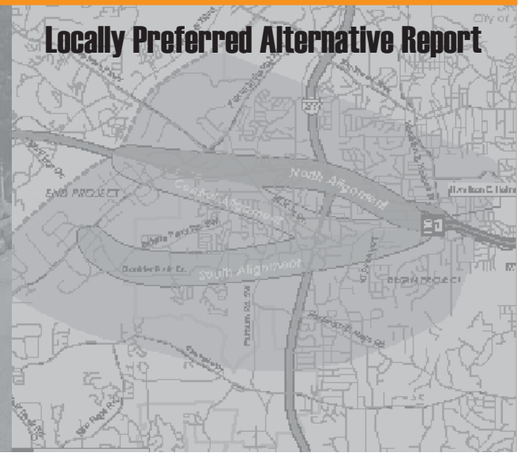
CHAPTER SEVEN: EVALUATION METHODOLOGY FOR COST AND COST EFFECTIVENESS MEASURES



CHAPTER SEVEN: EVALUATION METHODOLOGY FOR COST AND COST EFFECTIVENESS MEASURES

Capital cost estimates for each alternative are based on conceptual engineering drawings. The capital cost methodology and results are described in Sections 7.1 and 7.2 of this report. Regionally accepted unit costs, derived by the GRTA, were used to generate each alternative cost estimate.

Operating and maintenance (O&M) cost estimates for each alternative are based on operating plans and ridership forecasts. MARTA's Office of Financial Planning and Analysis produced the O&M cost estimates for MARTA service. Unit costs for non-MARTA bus service have been derived from work completed by GRTA. The O&M cost methodology and results are described in Sections 7.3 and 7.4. These cost estimates were used to determine cost-effectiveness for each alternative, which is presented in section 7.5.

7.1 Capital Cost Methodology

Capital cost estimates were based on conceptual drawings produced for each alternative. For BRT alternatives, plan drawings were prepared on aerial photography at a scale of 1"=100'. For HRT alternatives, plan and profile drawings were prepared. These drawings indicate type of construction needed (e.g. fill, retained fill, structure, etc.) based on MARTA's design guidelines. Station areas have also been defined on aerial photography.

Unit costs were derived from work produced by GRTA, as part of the Regional Transit Action Plan (RTAP). GRTA developed unit cost guidelines for various transit modes, including BRT, LRT, and HRT, for use in a number of studies being conducted in the Atlanta region. The use of consistent cost guidelines allow valid comparisons to be made among projects that are being studied by regional and local agencies in other corridors. The guidelines are presented in a report: Transit Facility Capital Cost Methodology & Unit Cost Guidelines, prepared for GRTA in October 2002.

The GRTA guidelines have been developed for 3 different levels of detail:

- Order-of-Magnitude Unit Costs – These general unit cost guidelines are appropriate at the early definition stage of a transit project, such as systems planning studies.
- Conceptual Unit Costs – These unit cost guidelines are appropriate at the feasibility analysis phase of a transit project.
- Alternatives Analysis Unit Costs – These detailed unit cost guidelines are appropriate as the project undergoes FTA's Alternatives Analysis process.

The cost estimate approach for this project used a level of detail that is consistent with the conceptual engineering that has been completed for the alternatives. Table 7.1 lists the line items and the associated unit costs for the BRT alternatives. Table 7.2 lists comparable information for the heavy rail alternatives. All capital costs are in 2002 dollars and the unit costs in these tables have been applied to the quantities developed for each of the alternatives under consideration.
Sources for different categories of quantities are as follows:

- Guideway lengths for each type of construction (e.g. in-street bus lanes, new busway for BRT, cut and cover, at-grade, elevated, etc. for HRT) are taken from the plan (and profile) drawings.
- New interchange structures were estimated independently by a bridge design engineer based on previous experience on GDOT projects and standard unit costs
- Station types (at-grade, elevated, etc.) were taken from the drawings.
- Parking lot sizes and bus bays were based on preliminary estimates of parking demand and preliminary bus operating plans.
- Special track work (crossovers) for HRT is based on current MARTA guidelines.
- Traffic signals and signal priority for BRT are based on an inventory of existing signals along the corridor (additional signals are assumed for large station parking lots). All alternatives include signal priority along Fulton Industrial Boulevard, while BRT 1 and BRT 1a also include signal priority along MLK Jr. Drive.
- Additional vehicles are based on bus and rail operating plans (see Transit Operations Plan Report). Vehicle quantities in tables in Appendix are incremental compared to the No-Build Alternative. Summary tables in this chapter show incremental costs relative to the TSM Alternative.
- Right-of-way estimates were prepared from parcel-level tax records and plan drawings.

Relatively high contingency costs have been added for each category of costs, since the engineering is still at an early stage. Soft costs (engineering, construction management, insurance, etc.) are based on the percentage factors from the GRTA methodology.

7.2 Capital Cost Estimates

Table 7.3 shows the breakdown of costs by major category (guideway, stations, vehicles, etc.) for the BRT alternatives and Table 7.4 does the same for the HRT alternatives. Both tables include the TSM Alternative for reference and the incremental cost for each alternative relative to the TSM alternative. This incremental cost is used in the calculations of cost-effectiveness, as specified in FTA's New Start Guidelines. The BRT alternatives range in cost from $52 to $91 million (2002 dollars).

- The least expensive are BRT 1 ($52M) and BRT 1a ($60M), which make use of the proposed HOV lanes along I-20, which are programmed for construction by GDOT. The BRT project costs consist mainly of new HOV ramps and stations.
- The other 6 BRT alternatives, which follow the Central Corridor along MLK Jr. Drive, are clustered between $84 and $91 million. BRT 2 is less expensive than the others because the curb-lane configuration requires less right-of-way for station platforms. The primary difference among the other alternatives is proportional to the number and location of stations.
- Vehicle costs are relatively modest, since the operating plans depend largely on existing

Table 7.1 : BRT Capital Unit Costs

Element/Item	Unit	Unit Cost	Source/Comment
1. Guideway Elements			
Busways			
Change 2-GP lanes to bus-only	Lin. Ft.	$269	I-285 unit cost figure.
New Busway facility - 2 lanes	Lin. Ft.	$379	PBSJ figure used for NSAS.
Add 2 bus lanes to existing road	Lin. Ft.	$521	PBSJ figure used for NSAS.
Add 2 HOV/Bus lanes to Expwy	Lin. Ft.	$568	PBSJ figure used for NSAS.
Queue jumpers/intersection impr.	Intersect.	$750,000	PBSJ figure (adding add'l. approach lane - 2 approaches)
Freeway Ramp Flyover	Each	$6,000,000	Allowance, based on PBSJ and Bart figures.
Other interchange improvement			
Arterial Grade Separation - Bridge	Each	$2,500,000	PBSJ figure used for NSAS.
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Guideway Costs			
2. Stations			
At-Grade BRT Station (180')	Each	$523,000	Approx. 2/3 of LRT station cost based on platform length.
Elevated BRT Station (180')	Each	$1,582,000	Approx. 2/3 of LRT station cost based on platform length.
Super Stop On-Street	Each	$75,000	Allowance.
Parking			
Surface Space	Space	$3,300	LRT unit cost figure.
Structured Space	Space	$13,400	LRT unit cost figure.
Feeder Bus Bays	Bay	$50,000	LRT unit cost figure.
Pedestrian Bridge	Each	$460,000	LRT unit cost figure.
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Station Costs			
3. Yard & Shop			
Maintenance Facility Building			
expand existing facility	bus	$100,000	
100-150 Veh. Storage	Each	$16,000,000	Based on Gwinnett Costs
Add-on for CNG Facility	Each	$3,500,000	Based on Larado CNG retrofit costs.
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Yard & Shop Costs			
4. Systems			
Overhead Catenary (ETB)	LF	$399	LRT unit cost figure.
Communications	Station	$125,000	Based on LYNX LYMMO figure.
Signal Pre-emption/ITS	Intersection	$37,000	LYNX LYMMO figure.
New Traffic Signals	Each	$150,000	LRT unit cost figure.
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Systems Costs			
5. Vehicles (change vs. No-Build)			
BRT Buses	Each	$1,200,000	60' Civis cost figure, includes bus guidance system.
Feeder Buses			
60' Artic. Clean Diesel Buses	Each	$420,000	APTA Vehicle cost info, inflated to 2002$
40' CNG Buses	Each	$313,000	MARTA Orion Bid Cost
40' Clean Diesel Buses	Each	$256,000	MARTA Orion Bid Cost
30' CNG Buses	Each	$300,000	MARTA Orion Bid Cost
30' Clean Diesel Buses	Each	$245,000	Based on ratio of 30' to 40' CNG buses.
Contingency (Prel. Engineering)	%age	5%-10%	Determined at 8/27 workshop
Total Vehicles Costs			
6. Special Conditions (incl. Conting.)			
Drainage	% 1-4*	2.0%	Assumed to be slightly less than LRT percentage.
Utility Relocation	% 1-4*	4.5%	Assumed to be slightly less than LRT percentage.
Noise Abatement	% 1-4*	1.0%	Assumed to be same as LRT percentage.
Signing & Striping	% 1-4*	0.5%	Assumed to be same as LRT percentage.
Construction Traffic Control	% 1-4*	2.0%	Assumed to be same as LRT percentage.
Urban Design/Landscaping	% 1-4*	1.0%	Assumed to be same as LRT percentage.
Other Special Conditions	% 1-4*	1.0%	Assumed to be same as LRT percentage.
Total Special Conditions Costs			
7. Right-of-Way			
Land Purchases	per Appraisals		
Relocations	per Appraisals		
Contingency (Prel. Engineering)	%age	20%-40%	Determined at 8/27 workshop
Total Right-of-Way Costs			
8. Soft Costs			
Project Reserve	% 1-4,6**	3.0%	Assumed to be same as LRT percentage.
Pre-Construction Soft Costs			
EIS/PE/Final Design	% 1-4,6**	7.0%	Assumed to be same as LRT percentage.
Third Party Reviews	% 1-4,6**	1.0%	Assumed to be same as LRT percentage.
Agency Mgmt. Of Above	% 1-7***	3.0%	Assumed to be same as LRT percentage.
During Construction			
Const. Mgmt./Engineering	% 1-4,6**	5.0%	Assumed to be same as LRT percentage.
Insurance/Legal	% 1-4,6**	2.0%	Assumed to be same as LRT percentage.
Third Party Reviews	% 1-4,6**	3.0%	Assumed to be same as LRT percentage.
Agency Mgmt. Of Above	% 1-7***	6.0%	Assumed to be same as LRT percentage.
Total Soft Costs			
TOTAL PROJECT COST			

Unit costs from GRTA methodology, Alternatives Analysis level; version #2, 10/30/02.

Table 7.2 : HRT Capital Unit Costs

Element/Item	Unit	Unit Cost	Source/Comment
1. Guideway Elements			
At-Grade Trackwork			
Double Ballasted	LF	$1,000	MARTA cost data from PB - includes contact rail system.
Double Embedded	LF	$1,400	MARTA cost data from PB - includes contact rail system.
Retained Fill Trackwork			
Double Ballasted	LF	$2,300	MARTA cost data from PB - includes contact rail system.
Double Embedded	LF	$2,700	MARTA cost data from PB - includes contact rail system.
Elevated Trackwork			
Short Structures	Each	$708,000	80' structure, 50% higher unit cost than longer elevated struct.
Double Track Elevated Structure	LF	$5,900	MARTA cost data from PB - includes contact rail system.
Below-Grade Trackwork			
In Cut	LF	$2,100	MARTA cost data from PB - includes contact rail system.
Cut & Cover Tunnel	LF	$9,900	MARTA cost data from PB - includes contact rail system.
Mined Tunnel	LF	$34,000	URS estimate
Special Trackwork			
Turnout	Each	$140,000	MARTA cost data from PB - Avg. of #10 and #20 turnouts.
Double Crossovers	Each	$877,500	MARTA cost data from PB
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Guideway Costs			
2. Stations			
At-Grade Station (600')	Each	$20,500,000	Avg. of MARTA cost data from PB. - includes fare collection.
Elevated Station (600')	Each	$30,500,000	Avg. of MARTA cost data from PB. - includes fare collection.
Underground Station (600')	Each	$63,000,000	Avg. of MARTA cost data from PB. - includes fare collection.
Parking			
Surface Space	Space	$3,300	For consistency, used same unit costs as other modes.
Structured Space	Space	$13,400	For consistency, used same unit costs as other modes.
FIB SOV Ramps	Each		
Feeder Bus Bay	Bay	$50,000	For consistency, used same unit costs as other modes.
Pedestrian bridge	Each	$460,000	For consistency, used same unit costs as other modes.
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Station Costs			
3. Yard & Shop			
Maintenance Facilities			
expand bus garage	per bus	$100,000	
100 Veh. Rail Storage	Each	$140,000,000	Avg. of MARTA cost data from PB.
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Yard & Shop Costs			
4. Systems			
Traction Electrification (inc. Substat.)	LF	$1,300	MARTA cost data from PB.
Signal System	LF	$500	MARTA cost data from PB.
Communications	LF	$300	MARTA cost data from PB.
Traffic Signals	Each	$150,000	Allowance, based on ranges of peers
Signal Pre-emption (on FIB)	Intersectior	$37,000	
Contingency (Prel. Engineering)	%age	20%-25%	Determined at 8/27 workshop
Total Systems Costs			
5. Vehicles (change vs. no-build)			
Heavy Rail Vehicles	Each	$2,500,000	MARTA cost data from PB.
Maintenance-of-Way Vehicles	HRT Line	$2,000,000	For consitency, used same unit costs as other modes.
Feeder Buses	Each	$256,000	assume 40' CNG
Contingency (Prel. Engineering)	%age	5%-10%	Determined at 8/27 workshop
Total Vehicles Costs			
6. Special Conditions (incl. Conting.)			
Drainage	% 1-4*	3.0%	For consistency, used same percentage as other modes.
Utility Relocation	% 1-4*	6.5%	For consistency, used same percentage as other modes.
Noise Abatement	% 1-4*	1.0%	For consistency, used same percentage as other modes.
Signing & Striping	% 1-4*	0.5%	For consistency, used same percentage as other modes.
Construction Traffic Control	% 1-4*	2.0%	For consistency, used same percentage as other modes.
Urban Design/Landscaping	% 1-4*	1.0%	For consistency, used same percentage as other modes.
Other Special Conditions	% 1-4*	1.0%	For consistency, used same percentage as other modes.
Total Special Conditions Costs			
7. Right-of-Way			
Land Purchases	per Appraisals		
Relocations	per Appraisals		
Contingency (Prel. Engineering)	%age	20%-40%	Determined at 8/27 workshop
Total Right-of-Way Costs			
8. Soft Costs			
Project Reserve	% 1-4,6**	3.0%	For consistency, used same percentage as other modes.
Pre-Construction Soft Costs			
EIS/PE/Final Design	% 1-4,6**	7.0%	For consistency, used same percentage as other modes.
Third Party Reviews	% 1-4,6**	1.0%	For consistency, used same percentage as other modes.
Agency Mgmt. Of Above	% 1-7***	3.0%	For consistency, used same percentage as other modes.
During Construction			
Const. Mgmt./Engineering	% 1-4,6**	5.0%	For consistency, used same percentage as other modes.
Insurance/Legal	% 1-4,6**	2.0%	For consistency, used same percentage as other modes.
Third Party Reviews	% 1-4,6**	3.0%	For consistency, used same percentage as other modes.
Agency Mgmt. Of Above	% 1-7***	6.0%	For consistency, used same percentage as other modes.
Total Soft Costs			
TOTAL PROJECT COST			

Source: GRTA methodology, Alternatives Analysis level; version #2, 10/30/02.
* - indicates line item unit cost is defined as a percentage of Element Groups 1 through 4.
** - indicates line item unit cost is defined as a percentage of Element Groups 1 through 4 and 6.
*** - indicates line item unit cost is defined as a percentage of Element Groups 1-7.

Table 7.3 : Capital Cost Estimates - BRT and TSM Alternatives

	Alternative & Cost in millions (2002 dollars)								
Cost Category	TSM	BRT-1	BRT-1a	BRT-2	BRT-3	BRT-3a	BRT-3b	BRT-3c	BRT-3d
1. Guideway	$0.0	$8.8	$14.2	$18.6	$18.6	$18.6	$18.6	$18.6	$18.6
2. Stations	$0.3	$3.7	$4.9	$6.2	$6.2	$5.4	$4.8	$4.8	$4.8
3. Yard & Shop	$0.9	$1.3	$1.3	$1.0	$1.0	$1.0	$0.9	$0.9	$0.9
4. Systems	$0.2	$0.8	$1.0	$2.0	$2.0	$1.8	$1.8	$1.8	$1.8
5. Vehicles	$2.0	$2.8	$2.8	$2.3	$2.3	$2.3	$2.0	$2.0	$2.0
6. Special Conditions	$0.2	$1.7	$2.6	$3.3	$3.3	$3.3	$3.1	$3.1	$3.1
7. Right-of-Way	$0.0	$25.5	$27.3	$37.4	$44.0	$43.0	$43.0	$42.2	$42.2
8. Soft Costs (Eng'g etc.)	$0.6	$7.4	$9.9	$12.9	$13.5	$13.1	$12.8	$12.7	$12.7
Total Project Cost	$4.1	$52.0	$63.9	$83.8	$91.0	$88.4	$87.0	$86.1	$86.1
Incremental cost vs. TSM	Base	$47.9	$59.8	$79.7	$86.8	$84.3	$82.9	$82.0	$82.0
Length	N.A	4.26	4.26	4.21	4.21	4.21	4.21	4.21	4.21
Ave. Increm. Cost/mile	N.A.	$11.2	$14.0	$18.9	$20.6	$20.0	$19.7	$19.5	$19.5

routes for service along the BRT facilities.

- Right-of-way is the largest cost component for all of the BRT alternatives. This is due primarily to the large station at Fulton Industrial Boulevard and I-20, which requires the acquisition of relatively expensive property. Adjustments to the specific property takes should be considered in the DEIS phase of the study in order to reduce and/or refine these costs.

The HRT alternatives range in cost from $463 - $504 million (all costs are in 2002 dollars).

- The least expensive are HRT 1 ($468M) and HRT 2 ($463M), which follow the Northern Corridor along I-20. Right-of-way is less expensive for these alternatives than for those which follow MLK Jr. Drive.

- HRT 1, which goes under Linkwood Drive, is slightly more expensive than HRT 2, which goes over Linkwood. However, the higher cost is due mainly to the higher station cost at MLK/I-20, where the HRT 1 station is elevated.

- The other four HRT alternatives, which follow the central corridor along MLK Jr. Drive, fall in two groups. The alignments north of MLK Jr. Drive (3 and 3a) are the most expensive, at $504 million each. The south-of-MLK alignments (4 and 4a) are estimated to cost $475 million each. The main differences between the north and south alignments are guideway (more elevated structure) and more expensive right-of-way.

- Rail vehicle costs are the same for all 6 alternatives, with 14 additional rail cars (2 six-car trains plus two spare cars). There are very minor differences in the number of feeder buses required.

- Guideway is the largest cost component for the HRT alternatives, followed fairly closely by station costs and then right-of-way. With BRT alternatives, some reductions may be possible in the next phase of study by adjusting specific property acquisitions for stations. Using a parking structure and therefore, taking less land could also be considered.

By comparing similar BRT and HRT alternatives, several observations can be made. HRT 1 and

Table 7.4 : Capital Cost Estimates - HRT Alternatives

	Cost in millions per Alternative (2002 dollars)							
Alternative	**TSM**	**HRT-1**	**HRT-2**	**HRT-3**	**HRT-3a**	**HRT-4**	**HRT-4a**	**HRT-5**
Cost Category								
Guideway	$ -	$ 98.7	$106.80	$ 107.2	$ 107.2	$ 96.3	$ 96.3	$ 245.0
Stations	$ 0.3	$ 90.2	$ 77.7	$ 91.5	$ 90.1	$ 92.1	$ 90.1	$ 130.7
Yard & Shop	$ 0.9	$ 0.5	$ 0.5	$ 0.5	$ 0.4	$ 0.5	$ 0.4	$ 0.4
Systems	$ 0.2	$ 52.7	$ 53.3	$ 53.0	$ 52.8	$ 54.6	$ 54.4	$ 52.8
Vehicles	$ 2.0	$ 41.2	$ 41.2	$ 41.2	$ 40.9	$ 41.2	$ 40.9	$ 40.9
Special Conditions	$ 0.2	$ 36.3	$ 35.7	$ 37.8	$ 37.6	$ 36.5	$ 36.2	$ 64.3
Right-of-Way	$ -	$ 57.2	$ 57.4	$ 75.7	$ 78.1	$ 64.9	$ 67.4	$ 61.8
Soft Costs (Eng. Etc)	$ 0.6	$ 92.3	$ 91.1	$ 97.5	$ 97.1	$ 93.6	$ 93.0	$ 157.2
Total Project Cost	**$ 4.1**	**$ 469.0**	**$ 463.6**	**$ 504.4**	**$ 504.2**	**$ 479.6**	**$ 478.6**	**$ 753.1**
Incremental Cost vs. TSM	Base	$ 464.9	$ 459.4	$ 500.3	$ 500.1	$ 475.5	$ 474.5	$ 749.0
Length in miles	N/A	3.9	3.94	3.92	3.92	4.04	4.04	3.92
Avg. Incremental Cost/Mile	N/A	$ 119.3	$ 116.5	$ 127.5	$ 127.5	$ 117.7	$ 117.4	$ 191.0

HRT 2 follow the same general alignment along I-20 as BRT 1a, with the same 2 station locations. The HRT alternatives cost about $465 million, while BRT 1a would cost $60 million. This significant difference in cost can be attributed to a number of factors which are listed below:

- One major difference is the use of already-programmed HOV lanes by BRT 1a, which eliminates most guideway and systems (e.g. electrification) costs.

- Station costs are significantly lower for BRT 1a, due to smaller size and less parking.

- BRT 1a requires only a small number of additional buses, while the HRT alternatives cost almost $40 million for new rail cars.

- Right-of-way costs are much less for BRT 1a due to smaller stations and no new right-of-way for the line segments in the proposed HOV lanes.

HRT 3a is comparable to BRT 3d because both follow the central corridor along MLK Jr. Drive, with a single intermediate station at Fairburn Road. HRT 3a is estimated to cost $504 million, versus $82 million for BRT 3d. In this case, BRT is significantly more cost effective due to the cost associated with adding 2 lanes to an existing street as opposed to building a new grade-separated double-track rail line. Additionally, right-of way costs are less for BRT 3d due to the smaller stations expected lower property aquisition cost at Fulton Industrial Boulevard Station.

HRT 5a follows the same horizontal alignment as HRT 3a, but is much more expensive ($753 million vs. $504 million) due to the use of tunneling in the Adamsville area.

7.3 Operating and Maintenance Cost Methodology

Operating and maintenance (O&M) costs are estimated for bus and rail improvements service in the study corridor. The various alternatives include changes to bus service operated by MARTA, CCT, GRTA, and Douglas County. The bus O&M costs and costs for MARTA rail services for each agency are estimated separately.

7.3.1 MARTA O & M Costs

MARTA's Office of Financial Planning and Analysis estimated O&M costs for MARTA bus and rail service. Estimates were produced by a resource build-up cost-estimating model. The model has been calibrated based on current and recent budget experience and input data for the model are estimates of future operating statistics. For rail service, the following parameters are used:

- Peak rail cars;
- Annual revenue car-miles;
- Annual revenue train-hours;
- Number of stations;
- Miles of track; and
- Number of rail yard/shop facilities.

Year 2025 rail operating statistics are estimated for each alternative with a spreadsheet model that has been calibrated based on existing MARTA service levels. Rail headways, run times, and service periods are defined in the Transit Operations Plan Report. Train length (number of cars per train) is calculated based on the peak line load, which is estimated by the ridership forecasting model specifically developed for this project, but based on the regional travel demand model. These figures are used to estimate the total number of trains and rail cars required to operate the service, along with weekday and annual rail car miles and train hours. Station and track statistics are based on the definition of the alternatives. All of the heavy rail extensions include 2 new stations and about 4 miles of double-track.

The following parameters are used for the O&M cost model for bus service:

- Peak buses;
- Annual revenue bus-miles;
- Annual revenue bus-hours; and
- Number of bus garages.

Year 2025 bus operating statistics are estimated for each alternative using the results of the ridership forecasting model, which in turn is based on the operating plans documented in the Transit Operations Plan Report. The headways for each route are defined in the operating plan. The ridership model produces an estimate of the peak travel time, considering forecast highway congestion. These figures are used to estimate the number of buses required to operate each route, along with weekday and annual bus miles and hours.

Table 7.5 lists the operating statistics for MARTA bus and rail service for all 16 alternatives. These statistics were added to the model. Costs for maintaining and operating new BRT facilities, including stations and bus roadways, were estimated separately. BRT facility costs were estimated using cost factors that have been derived from experience in other cities and/or scaled from LRT facilites. Annual O&M costs for each station are estimated to be $120,000. Whereas, O&M costs are assumed to be $92,000 for each mile of two-lane exclusive bus roadway. These costs cover maintenance, utilities and security.

The MARTA model produces an estimate of the total O&M cost for the system in FY 2003 dollars. Since the only service changes are in the study area, the incremental cost, relative to the TSM alternative, is used in the cost-effectiveness calculations (see next section). Although the alternatives are being analyzed based on 2025 conditions, including demographics and ridership, all costs are expressed in today's dollars. Later in the study process, an analysis of future cash flow will consider the impact of inflation on all of the project costs and revenues.

7.3.2 Other Agencies

The bus operating costs for other agencies are based on work done for GRTA as part of the RTAP, which produced estimates of suburban bus O&M costs, based on the experience of CCT, Gwinnett County Transit (GCT) and Clayton County Transit (C-Tran). The unit cost for bus services is based on a "platform" hour, which is defined as the total number of employee hours needed to provide the necessary hours of revenue service (revenue hours plus non-revenue hours equal platform hours). To compute the revenue hours, an assumption of 20% non-revenue hours was used, based on the operating statistics of these systems.

For CCT or GRTA local service in Cobb County, the estimated incremental cost would be $62 (2004 dollars) per platform hour for diesel buses, which equates to $74.40 per revenue hour, assuming the additional 20% for non-revenue hours. Therefore, to convert to 2002 dollars, an estimate of $72.23 per revenue bus-hour is being used for CCT, Douglas and GRTA all-day service.

Express routes have higher ratios of non-revenue to revenue service hours because they often run without passengers in the off peak direction. For GRTA express routes, the RTAP estimate is $66/platform-hour (2004 dollars), which is $126.19 per revenue hour (assuming +91% for non-revenue hours). Therefore, $122.51 per revenue hour is used to calculate express service O&M cost estimates.

O&M costs for CCT, Douglas and GRTA are being expressed as an incremental increase above and beyond the TSM alternative for this study. The operating statistics for non-MARTA bus service are estimated using the same process described above for MARTA service. The operating plans and ridership model outputs are used to estimate the number of buses required (used in the capital cost estimates), and the annual revenue bus-hours (used to estimate O&M costs).

Table 7.5 : MARTA Operating Statistics

Annualized BUS Costs						
Alternative	Peak Buses	Revenue Miles (Millions)	Revenue Hours (thousands)	BRT Stations	BRT Busway (Miles)	Bus Garages
No Build	657	30.21	2,422	0	0	4
TSM	664	30.63	2,460	0	0	4
BRT 1	667	30.94	2,469	1	0.2	4
BRT 1a	667	30.94	2,469	2	0.2	4
BRT 2	665	30.83	2,459	4	4.2	4
BRT 3	665	30.83	2,459	4	4.2	4
BRT 3a	665	30.83	2,457	3	4.2	4
BRT 3b	664	30.83	2,455	2	4.2	4
BRT 3c	664	30.83	2,455	2	4.2	4
BRT 3d	664	30.83	2,455	2	4.2	4
HRT 1	662	30.43	2,448	0	0	4
HRT 2	662	30.43	2,448	0	0	4
HRT 3	662	30.36	2,448	0	0	4
HRT 3a	661	30.32	2,444	0	0	4
HRT 4	662	30.36	2,448	0	0	4
HRT 4a	661	30.32	2,444	0	0	4
HRT 5	661	30.32	2,444	0	0	4

Annualized Heavy Rail Costs						
Alternative	HRT Track Miles	HRT Stations	Peak Rail Cars	Revenue Miles (Millions)	Revenue Train Hours	HRT Yards
No Build	125.60	43	306	45.03	260,900	3
TSM	125.60	43	306	45.03	260,900	3
BRT 1	125.60	43	306	45.03	260,900	3
BRT 1a	125.60	43	306	45.03	260,900	3
BRT 2	125.60	43	306	45.03	260,900	3
BRT 3	125.60	43	306	45.03	260,900	3
BRT 3a	125.60	43	306	45.03	260,900	3
BRT 3b	125.60	43	306	45.03	260,900	3
BRT 3c	125.60	43	306	45.03	260,900	3
BRT 3d	125.60	43	306	45.03	260,900	3
HRT 1	133.44	45	318	46.89	273,200	3
HRT 2	133.44	45	318	46.89	273,200	3
HRT 3	133.52	45	318	46.90	273,200	3
HRT 3a	133.52	45	318	46.90	273,200	3
HRT 4	133.52	45	318	46.90	273,200	3
HRT 4a	133.52	45	318	46.90	273,200	3
HRT 5	133.52	45	318	46.90	273,200	3

7.4 Operating & Maintenance Cost Estimates

Table 7.6 lists the incremental O&M costs for each operating agency for each alternative, as well as the total for each alternative. All costs are annual incremental costs in FY 2003 dollars.

Table 7.6 : Incremental Operating & Maintenance Cost Estimates

	MARTA			Non-MARTA Bus				subtotal	Grand
Alternative	Rail	Bus	Total	CCT	Douglas	GRTA	Subtotal	all bus	Total
No Build	$0.0	-$2.2	-$2.2	$0.00	-$1.99	$0.00	-$2.0	-$4.2	-$4.2
TSM	base	base	base	base	base	base	base	base	base
BRT 1	$0.0	$1.3	$1.3	$0.27	-$0.06	0.06	$0.3	$1.6	$1.6
BRT 1a	$0.0	$1.4	$1.4	$0.27	-$0.06	0.06	$0.3	$1.7	$1.7
BRT 2	$0.0	$1.4	$1.4	$0.22	$0.24	-0.10	$0.4	$1.8	$1.8
BRT 3	$0.0	$1.4	$1.4	$0.22	$0.24	-0.08	$0.4	$1.8	$1.8
BRT 3a	$0.0	$1.4	$1.4	$0.22	$0.24	-0.08	$0.4	$1.7	$1.7
BRT 3b	$0.0	$1.1	$1.1	$0.22	$0.24	-0.08	$0.4	$1.5	$1.5
BRT 3c	$0.0	$1.1	$1.1	$0.22	$0.24	-0.10	$0.4	$1.5	$1.5
BRT 3d	$0.0	$1.1	$1.1	$0.22	$0.24	-0.10	$0.4	$1.5	$1.5
HRT 1	$8.2	-$0.9	$7.3	-$0.44	-$0.06	-0.22	-$0.7	-$1.6	$6.5
HRT 2	$8.2	-$0.9	$7.3	-$0.44	-$0.06	-0.20	-$0.7	-$1.6	$6.5
HRT 3	$8.2	-$1.1	$7.1	-$0.44	-$0.06	-0.22	-$0.7	-$1.8	$6.4
HRT 3a	$8.2	-$1.3	$6.9	-$0.44	-$0.06	-0.22	-$0.7	-$2.0	$6.2
HRT 4	$8.2	-$1.1	$7.1	-$0.44	-$0.06	-0.20	-$0.7	-$1.8	$6.4
HRT 4a	$8.2	-$1.3	$6.9	-$0.44	-$0.06	-0.20	-$0.7	-$2.0	$6.2
HRT 5	$8.2	-$1.3	$6.9	-$0.44	-$0.06	-0.20	-$0.7	-$2.0	$6.2

7.5 Cost and Cost-Effectiveness Evaluation

Cost is one of the 4 categories used to fully evaluate each the alternative. Specific measures include direct measures of cost, as well as measures of cost-effectiveness, which combine cost estimates with other performance measures to determine how effectively each alternative meets the project goals. As part of the New Starts process, FTA specifies some of these evaluation measures. FTA is in the process of revising its procedures, so this study uses parts of the existing and proposed new procedures.

7.5.1 Absolute Costs

Each of the absolute cost measures are discussed below. Each measure is evaluated on a scale with 3 ratings. The ranges associated with each rating, are as shown in Table 7.7 and the results are shown in Table 7.8.

Table 7.7 : Rating Methodology

	Capital Costs	O & M Costs
Very Desirable (3)	<$100 million	<$2.0 million
Desirable (1)	$100 – 300 million	$2.0 – $5.0 million
Less Desirable (-1)	>$300 million	>$5.0 million

Table 7.8 : Capital and O & M Costs (Millions of 2002 dollars)

Alternatives	Capital Costs	Rating	Annual Incremental O & M Costs	Rating
TSM	$4		-	-
BRT 1	52	3	$1.55	3
BRT 1a	64	3	1.68	3
BRT 2	84	3	1.82	3
BRT 3	91	3	1.82	3
BRT 3a	88	3	1.73	3
BRT 3b	87	3	1.52	3
BRT 3c	86	3	1.52	3
BRT 3d	86	3	1.52	3
HRT 1	468	-1	6.5	-1
HRT 2	463	-1	6.5	-1
HRT 3	504	-1	6.4	-1
HRT 3a	504	-1	6.2	-1
HRT 4	479	-1	6.4	-1
HRT 4a	478	-1	6.2	-1
HRT 5	753	-1	6.2	-1

A. Capital Costs

Capital costs include all costs associated with implementing the project, such as construction, design, right-of-way, vehicles, insurance, and contingency. The HRT alternatives have capital costs ranging from $463 million to $753 million. They are significantly more expensive than the BRT alternatives, which are in the range of $52 to $91 million. Therefore, all of the HRT alternatives receive a rating of Less Desirable and all of the BRT alternatives are given a rating of Very Desirable.

B. Operating and Maintenance Costs

Total annual O&M costs; estimated in Section 7.4, include costs for MARTA rail service, and for bus service operated by MARTA, CCT, GRTA, and Douglas County in the study corridor. O&M costs are stated on an incremental basis, with the TSM Alternative as the basis for calculating the incremental costs.

All of the HRT alternatives are clustered in a relatively small range ($6.16 to $6.55 million), and are significantly more expensive than the BRT alternatives, which are clustered in the range of $1.55 to $1.82 million. Therefore, all of the heavy rail alternatives receive ratings of Less Desirable, while all of the BRT alternatives are rated Very Desirable.

7.5.2 Cost Effectiveness

The basic premise behind the cost effectiveness criteria involves an estimate of the benefits of a transit investment over the life span of the facilities. The performance measures are calculated by annualizing absolute costs and dividing by an assortment of future operating and productivity projections. Calculations and annualization factors are shown in Tables 7.9 and 7.10, while Tables 7.11 and 7.12 depict the rating methodology and rankings across these criteria.

A. Cost per New Rider

FTA has traditionally evaluated New Start projects by estimating the incremental annualized cost per new rider. This reflects the cost of attracting one new rider to use the transit system. This has been used as a measure of benefits, including improvement in air quality and congestion attributable a reduction in auto trips. Since FTA no longer uses this statistic, these figures were not included in the West Line evaluation, but were generated in order to compare West Line alternatives to other MARTA initiatives

Table 7.9 : Annualization Factors

Cost Category	Useful Life (Years)	Annualization Factor
Right-of-Way	100	0.07
Structures and Trackwork	30	0.081
Stations	30	0.081
Access Facilities (Parking, Ramps, Bus Bays)	20	0.094
Systems (Electrification, Communications, etc.)	30	0.081
Rail Vehicles	25	0.086
Buses	12	0.126

This measure, as well as the subsequent one, uses the total annualized cost of an alternative. This combines the capital and O&M costs. Capital costs are annualized, using FTA guidelines for the useful life of various project elements. Table 7.9 shows the useful lives and the resulting annualization factor, based on a discount rate of 7%. Capital costs have been annualized using the annualization factors above, and the results are in Table 7.10.

Table 7.10 : Annualized Cost and Cost per New Rider Calculation

Alternative	Incremental Q&M Cost	Capital Cost	Annual Cap. Cost	Total Annual. Increm. Cost	Weekday New Riders	Annual New Riders	Cost per New Rider
	millions	millions	millions	millions		millions	
Baseline	$0.00	$4	$0.43	base	base	base	base
BRT 1	$1.55	$52	$4.20	$5.3	416	0.12	$42.52
BRT 1a	$1.68	$64	$5.20	$6.5	1,687	0.51	$12.79
BRT 2	$1.82	$84	$6.70	$8.1	804	0.24	$33.68
BRT 3	$1.82	$91	$7.23	$8.6	804	0.24	$35.73
BRT 3a	$1.73	$88	$7.00	$8.3	1,513	0.45	$18.37
BRT 3b	$1.52	$87	$6.90	$8.0	1,112	0.33	$23.97
BRT 3c	$1.52	$86	$6.80	$7.9	1,112	0.33	$23.80
BRT 3d	$1.52	$86	$6.80	$7.9	1,112	0.33	$23.80
HRT 1	$6.55	$469	$37.60	$43.7	4,987	1.50	$29.24
HRT 2	$6.55	$463	$37.20	$43.3	4,987	1.50	$28.94
HRT 3	$6.38	$504	$40.20	$46.2	4,520	1.36	$34.06
HRT 3a	$6.16	$504	$40.10	$45.9	4,333	1.30	$35.30
HRT 4	$6.38	$479	$38.40	$44.4	4,520	1.36	$32.71
HRT 4a	$6.16	$478	$38.20	$44.0	4,333	1.30	$33.83
HRT 5a	$6.16	$753	$60.50	$66.3	4,333	1.30	$50.99

The resulting annualized cost typically represents just below 8% of the total capital cost. The incremental annualized capital cost (relative to the TSM Alternative) is added to the annual incremental O&M cost to give the total annualized incremental cost for each alternative. The annual new riders

for each alternative are derived from the New Riders measure in the mobility chapter, using an annualization factor of 300 days. The weekday and annual numbers represent linked trips.

The right most column in Table 7.10 shows the resulting calculation of incremental cost per new rider in year 2002 dollars. Since this is a measure of cost-effectiveness, a lower cost per new rider indicates more effective performance. Alternative BRT 1a has the lowest cost – $12.79 per new rider. Other BRT alternatives range from $18 to $43. The HRT alternatives range from $29 to $51. As mentioned earlier, FTA has now switched to a different measure of cost-effectiveness, Accordingly, ratings are not assigned to these results, but they are presented for information, and to permit comparison with other projects.

B. Cost and User Benefit

FTA is now proposing to use annualized cost per transit system user benefit, which is a measure of travel timesavings. However, the Atlanta regional forecasting model has not been updated to perform this calculation exactly as FTA dictates. Therefore, a similar measure of travel timesavings is being used in this analysis. The annualized incremental cost, as described above, is divided by the estimated annual travel time saving to produce a measure of cost per hour saved for each alternative.

The results follow a similar pattern to the cost per new rider. BRT 1a has the lowest (best) figure of $25.65 and receives a rating of Very Desirable. BRT 1 and BRT 3a have figures in the range of $39 to $51 and are rated Desirable. The remaining alternatives have costs per hour from $69 to $112, and are rated Less Desirable. Table 7.11 shows the rating scale used for this measure and the 2 measures described below. Results are listed in Table 7.12.

Table 7.11 : Rating Methodology

	Incremental Cost per Hour of Travel Time Saving	Operating Cost per Passenger Mile	MARTA Fare Recovery Ratio
Very Desirable (3)	<$30	<$0.456	>32%
Desirable (1)	$30 - $60	$0.456 - $0.466	29.9 – 32%
Less Desirable (-1)	>$60	>$0.466	<29.9%

C. Operating Cost per Passenger Mile

The calculation of operating cost per passenger mile uses the regional transit passenger-miles, from the ridership model, and total regional operating costs. Since regional figures are used, the impact of the changes in the study area is greatly diluted, resulting in very small differences among the alternatives. The HRT alternatives have slightly lower (i.e. more cost-effective) figures than the BRT alternatives, reflecting the higher passenger-miles that result from higher numbers of passengers. The HRT alternatives are rated Very Desirable, and the BRT alternatives Desirable.

D. Fare Recovery

Another measure that compares costs to ridership is the fare recovery ratio, which measures how much of the annual O&M cost would be covered by passenger (farebox) revenues. Higher (desirable) ratios can result from higher ridership and/or lower costs. This measure has been calculated for MARTA bus and rail service, using the ridership model estimates of total MARTA boardings, MARTA's current average fare per boarding, and the total MARTA O&M cost for each alternative.

There is relatively little difference among the alternatives, since only a small portion of MARTA's two-county system is being affected. The BRT alternatives generally have higher fare recovery than the HRT alternatives; which this is primarily due to the higher operating costs for the HRT alternatives. BRT 1a has the highest figure at 30.1%.

Table 7.12 : Cost and User Benefit, Operating Cost per Passenger Mile, & Fare Recovery

Alternatives	Incremental Cost per Hour of Travel Time Saving	Rating	Operating Cost per Passenger Mile	Rating	MARTA Fare Recovery Ratio (% of Ops Cost)	Rating
TSM	Base	-			29.8	
BRT 1	$40.88	1	$0.461	1	29.9	1
BRT 1a	25.65	3	0.462	1	30.1	1
BRT 2	69.56	-1	0.459	1	30.0	1
BRT 3	73.79	-1	0.460	1	30.0	1
BRT 3a	50.66	1	0.460	1	29.9	1
BRT 3b	78.52	-1	0.459	1	29.9	1
BRT 3c	77.95	-1	0.459	1	29.9	1
BRT 3d	77.95	-1	0.459	1	29.9	1
HRT 1	75.75	-1	0.455	3	29.7	-1
HRT 2	74.98	-1	0.455	3	29.7	-1
HRT 3	73.72	-1	0.455	3	29.8	-1
HRT 3a	77.61	-1	0.457	3	29.6	-1
HRT 4	70.79	-1	0.455	3	29.8	-1
HRT 4a	74.38	-1	0.457	3	29.8	-1
HRT 5	112.14	-1	0.457	3	29.6	.1

7.6 Summary of Cost and Cost-Effectiveness Evaluation

This section has compared the results of the performance measures to determine how well the alternatives fulfill the cost and cost-effectiveness evaluation criteria. The performance measures were rated across all alternatives and benchmarked against the TSM Alternative. These ratings were used to calculate composite ratings, the sum of all performance measure ratings, and an overall score, the sum of all the composite ratings. These scores indicate how the alternatives compared relative to one another using the cost and cost-effectiveness criteria.

In looking at the cost and cost-effectiveness evaluation criteria, the BRT alternatives outperformed all the HRT alternatives. The HRT alternatives have extremely high capital costs, and somewhat higher O&M costs. This resulted in lower ratings for most of the performance measures for all of the HRT alternatives. Therefore, the composite rating for all of the HRT alternatives is Less Desirable.

There was more variation among the BRT alternatives. BRT 1a generally performed the best, followed by BRT1, due to lower capital costs. BRT 3a also scored well, due to higher ridership. These 3 alternatives have overall ratings of Very Desirable. The remaining BRT alternatives have an overall rating of Desirable.

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