CHAPTER VII
DETAILED EVALUATION OF ALTERNATIVE TECHNOLGIES AND ALIGNMENTS

The following chapter summarizes the technical background, comparisons, and community issues considered in the evaluation of the transit alternatives. Based on the information presented in the following evaluation, the Policy Oversight Committee recommended a preferred corridor and technology to be carried forward to the next phase of the study.

A. TTA Phase I & MIS Phase II System Interface

In the Phase I MIS, the 9th Street Station was assumed to be the connection point between TTA's Phase I Regional Rail System and the Phase II MIS study alternatives. However, at the request of Duke University, an additional detailed comparative analysis was performed to consider alternate sites within the study's project area for a transfer between alternative technologies.

Two alternate sites were considered, Campus Drive and Buchanan Boulevard (TTA Phase I Duke East Station concept), and then compared to the TTA Phase I 9th Street Station concept. The sites were compared based on vehicular and pedestrian accessibility, adjacency opportunity with neighboring developments, transit linkages for both local transit and the TTA Phase I interface, site accommodation and constructability. The analysis is summarized in Table VII-I. The highlighted areas indicate criteria results which are more favorable than other alternatives.

Overall, the 9th Street Station site is the preferred site based on: 1) clearest vehicle access from primary arteries and best transit bus circulation from all directions, 2) least costly connection to the Erwin Road transit corridor, and, 3) adjacency to the Erwin Road / 9th Street redevelopment, First Union Plaza and Duke University.

Table VII-I. Potential MIS Phase I & II Interface Station Locations Comparative Analysis

Criteria	9th Street	Campus Drive	Buchanan Blvd. (Duke East Station)
Transit Linkages			
DMU Alt No. 1 Extension of TTA Phase I	No effect on future service.		
Erwin Road Alignment Alternatives (LRT Alt No. 1 Busway Alt Nos. 1 & 2 BMT Alt Nos. 1 & 2)	• *Forced transfer for "through" service* • ***Costly,** difficult connection to Erwin Road corridor and destinations southwest of Duke West Campus* • *R/W constraints between NCRR, NC 147 and Erwin Road*	• Forced transfer for "through" service • **More Costly,** difficult connection to Erwin Road corridor and destinations southwest of Duke West Campus • R/W constraints between NCRR, NC 147 and Erwin Road	• Forced transfer for "through" service • **Most Costly,** difficult connection to Erwin Road corridor and destinations southwest of Duke West Campus • R/W constraints between NCRR, NC 147 and Erwin Road
Western Alignment Alternatives (LRT Alt No. 3 Busway Alt Nos. 3 & 4	• No effect on future service, assuming TTA Phase 1 Technology extends to Hillsborough/Fulton Station • Costly, difficult connection to US 15-501 Corridor Study		
Local Transit	*Best transit/bus circulation opportunity from all directions*	• Duke University Transit via Campus Drive • DATA/TTA via Main Street on Pettigrew	• Buchanan Blvd.
Adjacency Opportunity	• *Erwin Square Redevelopment / 9th Street* • *Commercial Development – First Union Plaza* • *Duke Central Campus*	• Duke East Campus • Smith Warehouse Redevelopment	• Duke East Campus • Smith Warehouse Redevelopment • Burch Avenue Neighborhood
Accessibility			
Auto (from south)	Via Anderson (RIRO)*	Via Campus Drive (private)	Via Buchanan Blvd.
(from west)	Via Erwin (RIRO)*	Via improved Pettigrew St. or Main St.	Via Main St. to Buchanan Blvd.
(from north)	Via 9th Street (RIRO)*	Via Swift Ave. to Pettigrew St. or Broad St. to Main Street	Via Buchanan Blvd.
(from east)	Via Main (RIRO)*	Via Main St. or Main St. to Swift Ave. to Pettigrew	Via Main St. to Buchanan Blvd.
Adjacent Road Capacity	*Good; supported by major thoroughfares Erwin Road and Main Street*	Supported by minor thoroughfares Campus Drive and Pettigrew	Supported by minor thoroughfare Buchanan Blvd.
Site Accommodation			
Intermodal Transfers	*Bus and Rail bisected by Erwin Road*	Bus from Main Street and rail bisected by other tracks.	*Bus and rail bisected by Buchanan Blvd.*
Pedestrian	*Via Erwin Road and pedestrian overpass over Erwin Rd from Pettigrew*	*Pedestrian crossover from platform to bus connection*	Platform not adjacent to bus, Kiss-N-Ride or Parking
Park-N-Ride	*Near platform station*	• On Campus Dr. lower level than platform • On Pettigrew St. bisected by Pettigrew	• Separated by Smith Warehouse
Site Constructability			
Grades	Significant; walls and bridges required	Significant; walls and bridges required	*Minimal*
Impacts to Existing Structures	*None*	*None*	Smith Warehouse

*RIRO - Right in, right out; movement does not allow for left hand turning movement.

B. Transportation Services / Mobility Issues

The following measures of effectiveness reflect direct output from the travel demand model in terms of comparing transit service and transit effectiveness. Qualitative measures of traffic and pedestrian safety for the Build Alternatives are also compared.

1. Transit Services and Coverage

The following two sections contain calculations that are based upon the patronage forecasting methodology presented in Chapter V of this report. Many of the original data tables containing the applicable ridership and service information are contained in that section of the report.

One aggregate measure of study area transit service applied in this report is daily passenger-miles of service. This measure is calculated by subtracting the 2025 average weekday passenger-miles estimate of the No-Build Alternative from each Build Alternative. The passenger-miles statistic is an aggregate combination of all transit service providers represented in the TRM. Original passenger-kilometer data (converted to miles traveled) is found in the Transit System Performance Summaries in Tables V-VI and V-XVII in Chapter V. Table VII-II displays the results of this measure.

Table VII-II. Passenger-Miles Comparison By Alternative

Evaluation Criteria	**Alternative**										
	No Build	***DMU Alt 1A***	***LRT Alt 1***	***LRT Alt 2***	***LRT Alt 3***	***Bus Alt 1***	***Bus Alt 2***	***Bus Alt 3***	***Bus Alt 4***	***BMT Alt 1***	***BMT Alt 2***
Passenger-Miles (per day) over No-Build	0	62,252	67,178	67,985	97,085	85,317	88,951	79,416	77,596	32,433	65,693

The percentage of the population served by transit was also calculated as a general measure of transportation service and mobility for the Triangle Region. Computations were based on multiplying the population in traffic analysis zones (TAZs) by the percentage of the population within 1/2 mile of a transit line (the "long walk" percentage in the model). Total population of the Triangle Region was calculated by summing all TAZs in the 2025 model. Transit service coverage does not change by alternative since the US 15-501 corridor is in an area with existing bus transit coverage. Table V-VII in Chapter V displays the results, which indicate that 47 percent of the population in the 2025 TRM forecasts are served by transit, regardless of any Build Alternative.

2. *Transit Effectiveness*

There are three transit effectiveness criteria that were calculated based on model travel demand, ridership results, and cost estimates of the 10 Build Alternatives in this MIS Phase II analysis. The *Percent Change in Daily Automobile Miles Traveled* criterion reflects the effectiveness of each transit alternative in reducing aggregate system-wide automobile traffic. This directly correlates with decreased road congestion and improved air quality.

Tables V-VIII and V-XXIV in Chapter V contain information related to daily passenger-kilometers of travel for each of the 10 Build alternatives and the No-Build. The change (or delta) in vehicle-kilometers traveled from those tables was divided by the total daily No-Build Alternative vehicle-kilometers value to calculate the percent reduction in VMT. The results are shown below in Table VII-V.

The second measure of transit effectiveness studied was cost per transit user. As in Phase I of the Major Investment Study, we have quantified the cost per transit user by:

$$\textit{Cost per Transit User} = \frac{\text{Total Annualized Capital Costs + Annualized O \& M Costs}}{\text{Total Annual Ridership (Unlinked Trips)}}$$

For the Phase II MIS, we have also calculated the incremental costs per incremental transit user (also referred to as the Cost Effectiveness Index) per FTA guidelines.

$$\textit{Cost Effectiveness Index} = \frac{\text{Total Annualized Capital Costs + Annualized O \& M Costs}}{\text{Total Annual New Ridership (Linked Trips)}}$$

TTA's annualization factor for ridership of 285 was assumed. The results have been tabulated below in Table VII-V.

Table VII-V. Transit Effectiveness Criteria

Evaluation Criteria	**Alternative**										
	No Build	***DMU Alt 1A***	***LRT Alt 1***	***LRT Alt 2***	***LRT Alt 3***	***Bus Alt 1***	***Bus Alt 2***	***Bus Alt 3***	***Bus Alt 4***	***BMT Alt 1***	***BMT Alt 2***
Percent Change in Daily Auto Vehicle-Miles Traveled (VMT) From No-Build	N/A	+0.15	+0.13	+0.08	+0.07	+0.08	(-0.05)	(-0.02)	+0.04	+0.09	+0.01
Cost per Transit User ($ per rider per year)	*$0*	*$14.45*	*$8.09*	*$7.46*	*$8.04*	*$9.95*	*$10.81*	*$11.04*	*$11.55*	*$8.97*	*$8.41*

Incremental Costs per Incremental Transit User* ($per new rider per year)	$0	*$292*	*$103*	*$104*	*$60*	*$44*	*$38*	*$47*	*$42*	*$117*	*$44*

* Taken as a ratio of annualized total capital investment (considering the life cycle costs of various elements) and operating costs divided by the forecasted increment in annual transit system ridership.

Table VII-III shows that, for the automobile VMT reduction criterion, only two Build Alternatives actually decrease overall network system miles traveled. Busway Alternatives 2 and 3 marginally reduce system-wide VMT and thus produce the most beneficial results in comparison with the other alternatives for the purposes of this study.

In terms of comparing Costs per Transit User for each alternative, Table VII-III reveals a range of costs between $7.46 and $14.45 per transit user. In general, LRT and BMT alternatives have lower costs per rider than do the DMU and Busway alternatives. Ridership for this measure of effectiveness is given in unlinked total daily boardings, which does not necessarily indicate the effectiveness per "new" transit system rider generated by each alternative.

The cost per new rider, defined as "the cost-effectiveness index" (CEI), is an FTA requirement to compare transit systems applying for New Starts funding and thus was considered to be an important transit effectiveness measure for this study. Table VII-V shows a wide range of incremental cost per incremental new user from $38/new user for Busway Alternative 2 to $292/new user for the DMU alternative. Relatively small increases in new ridership are a key factor in the large range of CEI values. In general, the Busway alternatives have the lowest CEI values compared to the other technologies, thus making them more cost-effective for this index criterion. Please note that the cost-effectiveness indices (incremental costs per incremental transit user) for FY 2000 FTA New Starts submissions ranged from $2.54 per new rider to $48.82 per new rider, with a median reported cost of $10.39 per new rider.

3. Traffic/ Pedestrian Safety

In evaluating the build alternatives for relative traffic and pedestrian safety concerns, alternatives were quantitatively and qualitatively compared to each other for potential conflicts between pedestrians and vehicles. Criteria considered for comparison of the alternatives include:

- The number of at-grade street crossings (quantitatively),
- Large population of pedestrian students at Duke (Erwin Road) and UNC (Manning Drive); and
- Potential conflicts resulting from a more active Coal Spur rail corridor along Erwin Road.

As Table VII-IV indicates, the alignments with segments of BMT have the potential for a higher number of conflicts between vehicles and pedestrians due the significant number of at-grade street crossings. Those alternatives with segments containing an Erwin Road alignment or BMT "Diamond Lanes" on Manning Drive, such as Bus Alternative No. 2, also have a higher conflict potential. Those alternatives, which followed the "Western" alignment adjacent to U.S. 15-501, in the northern project area, generally had fewer conflicts than the other alternatives.

Table VII-IV. Evaluation Criteria for Traffic and Pedestrian Safety

Evaluation Criteria	**Alternative**									
	DMU Alt 1	***LRT Alt 1***	***LRT Alt 2***	***LRT Alt 3***	***Bus Alt 1***	***Bus Alt 2***	***Bus Alt 3***	***Bus Alt 4***	***BMT Alt 1***	***BMT Alt 2***
Potential Traffic Pedestrian Conflicts										

Legend

More Potential Conflicts

Relatively Equal Amount of Potential Conflicts

Less Potential Conflicts

C. Community And Environmental Impacts

The following section describes both a qualitative comparison and quantitative estimate of the community and environmental impacts for each alternative; the results are summarized in Table VII-V.

Table VII-V. Community and Environmental Impacts

Evaluation Criteria	Alternative										
	No Build	*DMU Alt 1*	*LRT Alt 1*	*LRT Alt 2*	*LRT Alt 3*	*Bus Alt 1*	*Bus Alt 2*	*Bus Alt 3*	*Bus Alt 4*	*BMT Alt 1*	*BMT Alt 2*
Residential Displacements	0	83	78	78	83	86	86	83	83	1	77
Business Displacements	0	10	7	9	10	10	7	10	10	4	5
Neighborhoods Affected	0	9	9	9	9	8	8	9	9	2	7
Community Sensitive Land Uses, Parks, Section 4 (f) Properties, Affected / Noise Issues*	0	9	7	7	9	8	8	9	9	6	6
Visual / Aesthetic Impacts											
Impacts to Historic Sites / Structures	None	None	None	None	None	None	None	None	None	None	None
Watershed Impacts											
Potential Wetland Impacts (acres)	0	4.9	4.9	4.9	4.9	4.5	4.5	4.5	4.5	1.3	4.5
New River and Creek Crossings / Total	0	3	4	4	3	4	4	3	3	2	3

Legend

- Higher Negative Impact
- Same Relative Impact
- Lower or No Negative Impact

Residential and Business relocations were provided by a windshield survey conducted by NCDOT in August 2001. Assumptions include the relocation of Odom Village by UNC as part of master plan capital improvements that would occur prior to the construction of the U.S. 15-501 improvements and the relocation of the Glenwood School for all alternatives. Business/ Residential relocation estimates also include the proposed Bus / LRT Maintenance and Storage Facility impacts for all LRT alternatives. Development, which has occurred in the study's preserved right of way corridor within Meadowmont and Friday Center area was also included in the business and resident relocation estimates. Bus Alternatives 1 & 2 impacts a university residence hall, which was excluded from the total relocation count. All "Western" Alignment alternatives would require relocating gravesites located in the Cedar Hill and New Bethel Memorial Gardens cemeteries. DMU Alternative 1 would require approximately 475 grave relocations, and Bus Alternatives 3 & 4 would require the relocation of approximately 400 gravesites.

Existing neighborhoods within the project area were identified and quantified for comparison. Nearly all the neighborhoods were proximal to proposed improvements, with the exception of the George King Road / Ephesus Church area and a multiple family housing development located in the University Drive area. Existing neighborhoods within the project area include:

- West Durham Neighborhood
- Cameron Woods
- Archstone Apartments
- Springfield Apartments
- Pope Crossing
- Ephesus Church
- Meadowmont, and
- Laurel Hill.

All alternatives, except BMT Alternative 1, have a potentially large number of residential relocations attributed to the impact to multiple family housing located between Garrett Road and University Drive. During the EIS phase of this project, a detailed relocation analysis will be performed and further refinement will be made of the alignment to minimize the impact to this residential area will be completed.

Community sensitive land uses such as religious institutions, hospitals, schools, and parks that may be noise sensitive were identified and quantified. In each case, it is not implied that acquisition will occur, only that the close proximity of the fixed guideway improvements have the potential to impose a noise or visual impact on the land use. Potential community sensitive land uses identified include:

- Two religious institutions
- Four schools
- Cedar Hill and New Bethel Memorial Gardens Cemeteries
- Lennox Baker Children's Hospital
- VA Hospital
- Duke University Medical Center
- Morreene Road Park
- Duke Wellness Center
- Washington Duke Golf Course
- Friday Center for Continuing Education
- North Carolina Botanical Gardens
- UNC Hospitals

The relative visual impacts from proposed guideway improvements were assessed based quantitatively on the amount of structure required. Qualitative considerations included considering the visual impact of the proposed flyover ramp over Manning Drive (Bus Alternatives 2 & 4 and both BMT alternatives). Other considerations include the visual impact of the Southern UNC alignment on the Mason Farm neighborhood (DMU Alternative 1, Bus Alternatives 2 & 4 and all LRT alternatives) and the presence of fixed guideway in the existing rural character of the Ephesus Church area. Those alternatives, which were equivalent in amount of visual intrusiveness on the surrounding environment when compared to each other, were evaluated as having the same relative visual impact. Bus Alternative No. 4 had the highest relative visual impact of all the build alternatives compared due to the cumulative effects of the Manning Drive flyover, guideway presence in the Ephesus Church area, and the significant length of structure.

Longleaf Historic Resources completed a survey of historic structures in the Phase I Major Investment Study in December of 1996. None of the Build Alternatives studied in this report directly impact any of the historic structures identified in the survey.

D. Capital Costs

As part of the detailed evaluation of the transit alternatives, functional designs were completed for each technology. Preliminary profiles based on topographical contours were performed in key areas, and CAD based mapping was produced for each alternative alignment. Phase I MIS unit costs were updated from 1998 to 2001 fiscal year dollars to determine the construction and vehicle cost estimates in Phase II. Table VII-VIII presents a summary of construction, right of way, utility relocation and vehicle capital costs for each alternative.

1. Right of Way and Utility Relocation

Functional designs for each alternative were provided to the NCDOT Right of Way Branch to determine the right of way and utility relocation costs. Based on field observations in August 2001, NCDOT provided right of way and utility relocation cost estimates. Development that has occurred in the study's preserved right of way corridor in the Meadowmont and Friday Center area was also included in the right of way and utility relocation estimates. Utility relocation estimates include relocating the Erwin Road substation in Busway Alternative Nos. 1 & 2 and a transmission line adjustment north of the U.S. 15-501 / Morreene Road interchange in Bus Alternative Nos. 3 & 4.

2. Construction

Construction cost estimates for all build alternatives were developed using updated MIS Phase I NCDOT unit costs and information provided by the NCDOT Design Services unit and the NCDOT Rail Division. NCDOT standard practice contingencies for engineering, mobilization and miscellaneous items were also added to compensate for the estimated cost difference between preliminary estimates and contract award amounts. Electrification costs for catenary and substations are also provided for all LRT Alternatives.

Assumptions for construction of the stations included simple metal structures with awnings for all bus and rail alternatives. For BMT and Busway options, platforms were assumed to be 150 feet by 15 ft each, with two platforms at each station location. For LRT and DMU, station platforms were assumed to be 450 feet by 25 feet; with only one centrally located platform per station location. MIS Phase I cost estimates were updated from FY 1998 dollars to FY 2001 dollars for parking and site improvements for all non-walking stations, including the elevated station at South Square Mall.

3. *Vehicles*

For the purposes of this study, we have assumed that future vehicle purchases would have the same unit costs in 2001. MIS Phase I vehicle unit costs for DATA and CHT buses were updated from FY 1998 dollars to FY 2001 dollars using an inflationary percentage rate of 3%. Vehicle costs for TTA buses were assumed to be $206,667, which is consistent with TTA's Phase I DEIS (April 2001). The DMU vehicle unit cost of $6.2 million per 2 car set assumed in TTA's Phase I DEIS was also used. Typical diesel LRT and electric LRT vehicles were assumed to have a $2.5 million and $2.0 million unit cost respectively.

Table VII-VI. Capital Costs for Alternative Combinations
(millions unless noted, 2001 dollars)

Evaluation Criteria	Alternative										
	No Build	*DMU Alt 1*	*LRT Alt 1*	*LRT Alt 2*	*LRT Alt 3*	*Bus Alt 1*	*Bus Alt 2*	*Bus Alt 3*	*Bus Alt 4*	*BMT Alt 1*	*BMT Alt 2*
Construction	$0	$187.3	$227.3 (E) $195.6 (D)	$220.8 (E) $189.1 (D)	$218.2 (E) $186.7 (D)	$133.5	$127.7	$149.0	$143.0	$54.9	$109.2
Utility Relocation	$0	$1.0	$1.4	$1.4	$1.1	$4.1	$4.2	$1.1	$1.1	$0.8	$4.3
Right-of-Way Costs	$0	$82.6	$73.6	$73.6	$84.0	$80.0	$72.1	$85.6	$77.7	$11.5	$62.2
Vehicle Capital Costs	$0	$35.9	$28.3 (E) $34.3 (D)	$26.3 (E) $31.8 (D)	$26.3 (E) $31.8 (D)	$12.1	$13.0	$11.3	$12.6	$14.5	$13.4
Bus**	$0	$4.9	$4.3	$4.3	$4.3	$12.1	$13.0	$11.3	$12.6	$14.5	$13.5
Rail	$0	$31	$24.0 (E) $30.0 (D)	$24.0 (E) $30.0 (D)	$22.0 (E) $27.5 (D)	$0	$0	$0	$0	$0	$0
Total Capital Costs	$0	$297.1	$330.5 (E) $304.9 (D)	$324.1 (E) $298.4 (D)	$329.6 (E) $303.6 (D)	$229.7	$217.0	$247.0	$234.4	$81.7	$189.1
Construction, Utility Relocation and Right-of-Way Costs per mile* **	$0	$19.48	$21.44 (E) $19.20 (D)	$20.97 (E) 18.73 (D)	$21.82 (E) $19.55 (D)	$15.43	$14.47	$16.72	$15.84	$4.48	$11.79

Notes:
* (E) Electric Vehicle / (D) Diesel Vehicle
** Incremental fleet increase over No-build.
*** Transit cost per mile includes fixed guideway only, vehicle costs excluded.
Capital Costs exclude rail storage and maintenance facility.

E. Transit Operating and Maintenance Costs

This section describes the methodology used to estimate operating and maintenance (O&M) costs for all modes included in the various alternatives, and presents the resulting estimates. Section 1 describes the methodology for producing bus O&M cost estimates for bus service operated by DATA, CHT, and TTA. It also includes costs for busway elements. Section 2 describes the methodology for rail O&M cost estimates, including the TTA Phase I Regional Rail system using DMU's, and possible light rail alternatives for the Durham-Chapel Hill corridor.

1. Bus O&M Costs

TTA has developed a bus O&M cost model that includes all of the transit operators in the region. For the Phase II MIS, changes in bus service are proposed for three of the transit operators: Durham Area Transit Authority (DATA), Chapel Hill Transit (CHT), and Triangle Transit Authority (TTA). Therefore the portions of the model dealing with those agencies have been updated for this study. Minor changes are proposed for Duke University bus service, and the TTA cost model does not include a forecasting component for Duke.

The bus cost model is based on data that are reported annually to the National Transit Database (NTD, formerly known as Section 15). Each operator's portion of the model has line items corresponding to the line items in the respective NTD reports. Each modeled line item is related to one or more input variables, with some items fixed or partially fixed. The input variables include annual bus-miles, annual bus-hours, and number of peak buses.

The model received from TTA (dated October 2000) had been calibrated to fiscal year 2000 data for TTA itself, but still included fiscal year 1998 calibration data for DATA and CHT. Therefore FY 2000 NTD reports were obtained for the latter operating agencies, and their subsections of the model were updated using those data. The model was also modified to permit more convenient handling of input data for multiple alternatives.

A further modification to the TTA sub-model includes three line items for estimating busway costs, as follows:

- Busway Station Maintenance/Cleaning, assumed as $22,000 annually per busway station;
- Busway Maintenance, assumed as $32,500 annually per busway mile; and
- Busway Security/Enforcement, assumed as $54,300 per busway station.

These assumptions were based upon 1997 information from Port Authority of Allegheny County, Pennsylvania, inflated to year 2000 dollars.

In conjunction with the new line items, additional input variables were defined for busway stations and busway miles.

Due to the large number of alternatives and operators, direct estimation of operating statistics for each affected route and operator was not practical. Therefore the input data for the bus models were derived from the ridership model. The TRANPLAN model uses the coded headways, routing and highway speed data to estimate bus-miles, bus-hours, and number of required buses for each route, for both a peak period and an off-peak period (3 hours each). However, the TRANPLAN model does not efficiently assign buses, since it calculates each direction independently, and does not account for interlining (coordinating the schedule of two routes so that a single vehicle operates some trips on each route), short-turning (some trips only cover part of the route, presumably the highest volume portion), or other operating efficiencies which could underestimate the O&M costs. Therefore the TRANPLAN operating statistics typically overstate the number of buses required. In order to compensate for this, the TRANPLAN estimates for a base year network (1995) were compared to actual operating statistics for that year, and appropriate adjustment and expansion factors were calculated. These factors were then used to convert TRANPLAN model output statistics for 3-hour peak and weekday off-peak periods, to annual estimates of bus-miles and bus-hours. The annual estimates, along with the adjusted number of peak buses, were then used as input to the O&M cost model for each transit operator.

2. Rail O&M Costs

TTA has developed an O&M cost model for its Phase I Regional Rail system. The system will use self-propelled diesel trains operating on separate tracks along existing railroad rights-of-way. For the 15/501 MIS Phase II, an extension of the regional system is being considered as one of the ten alternatives (DMU Alternative 1). The TTA Phase I rail (DMU) cost model was used to estimate the incremental operating costs of the extension.

Three of the alternatives use light rail between Durham and Chapel Hill. Therefore the TTA Phase I rail cost model was modified to apply to light rail. The modifications were based on work that MPA has recently completed in Tampa, where both DMU and LRT are being considered. The following line items in the TTA model were modified to reflect the differences in the two modes of transit:

- The line item for diesel fuel was replaced with propulsion power, assumed at $0.66 per revenue car-mile. This cost is the average paid in FY 2000 by nine existing U.S. light rail systems.

- Because of differences in vehicle technology, it is assumed that vehicle maintenance staff requirements would be 20% less for light rail than DMU. Accordingly, productivity factors for mechanics and mechanic assistants have been increased in the LRT model.

- Facilities maintenance labor costs are assumed to be higher for LRT than DMU because of the need to inspect and maintain the catenary system. Accordingly, a new position has been added to the model for traction power maintainer, with the same productivity as the position of track inspector and the same average wage as a signal maintainer. The formula to calculate the number of signal maintenance supervisors was modified to include traction power maintainers.

- Also, because of the catenary, the facilities maintenance cost for track/signal materials is assumed to be 25% higher for LRT than DMU. Therefore, the DMU unit cost of $14,893 per route-mile was increased to $18,616 for LRT.

3. *Results*

Table VII-VII lists key bus and rail operating statistics for each of the ten Build Alternatives and for the No-Build scenario.

Bus statistics are given separately for DATA, CHT, and TTA. They include annual bus-miles, annual bus-hours, fleet size, and annual operating cost. All operating statistics are for the forecast year of 2025, and costs are expressed in FY2001 dollars.

Rail statistics and costs are for the new facility. Costs for the DMU alternative were calculated by comparing the estimated cost of the extended system to the TTA Phase I system. DMU Alternative 1A assumes 15 minute peak / 30 minute off-peak headways; DMU Alternative 1B assumes 7.5 minute peak / 15 minute off-peak headways.

The last row of the table shows the total incremental cost of changes in both bus and rail service, compared to the No-Build. For example, LRT Alternative 1 has $3.1 million of additional bus costs, and $7.75 million of LRT costs, for a total incremental cost of $10.9 million. The DMU alternative has the lowest incremental cost, $9.3 million. The total incremental costs for the other nine build alternatives are clustered in a relatively narrow range, from $10.5 million for the Busway Alternative 3 to $11.7 million for Busway Alternative 2.

Table VII-IX. Summary of Operating Statistics and Costs by Alternative

Alternative	FY 2000	No-Build	DMU Alt. 1A	DMU Alt. 1B	LRT Alt. 1	LRT Alt. 2	LRT Alt. 3	Bus Alt. 1	Bus Alt. 2	Bus Alt. 3	Bus Alt. 4	BMT Alt. 1	BMT Alt. 2
BUS OPERATIONS													
DATA													
Annual Bus-Miles (M)	1.82	4.4	4.7	4.7	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.4	4.5
Annual Bus-Hours (K)	137	277	285	285	283	283	283	283	283	283	283	277	283
Fleet Size	29	98	101	101	99	99	99	99	99	99	99	97	99
Operating Cost (M)	**$7.2**	**$15.5**	**$16.1**	**$16.1**	**$16.0**	**$16.0**	**$15.9**	**$15.9**	**$15.9**	**$15.9**	**$15.9**	**$15.6**	**$15.9**
CHT													
Annual Bus-Miles (M)	1.26	3.4	4.1	4.1	4.1	4.1	4.1	4.2	4.3	4.2	4.2	4.3	4.3
Annual Bus-Hours (K)	93.5	212	251	251	251	251	251	251	253	251	253	253	253
Fleet Size	45	115	131	131	131	131	131	131	132	131	132	132	132
Operating Cost (M)	**$6.5**	**$15.1**	**$17.8**	**$17.8**	**$17.8**	**$17.8**	**$17.8**	**$18.0**	**$18.2**	**$18.0**	**$18.2**	**$18.3**	**$18.2**
TTA													
Annual Bus-Miles (M)	1.27	3.7	3.5	3.5	3.5	3.5	3.5	5.8	5.9	5.5	5.6	6.2	6.0
Annual Bus-Hours (K)	58.9	204	200	200	200	200	200	322	331	310	325	367	344
Fleet Size	25	81	79	79	79	79	79	117	120	113	118	130	122
Busway Miles	0	0	0	0	0	0	0	13.9	13.0	14.1	13.2	2.0	6.5
Busway Stations (1)	0	0	0	0	0	0	0	12	12	13	13	7	10
Operating Cost (M)	**$3.7**	**$12.4**	**$12.3**	**$12.3**	**$12.3**	**$12.3**	**$12.3**	**$20.1**	**$20.5**	**$19.6**	**$20.0**	**$20.8**	**$20.4**
TOTAL BUS OPERATIONS													
Annual Bus-Miles (M)	4.4	11.4	12.2	12.2	12.1	12.1	12.1	14.5	14.7	14.3	14.4	14.9	14.8
Annual Bus-Hours (K)	289	692	736	736	734	734	734	857	867	845	861	897	881
Bus Fleet Size	99	294	310	310	309	309	309	347	352	343	350	359	353
Bus Operating Cost (M)	**$17.4**	**$43.0**	**$46.3**	**$46.3**	**$46.1**	**$46.1**	**$46.1**	**$54.1**	**$54.7**	**$53.5**	**$54.1**	**$54.7**	**$54.6**
Increment vs. No-Build	*N/a*	*base*	*$3.3*	*$3.3*	*$3.1*	*$3.1*	*$3.1*	*$11.1*	*$11.7*	*$10.5*	*$11.1*	*$11.7*	*$11.6*
RAIL OPERATIONS													
TTA (2)													
			Incremental	*Incremental*		(3)							
Annual Bus-Miles (M)	0	0	0.98	1.96	0.79	0.79	0.78	0	0	0	0	0	0
Annual Bus-Hours (K)	0	0	17.7	17.7	37.0	37.0	35.5	0	0	0	0	0	0
Fleet Size	0	0	10	22	12	12	11	0	0	0	0	0	0
Stations	0	0	7.5	7.5	13	13	12	0	0	0	0	0	0
Rail System Miles	0	0	13.9	13.9	14.1	14.1	13.9	0	0	0	0	0	0
Operating Cost (M)	**$0.0**	**$0.0**	**$6.0**	**$9.6**	**$7.8**	**$7.4**	**$7.5**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**	**$0.0**
Bus & Rail Operating Costs (M)	**$17.4**	**$43.0**	**$52.3**	**$56.0**	**$53.9**	**$53.6**	**$53.6**	**$54.1**	**$54.7**	**$53.5**	**$54.1**	**$54.7**	**$54.6**
Increment vs. No-Build	*N/a*	*base*	*$9.3*	*$12.9*	*$10.9*	*$10.6*	*$10.6*	*$11.1*	*$11.7*	*$10.5*	*$11.1*	*$11.7*	*$11.6*

1. For costing, BMT stations = ½ Busway station.
2. Rail costs are incremental costs and do not include TTA Phase I Regional Rail costs.
3. LRT Alternative 2 also reduces DMU stat's by 1 mile, 1 station and 70K car-miles.
4. All costs in FY 2000 dollars.