
• Support potential for transit-oriented development at existing and proposed stations in support of local land use plans	• Number and size of transit-oriented development opportunities • Potential for new development	• All alternatives have nearly identical alignments and station locations and similar volumes of service. Therefore, these development measures are not a differentiating factor among the alternatives except Low Investment BRT, which would not support the planned transit oriented development at Chevy Chase Lake. High Investment BRT and LRT would not have a station at Fenton Street, would therefore not support transit-oriented development at this location.							
Support Attainment of Regional Clean Air Goals									
• Support attainment of regional air quality goals	• Change in regional emission burden	--	All alternatives produce small but beneficial changes in regional emissions						

6.3. Effectiveness

6.3.1. Increase Mobility and Improve Accessibility

The corridor has four major activity centers, Bethesda, Silver Spring, College Park, and New Carrollton, each with a substantial employment base and surrounding residential concentration and each with a Metrorail Station. Other key activity centers are the University of Maryland campus with 36,000 students and 12,000 employees, and the Takoma Park/Langley Park area. The corridor is fully developed with residential communities of varying income levels. They all share a characteristic of relatively high transit usage and low vehicle ownership, but for many this is by choice because of the transit access and connectivity provided by the Metrorail and extensive bus systems. While fast and reliable transit service is provided by the Metrorail into the District of Columbia and other activity centers along these radial routes, the transit service along the Purple Line corridor is hampered by slow and unreliable operations because it operates over a congested and indirect roadway network and often requires transferring between multiple routes and transit operators.

By 2030 and beyond, under the No Build conditions, the roadway congestion will increase due to increases in population and employment, resulting in vehicular trip growth. This will worsen transit travel times and reliability in the corridor. While Metrorail does provide some transit options for these trips, it requires taking circuitous routings into downtown Washington DC and back out again. Several communities in the corridor, especially the Takoma Park/Langley Park area, are in a wedge between the Metrorail lines and do not have even this option.

The TSM alternative would provide bus service that would operate as a single route for the entire corridor length and would not make as many local stops in order to improve travel times between the major activity centers. However, it would be hampered by the same roadway conditions as the current and future No Build bus services.

Because they would have similar alignments and stations, all the Build alternatives and the TSM alternative would serve essentially the same travel markets: providing access to the major activity centers along the corridor, and to the Metrorail at Bethesda, and Metrorail and MARC services at Silver Spring, College Park, and New Carrollton. The alternatives differ in the travel times and reliability they would provide. High Investment LRT would provide the fastest travel times along the corridor because of its higher investment in grade-separated segments that provide a travel time advantage over surface alignments, especially in East Silver Spring and the Riverdale Park area. By providing less grade separation and less exclusive surface-running operating environments, Low and Medium Investment LRT would offer slightly slower travel times than High Investment LRT. The LRT alternatives would offer faster end-to-end travel times than their BRT counterparts. West of Silver Spring, the BRT travel times are longer than their LRT counterparts because of routing differences. Westbound High Investment and Medium Investment BRT would follow a loop from the Georgetown Branch right-of-way under the buildings on either side of Wisconsin Avenue and on surface streets in downtown Bethesda, slowing the operating speeds. While this slower travel time would degrade the market attractiveness relative to the LRT alternatives for trips connecting to the Bethesda Metro Station, these two alternatives would actually provide better access to the downtown Bethesda employment market. Low Investment BRT and the Medium Investment BRT variation via Jones Bridge Road, because of their routing along Jones Bridge Road, would have the slowest travel time between Silver Spring and downtown Bethesda, although they would provide a direct

connection to the National Institutes of Health/ National Naval Medical Center area. These travel markets are already served by a number of transit services and would be comparably or even better served by the other Build alternatives using the Master Plan alignment.

As a result of having similar alignments, station locations, and service plans, the attractiveness of the Build alternatives to the transit markets and the resulting user benefits would primarily be a function of the travel time improvement differences among the alternatives. The LRT alternatives would attract more riders and new transit trips than the BRT and would generate more user benefits. The High Investment alternatives under LRT and BRT would produce higher number of riders, new trips, and user benefits than their respective Low and Medium Investment counterparts.

All alternatives have similar alignments and station locations. Therefore, the number of residents, employers, transit-dependent populations, and zero-car households served by the alternatives would be virtually the same and therefore are not a differentiating factor among the alternatives.

All alternatives have similar service plans and station locations. Therefore, transferring and interconnectivity to Metro, MARC, Amtrak, and bus services are not differentiating factors between the alternatives, except that the BRT alternatives would provide better connectivity with the existing bus facility at the Bethesda Metro Station.

High Investment LRT would be the most effective in addressing the mobility and accessibility objectives.

6.3.2. Improve Transit Operating Efficiencies

When transit vehicles have to operate within shared roadway environments, including crossing roadway intersections, the potential for delay increases. This in turn decreases the reliability of the service and lessens the operational efficiency. Because of the investment in tunnel segments, grade separation, and dedicated lanes, High Investment BRT and LRT would provide the most efficient and reliable operations. To a lesser degree, Low and Medium Investment BRT and LRT would provide these benefits. Dedicated lanes on the surface can provide many of the operational benefits of grade separation, at a lower cost.

Improved operating speeds enable more efficient operations because fewer vehicles and operators are required to provide the transit service. The BRT alternatives would have lower operating costs than the LRT alternatives. However, further refinement of the services' operating plans relative to the ridership demand level may lessen these differences. The incremental cost of adding more service is less for the LRT alternatives than for the BRT alternatives.

With the introduction of any one of the BRT or LRT alternatives as well as TSM, there would be opportunities to adjust the existing and future No Build bus network in the corridor to account for service redundancies, thereby reducing operating costs to the transit providers. However, these reductions would be similar across all alternatives.

6.3.3. Enhance Environmental Quality

All of the alternatives generally follow existing roadways and railroad rights-of-way. As a result, the environmental and community impacts are relatively minor in type and degree for projects of this nature. The roadways along which the alignment would run typically have heavy automobile, truck, and bus traffic operating along them.

High Investment BRT and all LRT alternatives would have some tunneled segments, which would in some instances run under residential and commercial properties. The effects on the surface structures and communities would be negligible. The tunnel portals and tunnel vent and emergency exit shafts would be the most noticeable features. This is especially true for tunnel portals located within residential areas such as in Silver Spring on Wayne Avenue and Arliss Street.

Because all the alternatives would have similar alignment characteristics, impacts on parks, wetlands, historic properties, business properties, and other environmentally sensitive sites would be similar between the alternatives, and are thus unlikely to be a differentiating factor among the alternatives.

In some specific instances, the impacts are seen by some in the local communities as onerous, specifically the change in the character of the Georgetown Branch right-of-way along which the Interim Georgetown Branch Trail is located. The re-introduction of rail operations with the Build alternatives, in conjunction with the construction of the permanent Capital Crescent Trail segment, as called for in the Montgomery County Master Plan for several decades, would remove essentially all the trees within the narrower portions of the right-of-way. While new landscaping would be added, it would be different in character than what exists today. The trees and vegetation on the properties abutting the right-of-way are expected to remain and would maintain much of the tree cover and visual character. The design features and character of the transitway and trail are intended to mitigate these concerns.

Some in the communities along certain street alignments, specifically Wayne Avenue, have concerns that BRT or LRT vehicles operating on the surface along this street would adversely affect the character of the street and adjoining neighborhoods. Others in the community view the introduction of these transit vehicles as compatible with the community character given that Wayne Avenue is already used by automobile, truck, and bus traffic.

6.3.4. Optimize Public Investment

Transportation system user benefits, community and economic benefits, and environmental benefits would be generated by all the Build alternatives to varying degrees depending on the specific attributes of the alternatives. These benefits would generally increase with increased levels of public capital investment. Ongoing public investment in operating and maintenance of the transit service would also be required. All the alternatives generate benefits and support a number of public objectives.

One measure that is useful for the comparative evaluation of the alternatives to show the degree of increased user benefits for increasing level of capital and operating costs is the FTA New Starts cost-effectiveness measure (see Section 6.4). Another measure is the annualized cost per new rider, which indicates the incremental benefit of each new rider attracted to transit. Based on these measures, the BRT alternatives would be more cost effective than the LRT alternatives, with Medium Investment BRT being the most cost effective. Medium Investment LRT is the most cost effective of the LRT alternatives. This demonstrates that the added investment in providing facilities that improve the operating speed and therefore the travel time for the Medium Investment alternatives generates more benefits relative to the costs than the Low Investment alternatives. However, the

incremental costs for providing additional improvements such as more grade-separated segments in the High Investment alternatives relative to the Medium Investment alternatives generate a diminishing rate of benefits.

While many of the mobility and cost-effectiveness measures are based on 2030 forecasts, consideration can be given to addressing the longer term transportation mobility capacity potential in the east-west corridor. The Purple Line corridor, especially for the Georgetown Branch right-of-way, purchased for use as a joint trail-transitway facility, would provide the only currently identified opportunity to increase east-west transportation mobility capacity inside the Capital Beltway (I-95/I-495) in Montgomery and Prince George's Counties. LRT technology has the potential to provide a higher passenger-carrying capacity in the corridor than BRT technology. Therefore, an LRT alternative that uses the Georgetown Branch right-of-way would provide the best opportunity to maximize the capacity for carrying passengers.

6.3.5. Support Local Plans for Economic and Community Development

Several areas in the corridor have been identified by local planning agencies as the focus of economic development. Improved transit service has been identified as an objective that would support this development. These areas include Flower Avenue/Long Branch, Takoma Park/Langley Park, College Park/Riverdale Park, and New Carrollton Metro Station.

All the alternatives, except No Build, would generally support the established county master plans and the state Smart Growth policies. Only the LRT alternatives support the Montgomery County Master Plan, which calls for LRT with the permanent Capital Crescent Trail along the Georgetown Branch right-of-way and along the CSX corridor to Silver Spring. All Build alternatives would support the Montgomery County Master Plan by constructing the permanent Capital Crescent Trail, although Low Investment BRT would not build the permanent trail west of Jones Mill Road (approximately two miles). The Prince George's County Master Plan supports the Purple Line in general, but does not identify a specific alignment. Both Montgomery and Prince George's Counties are in the process of developing functional master plans for the 16-mile Purple Line between Bethesda and New Carrollton.

All alternatives have nearly identical alignments and station locations and similar level of service and all would support the established economic and community development plans of the counties and local jurisdictions along the corridor. Therefore, these development measures are not a differentiating factor among the alternatives.

6.3.6. Contribute to Attainment of Regional Air Quality Goals

The TSM and all the BRT and LRT alternatives would attract automobile trips to transit thereby reducing automobile-generated mobile-source air pollutant emissions. Transit service is more fuel efficient and less polluting than automobile travel. High Investment LRT would attract the most automobile trips to transit. The LRT alternatives attract more automobile trips to transit than the BRT alternatives.

6.4. Cost Effectiveness

The cost-effectiveness analysis is a mechanism for comparing the total costs of a project to its benefits. A key measure used to determine the relative advantages of proposed transit systems is known as the cost-effectiveness index. This index is used to measure the benefits that users experience as a result of a new transit improvement, such as a LRT or BRT, compared with a TSM Alternative.

The cost-effectiveness index is determined by a formula described in *Technical Guidance on Section 5309 New Starts Criteria* (September 1997, with subsequent amendments) published by the FTA. The User Benefit measure is based upon basic economic theory; it measures the change in consumer surplus attributable to a new transportation investment. It is derived as the result of an arithmetic calculation of the total annual net cost of an alternative, divided by its benefits. The cost-effectiveness measure is calculated as:

$$\frac{\text{Change in (Annual Operating Cost + Annualized Capital Cost) from TSM}}{\text{User Benefits over the TSM Condition}}$$

The cost terms in the numerator are calculated as the difference in costs between the Build alternatives and the TSM Alternative. Thus, only the costs associated with the alternative are included. Both annual operating costs and the annualized capital costs are considered, regardless of the funding source.

The denominator term "user benefits over the baseline (TSM) condition" is a measure of change in total cost of travel from the TSM Alternative (including both time and monetary costs) expressed in terms of minutes. It is calculated within the region's mode choice model for all alternatives, including the baseline (No Build or TSM Alternative), and uses a measure of the traveler's value of time to convert monetary and other costs to their equivalence in time, which is added to actual time savings. In this way, the measure includes a more comprehensive accounting of the total costs of travel. The measure reflects the benefits for all travelers, not just transit users. It is frequently referred to as "Transportation System User Benefits" or "User Benefits."

The general methodology of this cost-effectiveness analysis translates the capital costs of the alternatives into equivalent uniform annual costs. These uniform annual capital costs reflect assumptions about the economic life of the capital components in each alternative (based on federal guidelines) and the cost of capital (i.e., the discount rate). Uniform annual capital costs are combined with annual operating and maintenance (O&M) expenses and then compared to the benefits of the alternatives to arrive at a cost-effectiveness index for the alternatives.

Placing the capital costs of the alternatives into a common framework involves calculating a stream of annual costs that is equivalent to their initial investment. These annual costs are referred to as an equivalent annual cost (EAC). The method of computing the EAC is straightforward: an annualization formula, which takes into account the discount rate and the useful economic life of major cost components, is applied directly to the initial year capital cost of each major component. For cost components with relatively long useful lives (over 25 years), this formula is approximately equal to the discount rate. In effect, the EAC represents the amount that would have to be invested each year to maintain the capital stock of the alternative at its initial level. The reason for converting the capital costs of each alternative to equivalent annual costs is that EAC can be compared with annual operating statistics and annual passengers, allowing for a reasonably uniform analysis of cost-effectiveness.

Because all costs used in the analysis are in constant dollars, the effects of inflation are already taken into account; the discount rate used in the analysis is a "real" discount rate that reflects prevailing interest rates net of the effect of inflation.

As noted above, key assumptions required for the derivation of equivalent annual cost include the choice of discount rates and the effective useful lives of all major cost components. These follow standard FTA Guidance for New Starts Projects, which provides information on depreciation rates for various cost elements, discount rates, and other direction on developing the user benefit numerator. Further information on the cost estimates is provided in Chapter 5, the *Capital Cost Estimating Methodology Technical Report*, and the *Operating and Maintenance Cost Estimate Technical Report*.

Table 6-3 presents the cost-effectiveness index for the alternatives with the mode-specific attributes user benefit included. As discussed in Chapter 3, user benefits can accrue to users of fixed guideway transit services due to attributes of these systems not reflected strictly in terms of travel times and out-of-pocket costs. These are referred to as "non-included attributes" or "mode-specific attributes" and account for perceived benefits that users feel they receive for amenities, comfort, reliability, safety and other characteristics of the mode. The degree to which these additional benefits accrue to the users depends on the definitions of the alternatives, including the guideway characteristics of the transit modal technologies. These would accrue to all the BRT and LRT alternative users to varying degrees depending on the specific attributes of the alternative. The inclusion of these mode-specific attributes, as are all the input values to the cost-effectiveness measure for New Starts purposes, is subject to discussions with FTA. However, the measure is very useful in the AA/DEIS for the comparative evaluation of the alternatives to show the degree of increased user benefits for increasing levels of capital and operating costs. The lower the number, the more cost-effective the alternative, under this particular method. It is also useful for assessing potential eligibility for New Starts funding.

Table 6-3: FTA Cost-Effectiveness Measures

	Total Capital Costs (2007 dollars)	Annualized Capital Costs (2007 dollars)	Annual O&M Costs (2007 dollars)	Annual User Benefit (Hours)	Annualized Cost per Hour of User Benefit
TSM	81,960,000	7,052,000	14,600,000	1,965,880	--
Low Investment BRT	386,390,000	31,266,000	17,300,000	3,441,270	$18.24
Medium Investment BRT	579,820,000	46,980,000	17,300,000	5,008,780	$14.01
High Investment BRT	1,088,480,000	87,040,000	15,800,000	6,164,200	$19.34
Low Investment LRT	1,206,150,000	96,480,000	26,400,000	5,784,940	$26.51
Medium Investment LRT	1,220,150,000	97,600,000	25,000,000	6,388,620	$22.82
High Investment LRT	1,634,840,000	125,895,000	22,800,000	7,299,040	$23.71

The results in Table 6-3 indicate that the BRT alternatives are more cost-effective than the LRT alternatives, with Medium Investment BRT being the most cost effective under this measure. Medium Investment LRT is the most cost effective of the LRT alternatives. This demonstrates that the added investment in providing facilities that improve the operating speed and therefore the travel time for the Medium Investment alternatives generates more benefits relative to the costs. However, the incremental costs for providing additional improvements in the High Investment alternatives relative to the Medium Investment alternatives generate a diminishing rate of benefits.

Medium Investment BRT Variations Serving Medical Center

In Section 2.4.5 two variations of Medium Investment BRT providing direct service to the Medical Center area were described: one where the alignment west of Jones Mill Road, instead of following the County–owned Georgetown Branch right-of-way that goes directly to Bethesda, would follow Jones Bridge Road to the Medical Center area and then follows Woodmont Avenue to the north entrance of the Bethesda Metro Station (as is the case for this section of Low Investment BRT), with an additional stop at St. Elmo Street along Woodmont Avenue; and the second, would extend the service of Medium Investment BRT from the north entrance of the Bethesda Metro Station, up Woodmont Avenue to the Medical Center Metro Station, directly across from the entrance to the NNMC, with a station at St. Elmo Street along Woodmont Avenue.

Table 6-4 provides a summary of the key effectiveness measures for the two variations relative to the Medium Investment BRT alternative. The Jones Bridge Road variation includes the $60 million capital cost of a new southern entrance at the Medical Center Metro Station.

The Jones Bridge Road variation shows that the longer routing to the larger Bethesda travel market results in a loss of 2000 daily boardings and 225,000 hours of annual user benefits relative to the Medium Investment BRT alternative. The FTA cost effectiveness index increases to $15.62 with the new station entrance, which is essential for the connection to the Metrorail Red Line at Medical Center under this variation. Without the entrance, the index goes to $14.04. The second variation, extending the Medium Investment BRT service to Medical Center from Bethesda increases the daily boardings by 6,000 and the annual users benefits by 236,000 hours. The cost effectiveness index for the second variation improves to $13.43. This indicates the benefits of serving the major Bethesda market directly while also providing a one-seat ride to the Medical Center area.

FTA annually defines ranges for rating projects submitted for consideration for New Starts funding. These ranges are updated occasionally to account for cost escalation and other such factors. Currently for FY09 New Starts Criteria submissions, a measure above $30.00 per hour is rated "Low," between $24.00 and $30.00 per hour is rated "Medium-Low," between $23.99 and $15.50 per hour is rated "Medium," between $15.49 and $12.00 is rated "Medium-High," and under $12.00 per hour is rate "High." These will likely change slightly by the time that a Purple Line Locally Preferred Alternative would be submitted to FTA for rating. All the alternatives would fall into the "Medium" range except for Low Investment LRT, which would fall into the "Medium-Low" range. For New Starts purposes at this point, an alternative should have a "Medium-Low" rating and preferably a "Medium" rating.

6.5. Financial Feasibility

Considerations of financial feasibility are based on the magnitude of the overall cost of the proposed transit improvements compared to the capacity of various funding programs and financial sources available to fund it. The overall

costs include both initial capital costs and the on-going costs of operations and maintenance. The funding sources include fare revenue from additional riders, federal programs, such as the FTA's New Starts program, State of Maryland funding, county and other sources, including private funding.

The proposed alternatives differ significantly in both capital and operating cost, ranging from a relatively minimal cost for the TSM and Low Investment BRT to more than $1 billion in capital costs and substantial annual operating costs for Medium and High Investment LRT. However, for the purposes of the AA/DEIS evaluation, all of the alternatives are potentially feasible provided that they generate sufficient transportation benefits to meet the requirements of the relevant federal and state funding programs.

6.6. Equity

Equity considerations generally fall within three classes:

- The extent to which the transit investments improve transit service to various population segments, particularly those that tend to be transit-dependent
- The distribution of the cost of the alternatives across population segments through the funding mechanism used to cover the local contribution to construction and operation
- The incidence of any substantial environmental effects, particularly in neighborhoods immediately adjacent to proposed facilities

The mobility and accessibility, economic and community development, and environmental benefits of the Purple Line alternatives generally accrue to the residents of the corridor as well as to the Washington metropolitan area, while the relatively few adverse effects are borne primarily by those persons residing in the corridor. Established regional and federal funding mechanisms would be used for construction and operation of the selected alternative, and new funding sources would be used to prevent diversion of resources (funding, service, or infrastructure) from other parts of the region.

6.6.1. Service Equity

All of the proposed alternatives, whether TSM, BRT, or LRT, would improve both the travel time, and the reliability of the transit service in this diverse corridor. The alternatives would function as both a line haul service connecting the major activity centers and communities along the corridor, and as a "collector-distributor" for trips using the Washington metropolitan area's extensive regional transit system, including the Metrorail, MARC, and Metrobus services and the local transit services operating in the two counties; and as an intra-corridor service for trips generated within the corridor. All alternatives would provide improved access to the corridor's employment centers; educational facilities; health centers; and institutional, cultural, recreational, entertainment, open space, retail, and governmental resources. No one group would receive a disproportionate share of these benefits to the detriment of another group.

6.6.2. Financial Equity

The Purple Line is expected to be financed by a combination of federal, state, and local funds. The existing funding structures of the MDOT/MTA, Montgomery and Prince George's Counties, and WMATA would continue to fund those services and capital programs throughout the region. A combination of new federal, state, and local funding and potentially, new sources of local funds, including new taxes, could be employed. The use of established federal and regional sources means no one group in the corridor or the region would receive a disproportionate share of the financial burden of the capital and operating and maintenance costs relative to the benefits received. No financial equity considerations would be raised by the project, either in terms of the source of subsidy or the level of fare payments required of passengers.

Table 6-4: Boardings, Costs, and Benefits of Medium BRT Variations

Measure	TSM	Medium Investment BRT	Variation 1 Medium Inv. BRT via Jones Bridge Road	Variation 2 Medium Inv. BRT extended to Medical Center
2030 Daily Boardings	16,900	52,000	50,000	58,000
Change Relative to Med Inv. BRT	NA	NA	(- 2000)	+ 6,000
Change Relative to TSM	NA	+34,900	+33,100	+41,100
2030 Annual User Benefits (hours)	1,966,000	5,008,000	4,783,000	5,244,000
Change Relative to Med Inv. BRT	NA	NA	(- 225,000)	+ 236,000
Change Relative to TSM	NA	+3,042,000	+2,817,000	+3,278,000
Capital Costs (2007 dollars)	$82,000,000	$580,000,000	$597,000,000	$585,000,000
Change Relative to Med Inv. BRT	NA	NA	+ $17,000,000	+ $5,000,000
Change Relative to TSM	NA	+$498,000,000	+$515,000,000	+$503,000,000
Annual O&M Cost (2007 dollars in millions)	$14,600,000	$17,300,000	$17,300,000	$18,300,000
Change Relative to Med Inv. BRT	NA	NA	$0.0	+$1,000,000
Change Relative to TSM	NA	+$2,700,000	+$2,700,000	+$3,700,000
FTA Cost-Effectiveness Measure (cost per hour of User Benefit) relative to TSM	NA	$14.01	$15.62 $14.04 without new southern Medical Center entrance	$13.43

6.6.3. Environmental Equity

Expanded transit services, whether TSM, BRT, or LRT, would provide environmental benefits to the region. By increasing transit use and attracting trips from automobiles, the alternatives would reduce emissions and energy, although these reductions would be a relatively small proportion of the regional totals. BRT and LRT are expected to provide enhanced economic development and community revitalization benefits to residents of the region and the corridor compared to the TSM Alternative. While there would be some adverse proximity effects for those communities located adjacent to the Georgetown Branch right-of-way purchased over two decades ago, and designated in the Montgomery County Master Plan for a joint

transitway and trail project, and along some of the street-running surface alignments, these communities would have access to the improved transit services provided and would be among the beneficiaries of the mobility and accessibility improvements.

6.7. Trade Offs

An overall assessment of how well each of the alternatives under consideration would help attain local goals and objectives involves consideration of all areas and measures described above. Moreover, it is dependent upon the priorities and value judgments placed on the individual items. Thus, while this section of the AA/DEIS report provides the necessary quantitative and qualitative assessments needed as a basis for decision-making, the final evaluation of performance of alternatives with respect to the attainment of local goals and objectives requires a collective analysis of the trade-offs involved in comparing relative advantages and disadvantages of the alternatives in each of the subject areas analyzed.

Transportation services and facilities connect people with their jobs, education, recreation, and other personal needs. Transportation services and facilities are essential for developing and sustaining the economy; they shape and affect our communities and environment. Therefore investments in transportation, particularly public investment in higher performing transit improvements, are intended to achieve objectives well beyond just mobility. Economic development, community development, and environmental objectives and measures must be considered along with mobility objectives when evaluating the high capacity transit alternatives for the corridor.

The No Build alternative would leave unaddressed the mobility problems for the various travel patterns to, from, and among the major activity centers, the residential communities and the regional transit system network, especially the Metrorail system. It leaves unaddressed the economic and community development, environmental, and master plan goals established for communities and jurisdictions along the corridor.

The TSM would address these problems to a limited degree, leaving many of the needs and goals unaddressed or under-addressed.

All the BRT and LRT alternatives would address the mobility problems and needs, and the economic and community development, environmental, and master plan goals established for communities and jurisdictions along the corridor. These goals would be maximized by the higher investment in LRT alternatives, particularly High Investment LRT. The capital cost and annual operating subsidy required for this alternative is substantial and would require a large commitment of federal, state, and local financial resources. A substantial amount of the benefits could be achieved at a lower cost by Medium Investment LRT. The BRT alternatives would require lower capital and annual operating subsidy investments and commitment of financial resources, but would provide lower achievements of mobility and other objectives.

As noted earlier, this document presents a record of the planning for the Purple Line up to the current time; however, interaction with local communities, agencies, and other stakeholders continues and ongoing studies may refine aspects of the alternatives, including possible additional design options. Three segments of the corridor under active study are the University of Maryland, the area east of downtown Silver Spring, and the Medium BRT variations between Jones Mill Road and downtown Bethesda. Coordination with stakeholders will continue throughout the planning process and could modify aspects of the alternative considered during the selection of the Locally Preferred Alternative.

An issue generating a high degree of interest in the Chevy Chase and Columbia County Club area is the use of the Georgetown Branch right-of-way in which the Interim Georgetown Branch Trail is located. The re-introduction of rail operations with the LRT alternatives, or introduction of BRT, in conjunction with the construction of the permanent Capital Crescent Trail segment, as called for in the Montgomery County Master Plan for several decades, would remove essentially all the vegetation within the narrower portions of the right-of-way. The trees and vegetation on the properties abutting the right-of-way are expected to remain and maintain much of the tree cover and visual character. The design features and character of the transitway and trail is intended to mitigate the impacts. The No Build and TSM Alternatives would not use the Georgetown Branch right-of-way but as described above would not address the needs and objectives for the corridor. The only Build alternative that would avoid the use of this segment of the Georgetown Branch right-of-way west of Jones Mill Road, would be Low Investment BRT and the Medium Investment BRT variation via Jones Bridge Road. While shifting any concerns of operating the transit service over to other communities along Jones Mill Road, this alternative also would be the least effective Build alternative in addressing the corridor needs and objectives. As discussed elsewhere in the AA/DEIS, even though Low Investment BRT and Medium Investment BRT variation via Jones Bridge Road run adjacent to the National Naval Medical Center, which will be the site of growth in employment and activity from the BRAC program, all the alternatives provide comparable if not better transit access and service in combination with existing Metrorail and bus services.

Tunnel and other types of underground construction of transit alignments require a much higher expenditure of capital funds than surface or even aerial alignments. The Build alternatives would employ tunnel sections where they would be required for topographic conditions or would provide operating speed improvements over surface alignments. The trade off of the higher capital cost and increase in mobility benefits was discussed earlier. Tunnels or underground construction, suggested by some for the Georgetown Branch right-of-way as an impact avoidance measure, would provide no operating speed or mobility benefits, while substantially increasing the capital costs and would thereby considerably lessen the cost-effectiveness of the alternative in the FTA New Starts rating. Similar suggestions for longer tunnels to avoid or further minimize community concerns, specifically along Wayne Avenue, would have similar effects since the longer tunnel segment provides little improvements in the mobility benefits relative to the higher capital cost.

Notwithstanding the effectiveness and cost-effectiveness of the Build alternatives, the availability of federal, state, and local capital funds may limit what could ultimately be spent for the implementation of a project in the corridor. Considerations of other transit projects in the state, transportation projects, and funding priorities, and availability of federal funds may establish an upper limit on what could be invested in the corridor. The response could involve: selecting an alternative that falls within the funding availability; implementing only a portion of an alternative (minimum operable segment or MOS), either as the full extent of the project or as an initial phase of the project with other phases implemented later; or deferring the implementation of a project until funding for the Locally Preferred Alternative is available.