EXECUTIVE SUMMARY

I. INTRODUCTION

A. Background

This document presents a summary of the US 15-501 Phase II Major Investment Study (MIS), focusing on the selection of a preferred transit alignment, transit technology and decisions made by the Study's Policy Oversight Committee. This document serves as a companion to the Phase II Major Investment Study report, which describes the process and recommendations in more detail.

In the US 15-501 Phase I MIS, reasonable and feasible transit/highway alternative combinations and a general level of investment have been identified. The Phase II MIS focuses on a refined transit alternative analysis, including more detailed engineering studies and additional public involvement input.

B. Study Area Context

US 15-501 is primary north-south highway route in North Carolina, extending from the Virginia State line south to the South Carolina State line. Within the Triangle region, US 15-501 is a four- to six-lane expressway connecting the Town of Chapel Hill and the City of Durham, with major interchanges at NC 54 and Franklin Street in Chapel Hill; and at I-40, US 15-501 Business, NC 147 (Durham Freeway), and I-85 in Durham. The Phase II MIS Study Area has been refined to include areas adjacent to Corridor "A" from the Phase I Study. Exhibit ES-1 illustrates the study area for this phase of the project.

C. Project History

In 1993-1994, the City of Durham, the Town of Chapel Hill, NCDOT, and private property owners in the US 15-501 corridor participated in the US 15-501 Corridor Study which focused on identifying areas of congestion and methods to improve mobility within the corridor. A Corridor Master Plan was developed. The study recommended the following multi-modal improvements: 1) upgrading US 15-501 to a controlled access facility (i.e., urban freeway), 2) preserve right of way for a future transit corridor, and 3) investigate TDM strategies. The Triangle Transit Authority's (TTA's) Triangle Fixed Guideway Study (February, 1995) and Draft Environmental Impact Statement (DEIS) (April, 2001) determined a need for rail or bus transit fixed guideway between Durham and Chapel Hill as part of the second phase of their regional rail system.

The US-15-501 Phase I MIS, completed in November of 1998, recommended that the following alternatives to be carried forward for future study:

- No-Build Alternative
- Travel Demand Management Strategies (TDM) such as bus preferential treatment (i.e., signal pre-emption), pricing programs to reduce fares such as employee subsidies, overall increased bus service, and employer based strategies - including staggered work hours and telecommuting.

Exhibit ES-1

- Enhanced bus service.
- Widening US 15-501 at- grade from Franklin Street in Chapel Hill to I-40 to 8 lanes, and upgrading US 15-501 to a 6-lane freeway from I-40 to US 15-501 Business in Durham.
- Construction of "circulation roads" at the US 15-501 / I-40 interchange to provide some congestion relief on 15-501 itself by providing alternative routes for local trips.
- HOV Lanes within the US-15-501 Corridor.
- Pedestrian and bicycle facility improvements including a sidewalk and dedicated bicycle lanes along Old Durham-Chapel Hill Road from US 15-501 to University Drive.

The Policy Oversight Committee also recommended that more detailed evaluation of rail and busway technologies was necessary before a final decision could be made. The POC recommended that these technologies continue to be evaluated for fixed guideway in Phase II of the US 15-501 MIS.

II. EVALUATION PROCESS

During the scoping process of the Phase II MIS, the transit technologies to be evaluated were defined as:

- TTA's Phase I Technology: a diesel multiple unit (DMU) that may or may not be a Federal Railroad Administration (FRA) compliant vehicle;
- Busway (i.e., fixed guideway with completely dedicated right-of-way);
- Busway / Mixed Traffic (BMT): a hybrid of on-street operation and exclusive busway; and
- "Lighter" rail technology than TTA Phase I, such as light rail or "lighter" DMU.

The TTA Phase I 9th Street Station was assumed to be the interface between the TTA Phase I and Phase II transit study, and Corridor "A" of the Phase I MIS was selected for further study in Phase II .

Case studies of the alternative evaluation process for other systems in the United States and Canada were reviewed to evaluate how other municipalities made similar initial decisions on a particular type of transit technology to use for their system. Transit systems of particular interest included cities that:

- Were implementing "new start" transit systems;
- Had comparable urban characteristics;
- Had reached their transit technology decision via a formal MIS process in the last few years; and
- Contained a transit corridor resembling the corridor from Durham to Chapel Hill in terns of length, number of stations, ridership and land use patterns.

III. PROJECT ALTERNATIVE DEVELOPMENT

Initial screening and reviewing of concepts from project stakeholders occurred during the Fall of 2000 through a series of Station Area Planning workshops held at Duke University and the University of North Carolina Chapel Hill (UNC). Alternatives were then selected for further refinement and evaluation by the project Technical Committee and Policy Oversight Committee. Public input was solicited throughout the development of the concepts with two series of public workshops held both in Durham and in Chapel Hill in September 2000 and January 2001. The final 10 Build Alternatives are listed and briefly described in Table ES-1. This evaluation of the alternatives included engineering concept drawings, travel demand projections, capital and operating cost estimates, identification of environmental and community impacts and evaluation of the input from the public, policy leaders and the project's Technical Committee.

TABLE ES-1 US 15-501 Phase II MIS Alternatives

No-Build
No-Build 2025 Base 2025 Land Use Assumes TTA Phase I Regional Rail System
TSM
Durham-Chapel Hill-Carrboro MPO 2025 Transportation Plan Intensive Bus Service Assumes TTA Phase I Regional Rail System
DMU Alternative 1
"Western" Alignment in Duke Area Refined Phase I MIS Corridor "A" Alignment Southern UNC Alignment
LRT Alternative 1 / Bus Alternative 1
Erwin Road Alignment / TTA Phase I Coal Spur Station Refined Phase I MIS Corridor "A" Alignment Southern UNC Alignment
LRT Alternative 2
Erwin Road Alignment Refined Phase I MIS Corridor "A" Alignment Southern UNC Alignment Extension of TTA future Phase I Technology
LRT Alternative 3 / Bus Alternative 3
"Western" Alignment in Duke Area Refined Phase I MIS Corridor "A" Alignment Southern UNC Alignment
Bus Alternative 2
Erwin Road Alignment / TTA Phase I Coal Spur Station Refined Phase I MIS Corridor "A" Alignment BMT "Diamond Lanes" Manning Drive Alignment
Bus Alternative 4
"Western" Alignment in Duke Area Refined Phase I MIS Corridor "A" Alignment BMT "Diamond Lanes" Manning Drive Alignment
BMT Alternative 1
5-lane Erwin Road Alignment / TTA Phase I Coal Spur Station Cameron Boulevard/Academy Road/University Drive Corridors Less Guideway Alternative BMT "Diamond Lanes" Manning Drive Alignment
BMT Alternative 2
7-lane Erwin Road Alignment / TTA Phase I Coal Spur Station Cameron Boulevard / US 15-501 / Exclusive Busway/ University Drive Corridor More Guideway Alternative BMT "Diamond Lanes" Manning Drive Alignment

IV. SUMMARY OF ALTERNATIVES EVALUATION

Table ES-2 presents a comparison for each of the evaluation criteria analyzed in this phase of the study. All cost estimates are in 2001 FY dollars unless noted otherwise. For the purposes of this study, the capital cost of the No-Build is assumed to be $0 and all Build Alternative cost estimates are relative to the zero-cost No-Build Alternative.

Table ES-2 MATRIX OF KEY EVALUATION MEASURES

Criteria	Measure of Effectiveness	DMU Technology	Light Rail (LRT)			Exclusive Busway				Busway/Mixed Traffic (BMT)	
		DMU Alternative 1[1]	LRT[2] Alternative 1	LRT[2] Alternative 2	LRT[2] Alternative 3	Bus Alternative 1	Bus Alternative 2	Bus Alternative 3	Bus Alternative 4	BMT Alternative 1	BMT Alternative 2
Transportation Services/ Mobility											
Transit Coverage (change from No-Build)	Passenger Miles (per day)	62,252	67,178	67,985	97,085	85,317	88,951	79,416	77,596	32,433	65,693
	% of pop served by transit	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
Transit Effectiveness	% Change in Auto VMT (per day)	+0.15%	+0.13%	+0.08%	+0.07%	+0.08%	(-0.05%)	(-0.02%)	+0.04%	+0.09%	+0.01%
Relative Traffic/Pedestrian Potential Conflicts between Alternatives (Safety)	Qualitative	Less	More	More	Less	Same	More	Less	More	More	Less
Modeling Forecasts											
Increase in Transit Ridership From No-Build	# Trips (Avg Weekday Linked Trips)	400 (A) 310 (B)	1,250	1,210	2,120	2,340	2,700	2,230	2,500	570	2,120
New Service Rail / Busway System Boardings	# Boardings (Avg Weekday Unlinked Trips)	8,030 (A) 5,640 (B)	15,950	16,910	15,830	10,330	9,420	9,520	9,030	7,450	11,210
Community Impacts											
Residential and Business Displacements	# Businesses	10	7	7	10	10	7	10	10	4	5
	# Residences	83	78	78	83	86	86	83	83	1	77
Neighborhoods Affected	# of Neighborhoods	9	9	9	9	8	8	9	9	2	7
Community-Sensitive Land Uses Affected	# of Land Uses	9	7	7	9	8	8	9	9	6	6
Relative Visual/Aesthetic Impacts between Alternatives	Qualitative	Equal	Equal	Equal	Equal	Equal	Equal	Equal	More	Less	Less
Environmental Impacts											
Historic Sites / Structures	# Sites / Structures	None	None	None	None	None	None	None	None	None	None
Wetlands	Estimated Acres	4.89	4.89	4.89	4.89	4.52	4.52	4.52	4.52	1.27	4.52
New River and Creek Crossings	# of Crossings	3	4	4	3	4	4	3	3	2	3

1. DMU Alternative 1(A) assumes 15 minute peak / 30 minute off-peak headways; DMU Alternative 1(B) assumes 7.5 minute peak / 15 minute off-peak headways.

HNTB

Table ES-2 MATRIX OF KEY EVALUATION MEASURES (CONT'D)

Criteria	Measure of Effectiveness	DMU Technology	Light Rail (LRT)			Exclusive Busway				Busway/Mixed Traffic (BMT)	
		DMU Alternative 1[1]	LRT[2] Alternative 1	LRT[2] Alternative 2	LRT[2] Alternative 3	Bus Alternative 1	Bus Alternative 2	Bus Alternative 3	Bus Alternative 4	BMT Alternative 1	BMT Alternative 2
Financial Issues/Impacts											
Right-of-Way Cost	$ million	$82.6	$73.6	$73.6	$84.0	$80.0	$72.1	$85.6	$77.7	$11.5	$62.2
Utility Relocations Costs	$ million	$1.0	$1.4	$1.4	$1.1	$4.1	$4.2	$1.1	$1.1	$0.8	$4.3
Construction Cost	$ million	$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	$143	$54.9	$109.2
Vehicle Capital Costs	$ million	$35.9	$28.3 (E) $34.3 (D)	$28.3 (E) $34.3 (D)	$26.3 (E) $31.8 (D)	$12.1	$13.0	$11.3	$12.6	$14.5	$13.4
Total Capital Costs ROW, Utility Relocation, Construction and New Vehicle Costs (excludes new LRT / BMT Maintenance facility)	$ million	$306.8	$330.5 (E) $304.9 (D)	$324.1 (E) $298.4 (D)	$329.6 (E) $303.6 (D)	$229.7	$217	$247	$234.4	$81.7	$189.1
Transit Operating and Maintenance Costs	$ per year (FY 2000)	$52.3 (A) $56.0 (B)	$53.9	$53.6	$53.6	$54.1	$54.7	$53.5	$54.1	$54.7	$54.6
Transit Cost Effectiveness	Cost-Effectiveness Index (CEI)	$291.92 (A) $418.63 (B)	$103.26 (E) $104.71 (D)	$104.30 (E) $105.80 (D)	$60.07 (E) $60.85 (D)	$43.94	$37.73	$47.15	$41.73	$117.22	$44.45
	Cost/Transit User	$14.54 (A) $23.01 (B)	$8.09 (E) $8.21 (D)	$7.46 (E) $7.57 (D)	$8.04 (E) $8.15 (D)	$9.95	$10.81	$11.04	$11.55	$9.97	$8.41
Physical Data											
Miles of Improvements		14.0	13.9	14.1	14.1	13.9	14.1	14.0	14.0	15.0	14.9
Miles of Structures		2.5	2.5	2.4	2.5	2.1	1.85	2.5	2.4	0.4	1.6
At-Grade Intersections		24	37	37	26	27	43	26	32	62	47
Number of Stations		11	14	14	13	14	14	13	12	12	14

1. DMU Alternative 1(A) assumes 15 minute peak / 30 minute off-peak headways; DMU Alternative 1(B) assumes 7.5 minute peak / 15 minute off-peak headways.
2. LRT Alternatives provide cost information for (E) electric vehicles and (D) diesel vehicles.

Note: Capital Cost of No-Build assumed to be $0; all alternative cost information is relative to No-Build.

V. OBSERVATIONS AND RECOMMENDATIONS

The merits and disadvantages of the various transit technologies were explored, considered and debated as part of the Phase II MIS Study. All build alternatives were fairly similar with respect to environmental / community impacts, and physical characteristics (miles of improvements, structure length, number of stations).

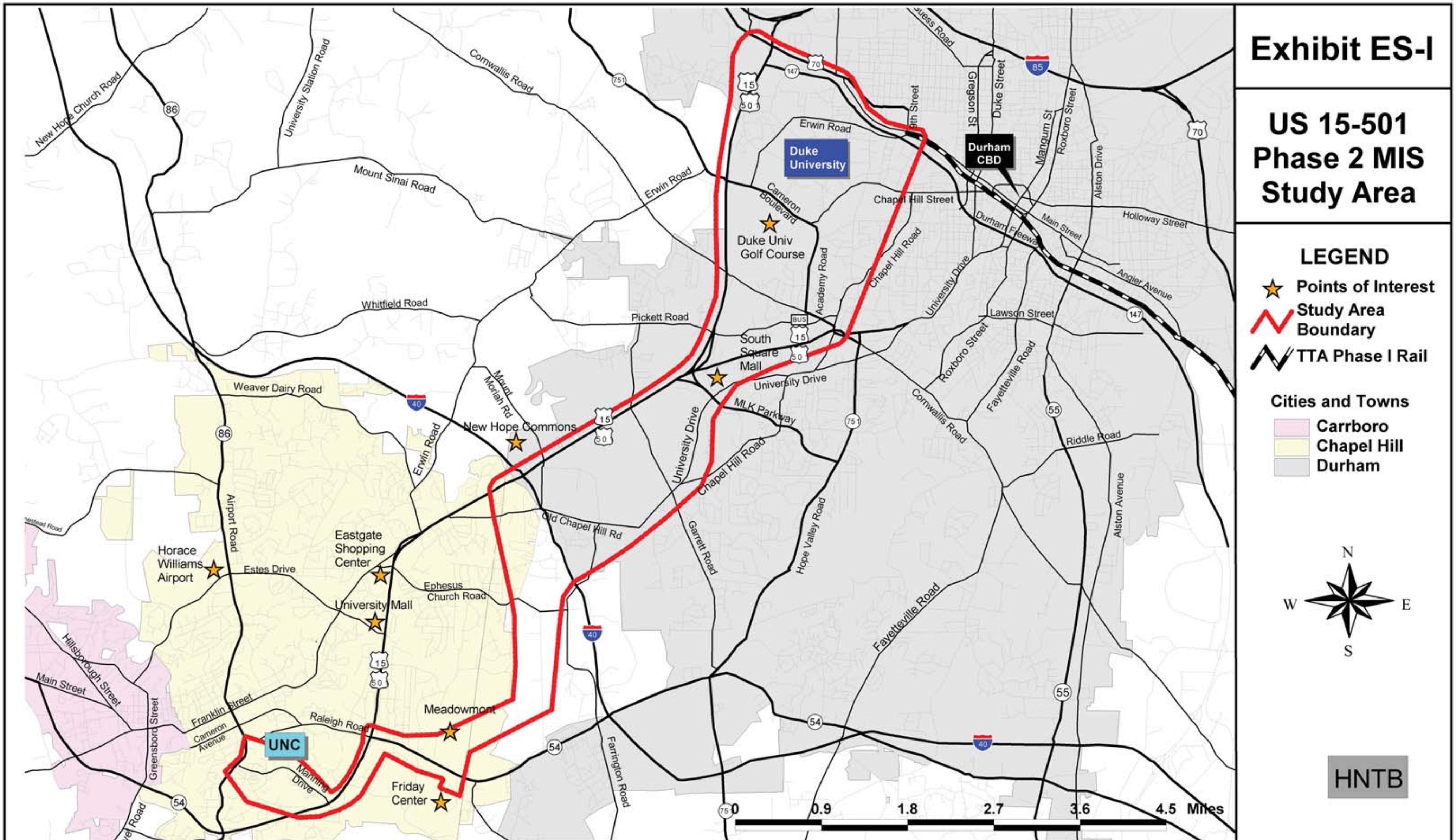
Although the DMU and LRT alternatives presented higher overall transit ridership, it was the exclusive busway options that attracted the highest number of "new transit" riders which directly reflects a corresponding decrease in auto trips. The cost effectiveness criterion applied to all the alternatives versus the No-Build Alternative (incremental cost per incremental new rider) shows that the Busway and Busway / BMT alternatives were more cost effective using the cost per "new rider" criteria. However, the total cost per rider was lower for the LRT alternatives. It appears that assumptions that were contained in the study's No-Build network may have overprojected the 2025 future base transit network in which this study used as a baseline to evaluate ridership and cost effectiveness of each alternative. The Policy Oversight Committee recommended a re-evaluation of the future base network and it's assumptions before finalizing a decision on the specific technology. The Policy Oversight Committee recommended that a re- evaluation of the future base network and its assumptions are necessary before finalizing a decision on the specific technology. The Policy Oversight Committee also recognized that the Busway and Busway / mixed traffic (BMT) technologies appear to be the most promising because: 1) of the flexibility of constructing a future transit system incrementally, and 2) were more cost effective when compared to other technologies based on the "new rider" cost effectiveness criteria.

These limited conclusions and recommendations on vehicle technology were based in part on modeling forecast results from the new Triangle Regional Travel Demand Forecasting Model (Version 5.0). Predicting transit ridership through modeling forecasts requires an iterative process of analyzing results, reassessing assumptions, and additional model runs. The modeling forecast results of the Phase II MIS Study reflect a single model run. Thus, the results should be viewed as an indication of potential ridership and not the final projected ridership. The study team recommends that further refinement of the regional model should be done prior to commencing the Environmental Impact Statement (EIS) phase of the project.

The Phase I MIS Corridor "A" was further refined in Phase II to encourage transit-friendly development consistent with future land use plans and projected development. In the Duke area, the consensus of the Policy Oversight and Technical Committees was that the benefits of a transit corridor along Erwin Road, which directly serves the University and Duke Medical Center, was more preferable to a "Western" Alignment along the NC 147 / NCRR corridor. The negative impact associated with the estimated 400 – 475 grave relocations in the path of the "Western" Alignment was a contributing factor in their decision. The Policy Oversight Committee recommends that the final determination of a transit corridor alignment within the UNC campus should await resolution through a cooperative process by the Town of Chapel Hill and the University. The recommended corridor for the Phase II MIS is presented in Exhibit ES-2.

The study team recommends adding the recommended Phase II transit corridor to the regional transportation plan and further recommends that the local governments consider this corridor when implementing local land use policies (i.e., zoning changes, establishment of public facilities, planning of parks and recreational facilities, and issuing building permits).

Exhibit ES-2



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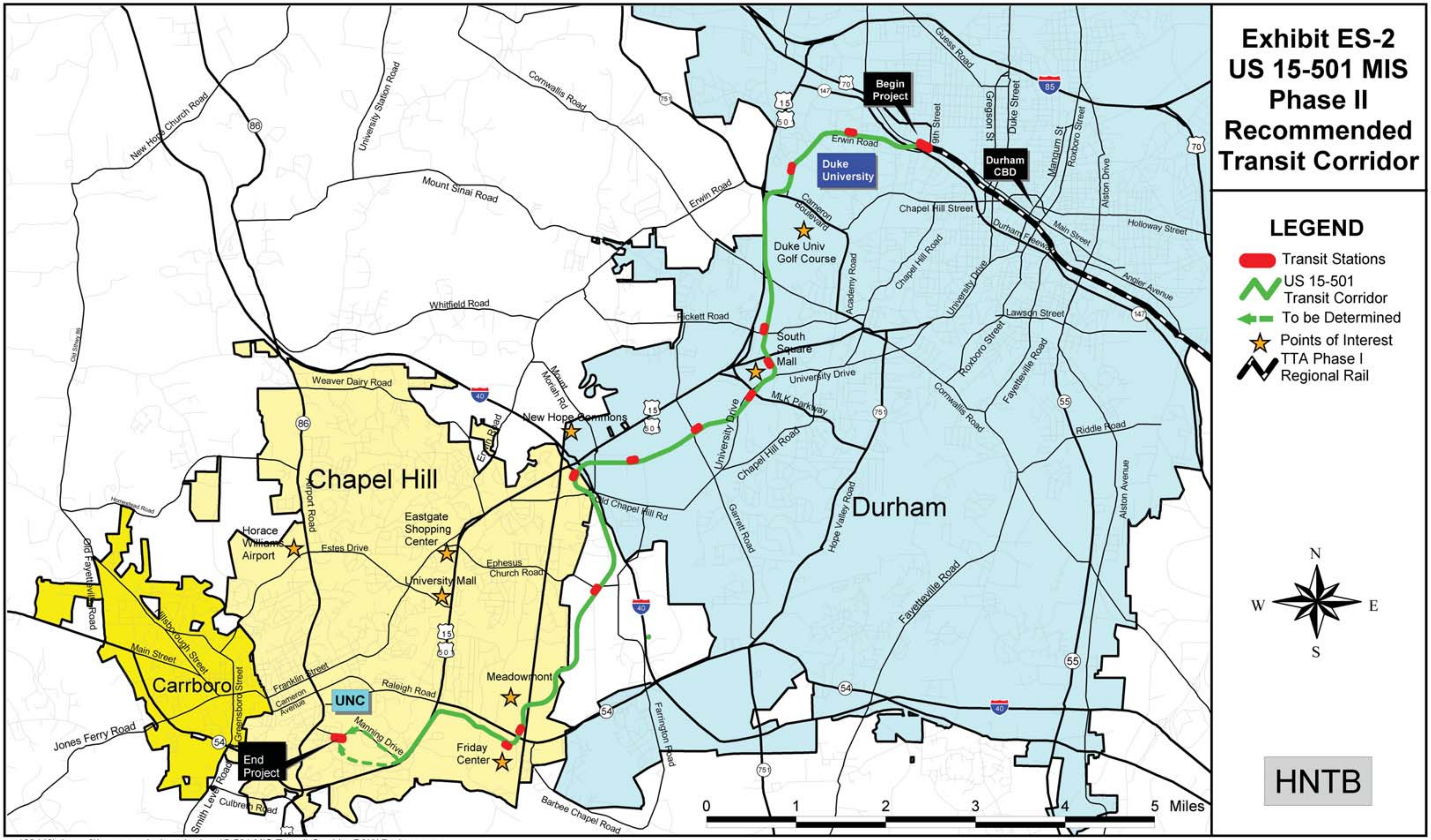

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CHAPTER I
INTRODUCTION

A. Background

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B. Study Area Context

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In 1993-1994, the City of Durham, the Town of Chapel Hill, NCDOT, and private property owners in the US 15-501 corridor participated in the US 15-501 Corridor Study which focused on identifying areas of congestion and methods to improve mobility within the corridor. A Corridor Master Plan was developed. The study recommended the following multi-modal improvements: 1) upgrading US 15-501 to a controlled access facility (i.e., urban freeway), 2) preserve right of way for a future transit corridor, and 3) investigate TDM strategies. The Triangle Transit Authority's (TTA's) Triangle Fixed Guideway Study (February, 1995) and Draft Environmental Impact Statement (DEIS) (April, 2001) determined a need for rail or bus transit fixed guideway between Durham and Chapel Hill as part of the second phase of their regional rail system.

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- Pedestrian and bicycle facility improvements including a sidewalk and dedicated bicycle lanes along Old Durham-Chapel Hill Road from US 15-501 to University Drive.

The Policy Oversight Committee also recommended that more detailed evaluation of rail and busway technologies was necessary before a preferred alternative/investment strategy is identified and any major state or federal investment in transportation facilities is made in the corridor.

CHAPTER II

STATE OF THE ART RAIL & VEHICLE TECHNOLOGY

A. Introduction of Transit Vehicle Technologies

As a result of the Phase I of the MIS and further screening prior to entering Phase II, Phase II considers the following technologies:

- Triangle Transit Authority's (TTA) Phase I technology (i.e., as defined in TTA's design criteria, but may not be a Federal Railroad Administration-compliant diesel multiple unit (DMU));
- Busway (i.e., fixed guideway with completely dedicated right-of-way);
- Busway/Mixed Traffic (BMT) (i.e., a hybrid of on-street operation and an exclusive busway); and
- lighter rail technology than TTA Phase I, such as light rail or a lighter DMU.

Within each of these categories lies a range of vehicle, alignment and support systems technologies that are available and have been applied in various locations around the world.

B. Candidate Transit Vehicle Technologies

The following identifies several transit technology "packages" exemplifying the range of High Occupancy Vehicle (HOV) and busway systems offering *rapid bus* services (i.e., vehicles separated from general traffic flows for some or all of their runs), and rail systems providing the kinds of *regional rail* services that would be appropriate given probable levels of passenger demand in the U.S. 15-501 corridor.

- Bus Rapid Transit: Systems using some mix of HOV lanes and/or exclusive busways, perhaps with vehicles that are automatically guided or otherwise innovative.
- Regional Rail: Systems using self-propelled or electrically-propelled rail vehicles, either diesel multiple units (DMUs) or electric light rail transit (LRT).

1. Level Boarding & Low Floor Vehicles

One of the characteristics of rapid transit has been the matching of vehicle entries and boarding platforms to the same, or nearly the same height. On heavy rail systems in larger cities such as in Atlanta and Washington, D.C., this is achieved by using station platforms raised to the height of the car floors, a little over three feet above the rail (for mainline railroads, passenger car floors are typically 4 feet-3 inches above the rail).

In years past, level boarding was not offered on bus, light rail, and most commuter rail systems. Vehicle floors were raised, as on heavy rail cars, and passengers had to climb several steps to board from low station platforms (about curb height, 6-8 inches above the rail or road), and special facilities, lifts or ramps, were needed to accommodate riders unable to use steps. Now, "low floor" vehicles make it possible to offer rapid transit-style level or near-level boarding for all passengers from low platforms raised just a few inches above normal curb height. The result is that stations can be more readily integrated into urban and suburban streetscapes, and in full compliance with the Americans with Disabilities Act (ADA).

Vehicles with kneeling capability, short-rise lifts, and/or bridge plates to close vehicle/platform gaps enhance accessibility for people with disabilities. However, the low floor level makes it impossible to place seats over the front wheel wells. As a result, some seats are lost at the front of buses. This problem is not experienced on low floor rail vehicles.

After 15 years of development, low floor buses, light rail vehicles, and DMU cars have become the norm for transit systems in Europe and elsewhere. Only low floor transit buses can be purchased now in Canada, and they are being ordered increasingly by U.S. transit operators. Now widely used in western Europe, low floor light rail vehicles also are operating in Portland (OR) and northern New Jersey, are being built for San Jose, and will be purchased for Minneapolis and Seattle. Western European railroads, similarly, have embraced low floor DMUs, which also have been ordered for southern New Jersey and will be purchased for the new Oceanside-Escondido line in southern California.

Nearly all of the vehicles discussed in the following sections are low floor buses or rail cars that can offer level boarding from low platform stations. Exceptions are the Curitiba-type bi-articulated bus, some LRT vehicles, and Type I DMU candidates, which achieve level boarding with high platforms like heavy rail systems such as the Washington Metro.

2. *Bus Rapid Transit*

The term, "bus rapid transit" (BRT), has been defined as "operation on an exclusive or reserved right-of-way that permits high speeds. It may include reverse lane operations on limited access roads."[1] The ability of rubber-tired buses to operate on all kinds of paved roads suggests that BRT may be more generally defined as:

[1] Gray, Benita H. (ed.). *Urban Public Transportation Glossary*. Transportation Research Board, Washington, D.C., 1989.

Bus Rapid Transit (BRT): A specialized form of bus transit that incorporates operation on exclusive and/or reserved alignments over a significant portion of its route. Such facilities may include dedicated busways, high occupancy vehicle (HOV) lanes within highways or streets, and/or transit malls. Portions of BRT routes may also use general traffic lanes to provide single-seat pick-up or distribution service. In addition, BRT may involve automatic vehicle guidance.

Thus, a standard bus that begins its run in a city center, then travels relatively freely along an HOV lane before returning to local streets to distribute its riders may be considered as a lower-level form of BRT. At the high end of the BRT spectrum would be routes located entirely, or almost entirely, on exclusive or reserved ways as defined above, and perhaps using guided buses. The following paragraphs provide information on the various BRT vehicle candidates.

a) Standard Bus

Transit bus fleets typically consist of a variety of rigid and, in some places, articulated transit coaches. Most common is the so-called "standard" 40-foot diesel coach (Appendix A, Figure A-1). Smaller 30-foot and 35-foot variants on the basic design also are used for more lightly-patronized lines, but fixed facilities are usually designed around the 40-foot standard. Denver's 16^{th} Street Mall shuttles (Appendix A, Figure A-2) are a specialized 100% low floor variant. Articulated buses (Appendix A, Figures A-3 and A-4) are sometimes appropriate for use on a system's more heavily patronized routes.

b) Guided Bus

At least two European suppliers are offering guided bus systems, and two more have experimental prototype installations under construction. All are based, to varying degrees, on adaptations of electric trolley buses, but two, Bombardier's *Tram on Tires* and the Matra *Civis*, also list diesel-powered versions. (Four of these technologies are illustrated in Appendix A, Figures A-5-A-8.) Primary differences among these candidates are in Table II-I as follows:

Table II-I. Primary Differences Among Guide Bus Packages

Item	Breda/Neoplan *Stream*	Matra/Irisbus *Civis*	Bombardier *Tram on Tires*
Body Types	Std & Articulated	Double Articulated	Double-Articulated
Propulsion	Electric	Electric or Diesel	Electric &/or Diesel
Electric Power Source	Embedded Power Strip	Overhead Wire	Overhead Wire
Guidance System	n/a	Non-Contact Optical	Embedded Rail

Developers of *Civis,* the *Tram on Tires* and another similar product, *Translohr,* each sought to provide a vehicle-guidance-power supply package that would combine some of characteristics of light rail (see below) while retaining the capability to operate on regular paved streets as well as exclusive paved transitways.

- **Stream:** Traction power delivery system being developed by Ansaldo Breda (*Stream* is an acronym, in Italian, for "magnetic pick-up electric transportation system"), and represents an alternative to overhead contact systems. Electric power is transmitted to vehicles from a power strip embedded at surface level in street pavement. Short sections are energized only when a stationary or moving vehicle is above. At all other points, the power strip is not energized, so it poses no hazards to pedestrians or other surface traffic crossing it.
- **Civis:** High-capacity, double-articulated vehicle that can be manually steered or guided via an optical sensor beneath the center-line of the vehicle that reads a path established by two closely-spaced painted lines on the pavement. The vehicle's electric propulsion uses power supplied from an overhead wire and/or an on-board motor-alternator set. For straight electric operation, a second overhead wire is required.
- **Tram on Tires:** Formerly *Guided Light Transit (GLT).* High-capacity, double-articulated vehicle that can be manually steered or guided via small wheel assemblies bearing on an embedded rail placed in the pavement beneath the center-line of the vehicle. Electric propulsion for this vehicle uses power supplied from an overhead wire and/or an on-board diesel-generator set. For straight electric operation, the negative return can be via the guidance rail or a second overhead wire.
- **Translohr:** High-capacity, double- or single-articulated vehicles that can be manually steered or guided via small wheel assemblies bearing on an embedded rail placed in the pavement beneath the center-line of the vehicle. The Translohr's electric propulsion uses power supplied from an overhead wire and/or an on-board diesel-generator set. For straight electric operation, the negative return can be via the guidance rail or a second overhead wire.

  It should be noted that *Stream* is not really a guided bus, as an operator must steer it down the lane with its pick-up shoe properly aligned over the embedded power strip. What *Stream* does is to provide a method for supplying electric power to electric buses without having to build an overhead contact system (OCS) like *Civis*, the *Tram on Tires*, or the conventional trolley buses used in Boston, Philadelphia, Dayton, Seattle and San Francisco.

Key points regarding the BRT options are:

- At grade location of lines and surface operation are feasible;
- Low level platforms compatible with sidewalks and streetscapes are feasible;

- Peak hour, peak direction (PHPD) vehicles needed to carry 1,500 passengers (67% seated):
  - Standard 40-foot buses ≈ 23
  - Articulated buses ≈ 16
- Number of vehicles per run: one (Vehicles cannot be coupled into trains.);
- Average headway (minutes between vehicles): ≈ 2.6 to 3.75 minutes; and
- Emerging technology for guided buses; proprietary vehicles and support systems are just entering or not yet in revenue service, and are available from few suppliers.

3. *Light Rail*

Modern light rail transit (LRT) represents the highest current level of development of an electric railway technology and has been continually refined for more than a century in countries around the world. As a specialized type of electric railway, LRT has characteristics making it especially well-suited to placement in urban and suburban environments, including highways and streets.

> ***Light Rail Transit (LRT):*** A rail transit technology capable of providing a broad range of passenger capacities. Modern electric rail vehicles operate singly or in short trains. Taking power from an overhead wire, they can run on either exclusive or shared rights-of-way with or without grade crossings, or occasionally in mixed traffic lanes on city streets.

By 1975, only eight U.S. cities retained remnants of what had once been a vast network of city, suburban, and even intercity trolley lines criss-crossing the country. All have been modernized and renovated since then, and 12 completely new LRT systems have been built and placed into revenue service.[2] Virtually all the new systems have been extended or have plans for additional lines. Several more cities are actively pursuing LRT projects.

Locational flexibility is the primary defining attribute separating LRT from other rail modes, and an advantage LRT shares with BRT. Tracks can be laid in any of three generic right-of-way (R/W) categories:

a) Category A - Fully controlled R/W
Grade separated (aerial, fill, cut, tunnel), at- grade with no crossings, or widely-spaced crossings with signal override and gate protection.

b) Category B - Separate R/W
Longitudinally separated (curbs, barriers, grade separation) from other traffic, but with vehicle and pedestrian grade crossings, e.g., curbed medians, side-of-street reservations, private R/W with few-to-frequent grade crossings.

[2] San Diego (1981), Buffalo (1984), Portland (1986), Sacramento and San Jose (1987), Los Angeles (1990), Baltimore (1992), St. Louis (1993), Denver (1994), Dallas (1996), Salt Lake City (1999), Jersey City (2000).

c) ***Category C - Shared R/W***

Surface streets with tracks in lane(s) that are reserved for transit by paint striping and/or signals, or lanes that are shared with other traffic.

On most new LRT systems, cars are large (80-90 feet long), high capacity (60-75 seats), high performance (50-65 mph), and capable of operation in trains of up to four cars (Appendix A, Figure A-9). Four double-width doors on each side of each car promote fast loading/unloading and, as a result, short station stopping (dwell) times. Smaller cars are used on city streetcar lines throughout Europe (Appendix A, Figures A-10 & A-11). In the past, cars with three steps up to a passenger compartment floor 39" above the rail were typical. Starting in the 1990's, a major change was the introduction of low floor cars (Appendix A, Figures A-12 & A-13). These Light Rail Vehicles (LRV) have passenger compartment floors not quite 14-inches above the rail through at least the center 2/3 of the car body, including all entries, with steps in the aisles leading up to standard-height floors above the normally constructed power trucks at the each end of the car. As long as they are separated from other traffic (except at grade crossings), systems with tracks on surface rights-of-way (R/W) can offer high quality service, sufficiently fast to compete with the automobile when the latter faces some congestion, yet at a fraction of the cost of a fully grade separated transit system.

Key points regarding the LRT option are:

- At-grade location of lines and surface operation are feasible;
- Low level platforms compatible with sidewalks and streetscapes are feasible;
- Peak hour, peak direction (PHPD) vehicles needed to carry 1,500 passengers (67% seated): $\approx$ 14;
- Number of vehicles per train: generally 2 or 3;
- Average headway (minutes between 2-car or 3-car trains): $\approx$ 8.6 or 12 minutes; and
- Mature technology; vehicles and support systems available from many suppliers.

4. Regional Rail

"Regional Rail" is a term used to distinguish rail passenger operations that connect cities and suburbs within a metropolitan region, as differentiated from "intercity rail" linking separated metropolitan regions, or "urban rail" systems located within central cities.

> ***Regional Rail:*** A rail transit technology capable of providing a broad range of passenger capacities. Modern diesel-powered rail vehicles operate singly or in trains. They can run on either exclusive or shared rights-of-way with or without grade crossings, or occasionally in reserved lanes on city streets. Operations may or may not be carried out over tracks that are part of the existing freight railroad system in the area.

As defined for the Triangle region, *Regional Rail* differs from traditional *Commuter Rail* in that it is not planned to share tracks with freight railroads. Depending on the forecast level of passenger demand, length of line, and opportunities for locating alignments, regional rail services may be provided by trains of locomotive-hauled or self-propelled railroad cars, or by electric light rail vehicles. Previous work in the U.S. 15-501 corridor suggests that further studies for this corridor should focus on self-propelled cars. In that regard, *Regional Rail* may be very similar to LRT, except in the use of diesel-powered instead of electrically-propelled rail vehicles.

However, it must be kept in mind that a wide range of DMU vehicles exists, in sufficient variety that analysts have agreed on three major classifications, as the vehicles might be applied on U.S. railroad and rail transit lines:

a) Type 1 - DMUs for Mainline Railroads

Such cars should be capable of operating in a mix of freight and other passenger trains, and should meet Federal Railroad Administration (FRA) structural requirements (800,000lb buff, etc.). Nippon-Sharyo and Bombardier have offered self-propelled versions of Electric Multiple Unit (EMU) and/or locomotive-hauled, push-pull cars, the former based on Indiana and Maryland cars, the latter on EMU cars recently delivered in Montreal (Appendix A, Figures A-14 & A-15). Adtranz has developed an FRA-compliant design that has been considered by Pennsylvania and, currently, by Triangle Transit Authority for the Raleigh-Durham corridor. All three designs are “classic” high floor, double-truck vehicles that will result in DMUs configured similarly to Budd Rail Diesel Cars (RDC) (Appendix A, Figure A-16), with end doors and step loading (unless high platforms are provided). Small numbers of the latter may be available for purchase and rebuilding, as was done for the Trinity Railway Express service operating in Dallas since 1996.

a) Type 2 - DMUs for Light Density Railroad Lines

Most of the European designs could be run on little-used lines that would be dedicated primarily to DMU operations (Appendix A, Figures A-17-A-20). Assuming little other railroad traffic on affected lines (e.g., limited local freight service), and the ability to time separate DMU and other trains with a day passenger/night freight pattern, waivers from FRA requirements should be obtainable based on existing and committed LRT lines (San Diego, Baltimore, Salt Lake City), the southern New Jersey DMU project now under construction, and demonstration trains such as Amtrak’s *Talgo* trains in the Pacific Northwest. Virtually all manufacturers offer either high and/or low floor cars that could fit this category, for example, LHB *Lint*, Bombardier Eurorail *Talent*, De Dietrich *Eurailbus*, and at least three entries from various predecessors now folded into Adtranz: ABB/Scania *Flexliners*, AEG/Daimler Benz *Regioliner*, and AEG/DWA GTW 2/6 (railroad version).

b) ***Type 3 - DMUs Compatible with Light Rail Alignments***Cars in this category should be capable of operating on LRT street-based alignments, preferably meeting typical LRT standards such as 8.7-foot car width, 82-foot horizontal curve radius, etc., and they should offer low floor loading. Unfortunately, no such cars are known to exist.

Such cars could be straight diesel or dual-mode diesel-electric/electric. They would not meet FRA requirements, since they would be designed for compatibility with LRVs. Operation on railroad lines likely would be limited, such as for the Type 2 cars above, namely, time separation.

One design recently built as a straight electric for Swiss regional lines is intended to become the basis for such a dual-mode car. In fact, a diesel-powered version of this design has been ordered for the new southern New Jersey diesel light rail project (Appendix A, Figure A-21). A transit variant of the Adtranz GTW 2/6, each of the 20 diesel LRVs will consist of two long passenger compartments, cantilevered off a short central body section like the new Portland LRVs, except that the center section houses the propulsion system instead of carrying passengers. Of modular design allowing a variety of lengths and widths, the initial batch are to be 98-foot long and 8.7-foot wide, with a 14.5-inch floor height through 2/3 of the passenger compartment, including all entries. Minimum turning radius is 130 feet, too broad for turns within many city street intersections.

Another possibility is the Siemens *RegioSprinter* (Appendix A, Figure A-22), a mid-1990s design for German branchline railroads, that is on the border between "diesel LRV" and "light railroad DMU." Its three-section, articulated car body is conceptually similar to the GTW 2/6; but the *RegioSprinter* has twin diesel engines and mechanical transmissions, one located under each driver's cab at the ends of the car. Since it was originally designed for light density European branch railroads, its turning ability is even less forgiving than the GTW 2/6. The minimum turning radius for a *RegioSprinter* is 265 feet.

Further refinement is needed to develop a DMU that can turn on the 82-foot curves common on new North American LRT street-running alignments. Short of re-designing the articulation joints and other elements of a less-capable vehicle, the only existing possibility is Bombardier's *Tram Train* (not to be confused with the *Tram on Tires*). Built as a three-section electric LRV for a new system in Saarbrucken, Germany (Appendix A, Figure A- 23), the car has low floor sections at the entries in each of the two end car bodies, with high floors under the driver's cabs and throughout the middle section. Its builder envisions that a diesel-generator set could be mounted under the center car body to power electric traction motors on each of the car's four trucks.

Key points regarding the Regional Rail diesel LRV (*Tram Train* or *GTW 2/6*) option are:

- At grade location of lines and surface operation are feasible;
- Low level platforms compatible with sidewalks and streetscapes are feasible;
- Peak hour, peak direction (PHPD) vehicles needed to carry 1,500 passengers (67% seated): $\approx$ 10;
- Number of vehicles per train: 1 or 2; and
- Average headway (minutes between 2-car or 3-car trains): $\approx$ 6 or 12 minutes.

C. Comparison of Vehicle Alternatives

The technology alternatives described in Section B possess a variety of physical, performance and service characteristics. Similarities and differences between technologies are explored in this section.

1. Technology Elements

Physical and operating characteristics of several technologies are presented in Appendix A, Table A-1. The conceptual design vehicles use maximum or minimum values, as appropriate, to accommodate a worst-case or recommended design standard.

Data for standard and articulated buses represent a composite of the 40-foot standard and 60-foot articulated urban transit buses currently in production, typically 70%-80% low floor designs. Exceptions are the "Mall Bus" column, which describes the 100% low floor vehicles used on Denver's 16th Street Mall, and the high floor "Bi-Articulated" bus, such as used in Curitiba, Brazil, where level boarding is achieved by using the unique raised tube stations to provide platforms at the same height as bus entries.

Information on the *Stream* in-pavement power distribution system, and the three French guided bus systems is taken from materials produced by the firms promoting these proprietary transit technologies. Because it uses standard 40-foot and articulated buses that have been adapted to its unique power system, *Stream* should produce the same capacity and performance results as for regular diesel vehicles. Results vary, however, for the guided buses, which, like the "Mall" and "Bi-Articulated" buses, are designed for in-city urban services.

Similarly, data for the candidate LRT and DMU rail vehicles also is taken from materials produced by supply firms. Unlike the guided buses, there are numerous manufacturers producing many different types of rail vehicles.

2. Consolidation of Vehicle Suppliers

In response to the globalization of the economy and, particularly, the creation of a Europe-wide single market, there has been in progress for several years a distinct pattern of consolidation in the rail car building business. Results of consolidation include:

- Concentration of production at the most efficient plants inherited from predecessor firms, and closure of less efficient facilities.
- Reduction in the number of candidates within each technology type, as the new firms - much like automobile manufacturers - attempt to focus on a few "models"

with “options” to reduce design and manufacturing costs and improve their price competitiveness.

Thus, Adtranz, in the late 1990s, developed new designs combining what were deemed the best features of similar products offered by predecessor firms that had been taken over, for example:

- LRVs for city systems: *Incentro*, based on *GTx-Series*, *Eurotram*, and *Variotram*
- DMUs for regional railroads: *Itino,* based on *Regio-Shuttle, Flexliner,* and *GTW 2/6*

If tooling remains in place and production has continued or only recently ended, or where one or more large orders makes the effort worthwhile, then the “older” vehicles can still be purchased. Marketing, however, is concentrated on the “new” vehicle platforms.

As of this writing, it appears that Adtranz will be merged into Bombardier, making Bombardier the world’s largest rail car builder, ahead of Alstom (a combination of previously separate French and English firms) and Siemens. A similar case is the joining of forces by several European bus builders in France, Italy, Spain, the Czech Republic and Hungary to create a new firm called Irisbus.

3. Operational Fit

The data in Appendix A, Table A-1, address physical and service issues that, taken together, provide the basis for assessing the operational fit of each candidate technology.

a) Dimensions

Alternative vehicles range from standard transit buses (40 feet long by 8.5 feet wide by 10 feet high) to large railroad passenger cars (up to 200 feet long by 10.5 feet wide by 13.1 feet high). The right-of-way, station platform, side and overhead clearances, and other physical facilities required to support operation of this range of vehicles will differ considerably from one option to another. Considering these factors together, it is clear that it will be less difficult to fit alternatives into existing highways and streets and the university campuses using smaller, street-capable vehicles. It will be more difficult to add a facility using railroad vehicles into the same places.

b) Low Floor

Traditional high floor vehicles require rather large, high platform stations to provide level boarding, or inconvenience passengers with slow boarding and alighting by using step entries from low platforms, combined with special lifts or ramps for people unable to climb stairs. Matching low floor vehicles to low platforms raised only a few inches above normal curb height eliminates these drawbacks. Station platforms are more easily integrated into the areas surrounding them, fast step on/step off passenger boarding and alighting is provided, and people using mobility aids are mainstreamed into the general passenger flow. All but two alternatives can be built using low floor vehicles.

c) Accommodations

Passenger capacity and comfort are important issues in designing a transit service. In the Research Triangle area of North Carolina, summer temperatures and humidity cause people to expect public facilities to be air conditioned. Provision of full air conditioning is now the norm for U.S. transit vehicles of all types, but it is not yet universal in Europe. Thus, to provide attractive service in this region, some of the technologies listed in Table II-I would need to be modified to add full air conditioning.

Regarding system capacity, bigger vehicles can carry more passengers, so fewer vehicles can do the same job as a larger number of smaller vehicles. This is not always an advantage. Where demand is light or moderate, use of vehicles that are too large may result in providing too much capacity or, alternatively, too little service. Table II-II compares the number of passengers transported per hour per direction based on the number of runs per hour for the three different vehicles.

Table II-II. Effect of Vehicle Capacity on Service Frequency

Item	Std 40' Bus	GLT	DMU (2-Car Trains)
Riders per Vehicle or Train	65	150	350
Passengers/Hour/Direction if:			
- 2 Runs/Hour (30 min H)	130	300	700
- 4 Runs/Hour (15 min H)	260	600	1,400
- 8 Runs/Hour (7.5 min H)	520	1,200	2,800
- 12 Runs/Hour (5 min H)	780	1,800	4,200

H = Headway = service frequency, the time interval between vehicles.

The table clearly shows why higher capacity transit is limited to a region's primary corridors where their efficiency can be utilized, while standard buses suffice for local distribution, circulation and feeder lines attracting fewer riders. The higher GLT and DMU volumes are consistent with the experience of several LRT and commuter rail lines operating in other U.S. cities.

d) Propulsion Alternatives

Most candidate vehicles can be provided with more than one type of propulsion, though to some extent, the assertions in Appendix A, Table A – 1, depend on how a vehicle is defined. For example, bus options are defined here as diesel-powered; but both 40-foot and articulated electric trolley buses are used in cities around the world. Similarly, LRT is assumed to be electrically propelled using power taken from an overhead contact system (OCS); but LRVs occasionally have small internal combustion engines (e.g., Lausanne) to avoid the expense of OCS in yards and shops. Finally, cars defined herein as Type 1 DMUs are, in fact, based on cars previously built and in operation as electric multiple unit commuter cars. In each case, the choice tends to be one type of propulsion or the other. The exceptions are the three French guided bus systems, whose designs expressly include the flexibility to use diesel or electric propulsion or both.

e) Operating Capability

This category of characteristics covers items that affect the ability of vehicles to operate under varying conditions.

- **Maximum Speed :** Vehicles intended for city and suburban services (U.S. diesel buses) tend to have higher maximum operating speeds compared to vehicles (basically, all the other rubber-tired candidates) targeted for central city services, which are more likely to combine lower speeds, heavier passenger loads, and more closely-spaced stops. As a practical matter, there is a performance trade-off between maximum operating speed and the rate of acceleration, with the choice for a particular service dependent on the relationships of corridor length and station spacing. Short city routes with a stop every block need rapid acceleration more than a high top speed, but long regional corridors with stations spaced miles apart benefit more from high speed than fast starts. Thus, an electric LRV will accelerate at 3 miles per hour per second (mphps), but may attain a speed of 50-60 mph, while an Amtrak train will accelerate at less than 1.0 mphps, but reach in excess of 100 mph. Generally, a diesel-powered vehicle will not accelerate as rapidly as a similar electric vehicle, simply because of the limits on how much diesel engine can be packed physically and economically into the available space, whereas an OCS can supply all the power and electric vehicle can use.
- **Grades and Curves:** Whether rubber-tired or steel-wheeled, vehicles intended for in-street alignments that include turns through intersections must be capable of operating around sharp curves, and on relatively steep grades. These requirements are met by the various steered and guided bus options, and by the LRT alternatives. Among DMUs, however, only one design (a diesel version of Bombardier's *Tram Train* that has not progressed beyond the concept stage) approximates the grade-climbing and turning capabilities of light rail vehicles. Other alternatives are based on the easier grades and broader curves found on railroads.
- **Directionality:** Manually steered rubber-tired vehicles are almost universally set up with one operating cab or position at the front of the vehicle. Steel-wheeled vehicles, which are guided as well as supported by their rails, typically are designed with a cab at each end, and can be run with equal facility in either direction. Some LRT systems use single-ended cars to reduce costs (fewer operating cabs and doors on only one side of the car) and increase seating. The trade-off is the requirement for a loop or other turnaround facility wherever direction is to be reversed, and a reduced ability to respond in

emergencies, because "short turns" cannot be effected easily at any point on the line, as they can be with double-ended cars. It should be possible to operate the guided buses as double-ended vehicles, so long as they are in "guided" mode, but *Translohr* is the only candidate that includes this feature in its design package.

- **FRA Structure:** Passenger-carrying cars operating on the tracks of the general railroad system of the U.S. must be built to the standards imposed by the Federal Railroad Administration (FRA). These regulations encompass many areas of design, but the standards covering car body strength have the most impact on light rail transit vehicles and the lighter DMUs, because such cars are designed to meet the less stringent standards of European railway and/or European and U.S. rail transit regulations. Commuter rail lines operating on tracks also used by freight and/or intercity passenger trains have acquired cars that meet the FRA's standards.

  Most of the newer LRT systems have kept their tracks separate from those of the general railroad system, in part to ensure that they will remain under Federal Transit Administration (FTA) rules and not FRA. Three systems - San Diego, Baltimore, and Salt Lake City - operate non-compliant light rail vehicles on tracks owned by the transit authorities, but that also carry freight trains. FRA has granted waivers to these systems, and to the similar southern New Jersey DMU line now under construction, on the basis that transit and freight trains will be positively separated in time, i.e., transit passenger services during day and evening hours, and freight trains on the line only in the late night hours when the transit service is not running. This limitation on freight operation is feasible on branches where local freight trains serve shippers along the line, but would be onerous for a freight railroad trying to run numerous through and local freight trains on a heavily-used main line. Under such conditions, FRA-compliant passenger equipment must be used, unless separate tracks can be built for the transit passenger operation. Even in the latter case, however, the center lines of adjacent transit and railroad tracks must be separated by at least 25 feet to avoid FRA regulation of items such as flagging for track workers on the other line.

  In its TTA Phase I planning, the Triangle region has chosen a Durham-North Raleigh route that is based on sharing existing railroad rights-of-way, and the vehicle choice appears to be leaning toward a FRA-compliant DMU, even though separate trackage is contemplated for the rail transit service. For the MIS Phase II route from Durham to Chapel Hill, however, both highway-based and new alignments are under consideration. As a result, design issues related to grades, curves and "urban fit" seem likely to be divergent between the TTA Phase I and MIS Phase II routes. Laying out alignments that accommodate railroad grades and curves, and that result in a comfortable blending of railroad rolling stock into built environments such as the university campuses is likely to pose challenges greater than laying out alignments for options using LRVs, guided buses, or standard buses.

4. *Costs*

There are two kinds of cost that must be considered: the initial capital investment to design and build fixed facilities, and to specify, procure and install vehicles and support systems, and the operating and maintenance expenses that will continue over the useful life of the project.

a) *Capital Investments*

The individual elements of capital investment can be classified as occurring in nine major categories:

- Guideway Elements: Roadbeds, structures, track or paving;
- Stations: Platforms, shelters and associated furnishings, transfer facilities, park-ride lots;
- Yards and Shops: Vehicle storage yards, maintenance buildings, tools & equipment;
- System Elements: Electrification, signals, communications, fare collection;
- Vehicles: Revenue (passenger) and non-revenue (maintenance & supervisory);
- Special Conditions: Utility relocation, demolitions, roadway changes, environmental issues;
- Right-of-Way: Land acquisition, relocation; and
- Project Soft Costs: Engineering & design, construction management, overall project management, finance charges, training/start-up/testing.

Not all capital cost elements would be incurred for every candidate transit vehicle technology. The following table lists technologies and the related cost elements to add a new service to an existing transit system that already has some bus service and facilities in place.

Table II-III. Correlation of Capital Cost Categories and Vehicle Technologies

Cost Category	Street Bus	Bus Rapid	Guided Bus	LRT	DMU-New	DMU-RR
Guideways:						
- Roadbeds	No	Some	Some	Yes	Yes	Some
- Structures	No	Some	Some	Yes	Yes	Some
- Paving	No	Some	Yes	Some	No	No
- Track	No	No	Steering	Yes	Yes	Some
Stations:						
- Platforms	Some	Yes	Yes	Yes	Yes	Yes
- Transfer facilities	Some	Yes	Yes	Yes	Yes	Yes
- Park-ride lots	Some	Yes	Yes	Yes	Yes	Yes
Yards & Shops:						
- Storage yard	Expand	Expand	Expand	Yes	Yes	Yes
- Maint. Building	&/or	%/or	&/or	Yes	Yes	Yes
- Tools & equipment	modify	modify	modify	Yes	Yes	Yes
Systems Elements:						
- Electrification	No	No	Maybe	Yes	No	No
- Signals	No	Ltd [a]	Ltd [a]	Yes	Yes	Yes
- Communications	Radio	Radio	Radio	Yes	Yes	Yes
- Fare Collection	On board	Maybe	Maybe	Yes	Yes	Yes
Vehicles:						
- Revenue	Yes	Yes	Yes	Yes	Yes	Yes
- Non-revenue	Maybe	Probably	Probably	Yes	Yes	Yes
Special Conditions:						
- Utility relocation	No	Some	Some	Yes	No	No
- Demolitions	Ltd	Some	Ltd	Some	Some	Ltd
- Roadway changes	Ltd	Some	Some	Some	Ltd (Xings)	Ltd (Xings)
- Environmental	Few	Some	Ltd	Yes	Yes	Ltd
- Railroad agreements	No	Ltd [b]	No	Ltd [b]	Ltd [b]	Yes
Project Soft Costs:						
- Eng. & design	Ltd	Yes	Yes	Yes	Yes	Yes
- Construction mgt	Ltd	Yes	Yes	Yes	Yes	Yes
- Project mgt	Yes	Yes	Yes	Yes	Yes	Yes
- Finance charges	Ltd	Probably	Probably	Probably	Probably	Probably
- Train/start-up/test	Ltd	Yes	Yes	Yes	Yes	Yes

[a] Traffic light prioritization. [b] Only portions of facility place within a railroad r/w.

The qualitative analysis in the above table suggests that for a given corridor, LRT is likely to be more costly to put in place than a DMU service. Furthermore, LRT is likely to cost more than guided bus or bus rapid transit, for which some segments can be placed in existing streets without major reconstruction, and/or new facilities built at intermittent locations instead of throughout the entire corridor.

b) *Operations & Maintenance*

It is usually most convenient to think of operating and maintenance (O&M) costs in terms of five large categories:

- Transportation: Costs of revenue vehicle operation;
- Maintenance of Equipment: Costs of servicing and repairing revenue vehicles;
- Maintenance of Way: Costs of servicing and repairing all other fixed facilities and systems elements;

- Claims: Costs of injuries and damages; and
- General and Administrative: Costs of managing the transit system.

The experience of U.S. transit systems operating more than one mode has been that rail, when properly used on the system's most heavily patronized line(s), usually costs less in O&M per passenger mile than the bus networks serving all the other lines, but that the overall effect is to produce a more cost-efficient system than if only buses were being operated.

There is the higher labor efficiency of larger vehicles running in trains. In Sacramento, for example, four-car trains of LRVs, each with only one operator, run on 15-minute headways to carry about 1,800 peak hour, peak direction riders. That level of demand would require about 30 standard buses, each with its own driver. The increase in operating labor utilization is so great that it more than offsets the increased expense of LRT fixed facility and systems maintenance personnel that an all-bus system would not experience. This high labor efficiency must be achieved for rail transit, whether LRT or DMU, to become a beneficial addition to a region's transit system.

D. Summary

Ordinary street bus routes provide an adequate level of service on most of the local transit routes in U.S. cities and suburbs. As metropolitan areas grow, road congestion associated with the increase in trip-making leads to opportunities to introduce higher-capacity transit in one or a few main travel corridors.

The attractiveness of such services increases with the extent to which they can be separated from the general traffic flows. Bus priority schemes are a first step, using traffic light prioritization, queue-jumper bus lanes through intersections, and later adding more extensive high occupancy vehicle (HOV) lanes.

When it appears some portion of transit passenger flows can be concentrated on one or more primary trunk lines, larger-capacity vehicles such as articulated buses, LRVs and DMUs can be considered. Each has its own advantages and drawbacks, as noted in the foregoing pages, and highlighted below.

- Can intermittent facility improvements built in increments over time lead to faster trips? If so, a bus rapid transit program may be in order.
- Is the desired technology proven in revenue service and available from multiple suppliers, or is it developmental and proprietary to a single manufacturer? If the latter, does it offer enough advantages to make the risk of being a "pioneer" application worth taking?
- Will peak ridership support the operation of trains of two or more cars? When this occurs, improvements in operating efficiency may favor using vehicles that can be

coupled into trains, i.e., a rail system, even though a corridor-length investment in facilities is needed initially.

- Is there a railroad line with capacity for traffic growth? A shared-track rail service may become feasible.
- Is there an alignment opportunity through some significant portion of the corridor, but not throughout? A technology that can run on reserved and exclusive alignments, and also in streets may be appropriate, either bus rapid transit (manually steered or guided) or LRT.

In a growing metropolitan region, the choice of appropriate transit technologies - vehicle and support systems - must be considered in terms of present, near-term future and long-term future needs and expectations.

CHAPTER III
LESSONS LEARNED FROM OTHER REGIONS

A. Introduction

As part of the evaluation of transit technologies for Phase II of the U.S. 15-501 Major Investment Study, case studies of the alternative evaluation process for other transit systems were reviewed. The goal of this exercise was to evaluate how other cities and regions across the United States and Canada made similar initial decisions on a particular type of transit technology to use for their system.

Systems that ultimately chose one of the technologies under consideration in Phase II of this study were evaluated. The criteria for selecting particular cities and their respective transit systems were quite broad. Particular emphasis was made to select cities that:

- Were implementing "new start" transit systems;
- Had comparable urban characteristics;
- Had reached their transit technology decision via a formal MIS process in the last few years; and
- Contain a transit corridor resembling the corridor from Durham to Chapel Hill in terms of length, number of stations, ridership, and land use patterns.

Transit systems that were an extension of a current system were also researched; however, the primary focus was to find cities that had recently arrived at a technology decision as a new start.

It has proved difficult to get specific information on the processes used for evaluation of alternatives, particularly in a context that could be applicable to the Durham-Chapel Hill region. Much of the justification for choosing a particular technology was not only unique to the city or region but the transit corridor under evaluation as well. Furthermore, due to the scope and schedule of this element of the Phase II MIS, not much detailed information could be received from the sources in a timely enough manner. This somewhat limited the amount of information that could be shared for this study's purpose. Information was considered and pursued from the following peer regions, but was eventually excluded from the report for the reasons listed below:

- The technology decision was perceived as relatively straightforward due to the characteristics of the corridor (i.e., DMU on an existing rail corridor; LRT extensions of same service).
- The implementation or planning, and hence the technology decision was not made within the last five or ten years. Therefore, it was assumed that there were enough differences in the state-of-the-art of transit planning then versus now that those experiences were not applicable to current decision-making in the Durham-Chapel Hill region.

The peer systems are divided by their particular choice of transit technology – rail or bus. No other transit technologies such as monorail or Personal Rapid Transit (PRT) were chosen for study because few relevant, comparable examples exist. The peer systems are further subdivided in the rail category by type of motive power, either electric or diesel multiple unit (DMU). In the bus category, the peer systems are further subdivided in each category by whether or not the transit technology is exclusive or mixed flow (in traffic) operation.

B. "Regional Rail" – DMU Technology

1. San Diego, California-Oceanside-Escondido Line

The North San Diego County Transportation Development Board has secured all environmental clearances and right-of-way for a 24-mile rail line serving 15 stations between Oceanside and Escondido, CA (see system map, Appendix B). DMU technology was selected over other transit concepts primarily due to a low ($11 million/mile) capital cost, as the rail corridor uses an existing railroad right-of-way. Using diesel vehicles eliminates the need to develop an electric power system for the corridor. Corridor termini include a major transit transfer station (with Coaster Commuter Rail System) in Oceanside and the north/south I-15 freeway corridor in Escondido.

2. Ottawa, Canada - RMOC Light Rail Pilot Project

For this pilot project, currently in operation in Ottawa, Ontario, a light rail transit line has been introduced on an existing rail corridor. The City selected DMU technologies because "new diesel light rail vehicles have recently entered the market and provide a possible technology for introduction in Ottawa-Carlton without the high cost of electrification…"

Ottawa currently has an established exclusive busway system, the Transitway, which has been established for many years and provides service along a broad east-west corridor in the metro area. The diesel-powered rail system is seen as a complement to the Transitway, to provide broad overall coverage to the areas not directly served by the Transitway.

Concerns about DMU technology focused on 1) the cars, and 2) whether not meeting North American standards is a safety issue. Also, only one manufacturer currently produced North American-compliant vehicles, and these were of the "high floor" variety and produced loading/unloading problems. Because of this (and other) reasons, the high floor DMU cars were ruled out and low floor models were chosen instead, although not North American-compliant. The vehicles have time separation from freight traffic.

The choice between rail and bus technologies received much public input. Rail technologies were seen as "a smoother, faster" ride and buses did not provide the same level of comfort. Because of the use of existing rail alignments, it was also felt that rail was more cost-effective when compared to bus.

C. Exclusive Busway

1. Pittsburgh, Pennsylvania – West Busway

The West Busway in Pittsburgh opened in September 2000, culminating a planning process that began in the late 1980's. Pittsburgh currently has both busway and LRT technologies in operation and both were studied for the West Busway Corridor. This corridor features a mix of residential and commercial land uses, with some stations located in high-density neighborhood centers. Other stations are located in lower-density suburban areas that have development potential. The results of that planning process showed the busway concept to be more flexible, as local bus routes could access the Busway and reconnect to the interstate freeways for express trips to the Pittsburgh airport. This reduced the amount of transferring. Fiscal limitations for an initial segment would allow a Busway connection from downtown to the interstate, but would seriously limit the length of any LRT line. LRT had higher initial costs and was thought to be more effective for high-density corridors, which the West Busway corridor is not.

2. Hartford/New Britain, Connecticut – New Britain-Hartford Busway

The Connecticut Department of Transportation (ConnDOT) completed a Major Investment Study of the Hartford West (I-84) Corridor in 1997. The principal transportation recommendation made by the study was to implement a 9-mile exclusive busway facility between the cities of Hartford and New Britain, CT. The busway corridor will be contained within existing railroad right-of-way in two sections, one currently owned by Amtrak and the other in state-owned abandoned rail property. Both local and express buses will use the facility, which is planned to have 12 stations. Stations were coordinated with existing development centers, if possible. Higher density residential and commercial development exists adjacent to proposed stations in both Hartford and New Haven. There are some station locations between the towns in the vicinity of lower density suburban development which are candidates for more intensive nodal development.

Evaluation between transit technologies in Hartford was accomplished by analyzing particular social, environmental and economic effects. Social effects included elements such as land use, relocations, historic properties and environmental justice. Environmental effects that were analyzed included impacts on wetlands, fish and wildlife, flood plains, water supply, noise and air quality. Finally, transit alternatives were compared for various economic effects such as user benefits and secondary economic impact.

The busway was selected as a major component of the preferred alternative for this corridor because it offers the travelers the greatest speed, flexibility of service, and ease of intermodal interface as compared with other modal alternatives. It also incurred lower initial capital and operating costs versus rail options. Initial capital costs were estimated to be around $75 million for the busway alternative and $97 million for the light rail alternative assuming both used the existing abandoned rail corridor. Transit technologies were analyzed against performance measures – both transit and highway – to determine ridership forecasts and degree of congestion reduction for each technology. The busway alternative generated the most ridership versus other transit technologies and performed the best, overall, in the performance categories. For example, the busway alternative generated 11,600 peak hour total ridership versus a comparable light rail alternative's 10,200. Correspondingly, the proposed busway generated an estimated 4,270 new riders versus 2,840 generated by the light rail alternative.

D. Busway Rapid Transit (Mixed Exclusive/Shared Lanes)

1. Cleveland, Ohio – Euclid Corridor Bus Rapid Transit Line

The Greater Cleveland Regional Transit Authority is developing a project that uses electrically-powered trolley buses to serve a densely developed corridor in the process of being redeveloped. Corridor termini are two major employment centers, Public Square and University Circle. The buses will provide local service for the entire length of the 7-mile corridor, using bus stations at 1,500-foot intervals.

Selection of this technology was fostered politically by Cleveland business leaders, although BRT versus LRT was looked at in a MIS in the early 1990's. The Euclid Corridor is to be completely redeveloped into a retail/residential district. Currently, the corridor features some of the highest-density areas in the Cleveland area. Much of it could be viewed as a "brownfield" redevelopment area that will use the electric trolley buses and associated stations as prime redevelopment nodes. Cleveland leaders wanted clean, quiet transit vehicles for this district. The Authority looked at diesel bus (judged not to be clean), or compressed natural gas (CNG) bus (not as quiet as electric) before settling on the trolley concept.

The trolley bus system is unique in the United States, proving to be approximately one-third the estimated cost of light rail. The fixed route nature of this system, though operating in street lanes for some of the corridor, simulates operating characteristics more akin to LRT operation versus BRT in mixed traffic flow.

2. Eugene, Oregon – East-West Rapid Transit Corridor

The Lane County Transit District is conducting final planning studies of a BRT system that will emulate rail-based systems using exclusive and mixed-flow busway technologies. This system will use guided busway technology for some portions of the East-West corridor and implement other BRT-type improvements such as ITS signal priority, improved bus stations, and barrier-free payment (i.e., automatic vehicle identification (AVI)) systems. A four-mile pilot corridor will be initially tested – with expansion to reach a total 10-mile corridor length. Land uses in the corridor vary from high-density development in the Eugene and Springfield Central Business Districts (CBDs) and the University of Oregon Campus to lower density residential suburban environments. No fixed station locations have been set as yet, but potential for new "greenfield" development exists in the suburban areas and higher density redevelopment in the CBDs.

Exclusive, guided busway technology was selected based on its lower costs versus rail systems and the fact that it could maintain the "appearance", permanence, and operational capabilities of rail systems. In addition, it would have more flexibility than rail systems, particularly from a phased implementation standpoint. Based on conversations with the Lane County Transit director, all technologies were studied in a MIS completed in the mid-1990s, but this was done primarily to keep other transit options open. Results from an earlier Urban Rail Feasibility Study indicated that LRT ridership levels, irrespective of technology, would only be 10,100 per day, using a high-end estimate. This level of ridership was felt to be too low to be competitive for FTA funding for a new rail system and that they would need a ridership estimate of at least 20,000 to make a feasible submittal for federal funding. BRT could be implemented for a lower cost now (4-10% of a new LRT alignment over the 10-mile corridor) and LRT could be developed in the BRT corridor in the future, if funding becomes available.

E. Light Rail Transit

1. Austin, Texas

Cap Metro, the Austin area transit agency, has reached the final planning phase for a light rail system. The first segment of this system would have 16 stations over a 15.6 mile Red/Green Line route. An MIS was conducted to decide on a transit technology on this corridor, and the evaluation factors for transit alternatives included; service capacity, right-of-way issues, economic development potential, costs (capital and operating), and safety. Electrified LRT was the preferred technology due to its capacity. It was provided for the north side of the city, which already had available rail right-of-way, with ample physical separation from existing rail traffic. The LRT alignment selected in the MIS had projected benefits of $892 million over its 30-year project life and a life cycle cost of $764 million, thus indicating significant positive net benefits. Initially, BRT alternatives were developed for the south side of the city, but residents demanded an extension of LRT, though it would have higher construction costs ($200 million to $50 million for BRT) in this area. LRT was also favored in terms of economic development, since industry leaders and developers liked the permanence" of tracks and the corresponding rail stations.

A deciding public referendum vote, for local funding, is scheduled for November 2001. Opposition to the light rail system, and its costs and impacts, has been quite vocal, but still yet as far as transit modes, LRT is the preferred technology.

2. Cincinnati, Ohio – I-71 Corridor

Cincinnati is in the final planning stages of a LRT system that will complement the I-71 highway corridor from the north and south suburbs through the CBD. The corridor could have up to 30 stations. A MIS was completed in March 1998 and an electrified LRT alternative was selected from busway and HOV/highway improvement alternatives. Public survey input into the decision-making process indicated that light rail was the preferred alternative (33%), over busway (14%), HOV (12%), TSM (11%), and highway widening (7%), with 20% of respondents indicating no preference as to improvement type or mode.

The busway alternative had more potential and definite impacts on the physical environment than LRT. Increased noise levels was major busway concern. In addition, the busway alternative had the potential for more business (up to 80 more) and residential (up to more 30 more) displacements than LRT. LRT capital costs ($1.158 billion) were slightly higher than busway ($835 million). Operating costs were similar ($110 million/year). LRT also outperformed busway in air quality measures – hydrocarbons, CO, and NOx.

Annual benefits of LRT transit service and associated secondary positive impacts (jobs, development, etc.) were estimated to be $84 million over a 30-year project life. No mention was found concerning a choice between diesel-powered and electric rail as separate alternatives in this MIS study.

3. Louisville, Kentucky

Louisville, KY has a planned light rail system project, termed Transportation Tomorrow (T^2), that is currently in Phase 3, Preliminary Engineering. This phase is projected to take about two years and will produce detailed data on cost of construction and ridership. The previous phase included a MIS that compared transit technology alternatives for a 13-mile corridor connecting the CBD and the Gene Snyder Freeway (urban loop) to the south. Both LRT and BRT technologies were compared on a segmented basis. Primary evaluation criteria included traffic impacts, environmental impacts, operations, ridership, development potential and costs. Summary scores were compiled for each segment (judging between 1.0 – poor and 4.0 – excellent for each criteria). Interestingly, for all segments, the matrix scores were usually identical for traffic, operations and ridership for both LRT and Busway alternatives. Busway consistently had lower relative scores for environmental impacts and development potential compared to the LRT alternative. The LRT alternative consistently had lower relative scores in terms of cost.

Overall, light rail proved to be more advantageous than a BRT because it was determined light rail would:

- Be quieter and cleaner
- Attract new riders
- Project a progressive image for the metropolitan area
- Foster economic development.

F. Case Study Summary and Recommendations

In summary, the case studies provided unique insights on why particular transit technologies were selected for areas that had common transportation problems but unique characteristics, whether political, social, geographic, or institutional, that favored one type of technology over another. Public and political undercurrents were a major factor, particularly in areas where a particular transit technology, bus or rail, had succeeded or failed in the past. The presence of available existing rail lines also has influenced the processes to a great degree. Busways are generally viewed as lower-cost, flexible solutions that could be "upgraded' to light rail in the future. Busway technology, though, is still being viewed as "rail-like", with all the supposed rail advantages, for the cities that have made that choice.

To make more concrete and in-depth comparisons between the regions researched in this report and the U.S. 15-501 study area, enhanced focus on a few "select" case studies is recommended. These examples would include the highest similarity between their particular physical characteristics and the Chapel Hill-Durham corridor. Appropriate examples would also have employed objective decision-making rationale between transit technologies, and have provided a clearly documented decision-making process that led to their selection. Based on the above criteria, the following systems may merit further, more in-depth study that will yield more comprehensive decision-making information for the 15-501 Phase 2 MIS:

- BRT– Eugene, OR (Lane Transit District)
- Busway – Hartford, CT (New Britain-Hartford Busway)
- Rail Transit LRT – Louisville, KY (T^2 – Transportation Tomorrow)

CHAPTER IV
EVALUATION METHODOLOGY AND CRITERIA

A. Introduction

In the Phase I MIS report issued in November 1998, a section was devoted to the evaluation methodology and criteria used in that phase. This section reflects the evaluation methodology and criteria, primarily developed in Phase I, that have been modified to reflect what was used in Phase II. Furthermore, the measures of effectiveness for each criterion have been modified, as appropriate, for this phase.

Phase II of the study focused on transit alternatives only. The objective of this phase was to determine a preferred transit technology and corridor.

B. Goals And Objectives

As stated in the Phase I MIS report, the primary goal of any major transportation investment should be to improve projected travel conditions and transportation efficiency. This should be accomplished in a manner that is cost-effective, financially feasible, environmentally sound, compatible with applicable regional plans, and recognizes both existing land use and the impact of future development and growth.

The particular objectives for Phase I MIS that apply to Phase II are:

- Improve mobility between Durham and Chapel Hill;
- Preserve and use existing transportation facilities, as appropriate for the transit alternatives, efficiently and effectively;
- Manage congestion on the existing transportation facilities that are used for the transit alternatives;
- Provide for and improve access to other modal transportation facilities, as appropriate;
- Support the area's existing and projected land use with travel choices that reduce peak hour auto use;
- Consider alternatives that enhance cost-effective utilization of transit;
- Preserve right-of-way for probable future transportation facilities, to the extent possible;
- Provide and promote modal integration/system linkages;
- Provide transportation solutions that have acceptable impacts on the natural and human environment; and
- Improve accessibility to jobs, goods, and services within the corridor; and
- Reduce reliance strictly on automobile alternatives.

C. Alternative Development and Evaluation Methodology

During the scoping of the Phase II MIS, the alternatives were defined. The transit evaluated were:

- TTA's Phase I technology (i.e., as defined in TTA's design criteria but might not be a Federal Railroad Administration-compliant diesel multiple unit (DMU));
- Busway (i.e., fixed guideway with completely dedicated right-of-way);
- Busway/Mixed Traffic (BMT) (i.e., a hybrid of on-street operation and an exclusive busway); and
- "lighter" rail technology than TTA Phase I, such as light rail or a "lighter" DMU.

The corridors evaluated were:

- **From 9th Street area to South Square Mall:**
  - Along NC 147 and US 15-501;
  - Along Phase I Corridor A, Southeast of US 15-501; and
  - Along a Corridor East of Duke's Main Campus.

- **South Square Mall to Fordham Blvd.:**
  - Along Phase I Corridor A, Southeast of US 15-501.

- **Fordham Blvd. to UNC-Hospitals**
  - Transit corridor per UNC Masterplan or other feasible corridors that result from Phase II's station area planning workshops.

To evaluate the alternatives, engineering concept studies, travel demand projections, overview of environmental issues, cost estimates, and evaluation of input from the public, interested groups and agencies were performed. The alternatives were evaluated using quantitative and qualitative criteria to determine the benefits and disadvantages of implementing each alternative.

While some of the evaluation was qualitative, several items couldn't be quantified. It is important to note that the extent and detail to which each criterion can be measured depended on the resources allocated to the concept development and the evaluation process. The Phase II MIS had been scoped to be cursory in detail, evaluating costs and impacts from available aerial photography and topographic mapping, based on conceptual designs.

As in the Phase I MIS, the same framework of evaluation categories were developed for each phase to differentiate and clarify the trade-offs among alternatives. To facilitate the evaluation process, the evaluation criteria was grouped into several categories:

1) Transportation Services/Mobility Issues;
2) Community Impacts;
3) Environmental Impacts;
4) Financial Issues; and
5) Regional Considerations.

D. Evaluation Criteria

A listing of the five evaluation criteria groups, potential individual criteria, and their measures of effectiveness, are listed below.

Evaluation Criteria	Measure of Effectiveness
1. Transportation Services/Mobility Issues:	
• Transit services/coverage;	Transit capacity (seat miles); Percent of population within station service area served by transit.
• Transit effectiveness;	Transit ridership and load factors, compare the reduction in auto VMT [1] with the no-build alternative.
• Traffic/pedestrian safety;	Qualitative judgment.
2. Community Impacts:	
• Residential and Business displacements;	Count/estimate from conceptual corridors, based on windshield survey.
• Neighborhoods affected and number of community sensitive land uses affected;	Count/estimate land uses affected; conceptual corridors, based on windshield survey.
• Visual/aesthetic impacts;	Professional judgment from conceptual corridors.
• Environmental Justice;	Overlay alternatives with demographic information from census tracts.
3. Environmental Impacts:	
• Historic sites/structures;	Count/estimate from conceptual corridors, using Phase I MIS historic survey.
• Wetlands;	Count/estimate from conceptual corridors and professional judgment.
• Watershed impacts;	Count/estimate from conceptual

	corridors and professional judgment.
• New river/creek crossings;	Count, based on conceptual corridors.
• Air Quality;	Provided change in VMT in the corridor from no build by alternative.

4. Financial Issues/Impacts:

• Right-of-Way;	Confirmed and used Phase I MIS costs where applicable, otherwise used costs per square foot.
• Construction;	Confirmed and used Phase I MIS costs where applicable, otherwise used costs per mile and included capital costs of park and ride facilities.
• Vehicles;	Used Phase I MIS unit costs, updated as appropriate
• User cost indicators;	Change in VMT and VHT [(2)] from travel forecasts.
• Transit operating and maintenance costs;	Preliminary computations based on service levels, mode, and system size.
• Transit effectiveness;	Incremental costs per transit user including incremental cost of expansion.

5. Federal, State, Regional, and Local Considerations:

• Consistency with local land use plans;	Professional judgment/ coordination with local governments and universities.
• Consistency with relevant regional goals/objectives;	Professional judgment/ coordination with local governments, universities, and MPO's long range plan.

(1) VMT = Vehicle Miles of Travel

(2) VHT = Vehicle Hours of Travel

CHAPTER V
PATRONAGE FORECASTING METHODOLOGY AND RESULTS

A. Background

The patronage forecasts for the US 15-501 Major Investment Study (MIS) Phase II, to the greatest extent possible, were made using the *existing and currently available* (at the beginning of Phase II) Triangle Regional Model (TRM, Version 5). This chapter contains the following subsections:

- Patronage forecasting methodology;
- Rail service forecasts; and
- Bus service forecasts.

B. Patronage Forecasting Methodology

The elements or stages of a travel demand model are commonly called "steps." Most models have four steps.

In the first step, called " trip generation," the trips likely to originate and terminate in each zone are calculated.

In the second model step, called "trip distribution," trip productions and trip attractions are matched to produce a matrix of trips for the region. Travel between zones are represented as a function of trips produced in the origin zone, trips attracted to the destination zone, an approximate measure of the "cost" of travel between zones and the relative "attractiveness" of competing zones.

In the third model step, called "modal split," travel volumes are "split" among the available modes of travel (i.e., highway and transit). The "choice" of a travel mode is based on the costs of travel (e.g., cost of fuel, bus fare) and travel time (e.g., actual travel time plus time spent parking a car or waiting for a bus).

In the fourth step, called "trip assignment," mode-specific trips are assigned to paths in their respective infrastructure networks. Highway trips are assigned using an equilibrium assignment algorithm and transit trips to representative peak and off-peak networks.

Travel demand forecasting models attempt to answer the following question: Given the projected levels of travel activity for the region, where should additional infrastructure capacity be placed? To answer this question, model results can be summarized in a number of ways, including:

- Total Trips (zone to zone)

- Highway assignments

- Transit assignments
  - total unlinked transit trips
  - by trip purpose/time period
  - by route
  - by boarding/alighting station and mode of access

- Evaluation criteria
  - highway vehicle-miles
  - passenger-miles
  - travel time savings

The Triangle Regional Model generally follows the common "four step" procedure (trip generation, trip distribution, modal split, and assignment) described above. Important modifications include composite impedance and congestion feedback loops for the home-based work (HBW) trip purpose. Inputs for the base (1995) and horizon (2025) years were provided. The process utilizes the TRANPLAN transportation planning software package and special programs developed for the TRM. The Triangle Regional Model is discussed in detail in other documentation, including the *Triangle Regional Model User's Manual* (NCDOT, September 2000).

C. Rail Service Alternatives

Rail service alternatives for Phase II of the US 15-501 MIS extend the proposed TTA Phase I rail line from Durham southwest to Chapel Hill. The two rail technologies being modeled are LRT and DMU. The alternatives further vary in the alignment segment and the transfer point between the TTA Phase 1 service and the proposed rail lines.

1. Description of Rail Service Alternatives

The following rail service alternatives were simulated:

- *DMU Alternative 1A:* DMU Alternative 1A extends the Phase I rail line beyond the 9th Street Station to the UNC Hospitals Station, with stops at Phase II stations in the "Western" alignment. Both the Phase I and Phase II DMU lines operate at 15 minutes headways during the peak period and 30 minute headways in the off-peak period.

- *LRT Alternative 1:* In LRT Alternative 1, the Phase I rail extends on the "coal spur" to its termination at the Duke Medical Center Station. The LRT alignment begins at 9th Street and follows the Erwin Rd. alignment that includes the Morreene Rd. and Pickett Rd. Stations. The Phase I rail operates at 15-minute and 30-minute headways in the peak and off-peak period, respectively. The LRT operates at 7.5-minute headways in the peak and 15-minute headways in the off-peak. Several bus routes that operate in Chapel Hill and Durham are diverted in order to connect to rail stations and parts and/or entire routes that duplicate the LRT service are removed.

- *LRT Alternative 2:* LRT Alternative 2 is essentially identical to LRT Alternative 1 except that the Phase I rail ends at the 9th Street Station.

- *LRT Alternative 3:* In LRT Alternative 3, the Phase I rail extends to the Hillsborough Rd. Station. The LRT line runs between Hillsborough Rd. Station and UNC Hospitals Station along the western alignment. The headways for all rail is the same as in LRT Alternatives 1 and 2.

2. Rail System Forecast Summary

The forecasts can be summarized in a number of ways, including modal choice results and transit assignment results. Table V-II shows 2025 average weekday person trips produced by the TRM modal choice model. For each alternative, auto and transit trips are listed by purpose (home-based-work, home-based-other, and non-home-based) and mode of travel. The transit person trips output by the modal choice model are *linked* trips. A linked trip is defined as a trip from the origin zone to the destination zone, regardless of the number of modes used. The difference in person trips between No-Build and TSM and the build alternative is shown as an increase in transit trips (and the corresponding decrease in auto trips). This is the number of *new* transit riders the alternative generates.

Unlinked trips, or boardings, were reported in Table V-I for the rail services and in Table V-III by operating company. Peak trips are the home-based-work (HBW) trips while off-peak trips include home-based-other (HBO) and non-home-based (NHB) trips. Please note that a decrease in boardings relative to another is not necessarily a sign of poor performance. The "new riders" measure in Table V-II is a more accurate measure of the alternative's ability to attract riders.

In addition, boardings at the station level are summarized and presented in Tables V-IV through V-VII. These are reported as one half the average daily number of passengers boarding and alighting the train at each stop. The number of daily trips is halved to avoid "double counting" since transit trips are assigned in *production-attraction* format. This daily boarding summary is presented as Table V-IV for the alternatives and is stratified by mode of access or egress (i.e. walk/bus or drive). Please note that the Triangle Regional Model allows for drive access "drop-off" or "kiss-and-ride" trips at stations with no parking provisions. In addition, the totals in Tables V-IV through V-VII will not equal the total fixed guideway boardings because transfers between routes of the same mode are not reported.

Tables V-V and V-VI show additional measures of performance for each of the rail alternatives**.** Table V-V shows the vehicle-kilometers and vehicle-hours traveled by automobiles in each of the rail service alternatives. These measures can compare the amount of auto usage between the alternatives. Table V-VI shows the average weekday passenger-kilometers for each rail service alternative broken down by company.

The population served by transit, shown in Table V-VII was computed by multiplying the population in a TAZ by the percentage of the population in 1/2 mile of a transit line (the "long walk" percentage in the model). Transit service coverage does not change by alternative (rail or bus) since the corridor is in area with transit coverage that is already established.

Table V-I. Rail System Boardings

Year 2025 Average Weekday Boardings (Unlinked Trips)

Alternative	**No Build**			**TSM**			**DMU Alternative 1A**		
	Peak	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
TTA Phase 1 (1)	18,380	10,490	28,870	18,150	10,490	28,640	24,110	12,790	**36,900**

(1) Includes New Service in Alternative 1

Alternative	**LRT Alternative 1**			**LRT Alternative 2**			**LRT Alternative 3**		
	Peak	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
TTA Phase 1 (1)	17,830	10,260	28,090	17,400	10,200	27,600	17,770	10,420	28,190
New Service	10,740	5,210	**15,950**	10,800	6,110	**16,910**	10,440	5,390	**15,830**

Table V-II. Modal Choice Summary for Rail Alternatives

Year 2025 Average Weekday Linked Trips

Alternative	No Build				TSM				DMU Alternative 1A			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,680	1,166,170	1,237,140	3,645,990	1,242,790	1,166,120	1,237,110	3,646,020	1,241,680	1,166,340	1,237,170	3,645,190
SH-2	107,550	1,505,500	857,070	2,470,120	107,500	1,505,570	857,050	2,470,120	107,480	1,506,210	856,880	2,470,570
SH-3+	22,230	0	0	22,230	22,220	0	0	22,220	22,220	0	0	22,220
Total Auto	1,372,460	2,671,670	2,094,210	6,138,340	1,372,510	2,671,690	2,094,160	6,138,360	1,371,380	2,672,550	2,094,050	6,137,980
DRIVE	13,350	6,530	4,160	24,040	13,270	6,310	4,120	23,700	14,320	6,820	4,550	25,690
WLK-LOC	37,270	25,940	9,690	72,900	37,600	26,360	9,810	73,770	34,880	24,910	9,200	68,990
WLK-PRM	11,620	4,840	2,060	18,520	11,330	4,620	2,020	17,970	14,160	4,700	2,320	21,180
Total Transit	62,240	37,310	15,910	115,460	62,200	37,290	15,950	115,440	63,360	36,430	16,070	115,860
New Riders **Delta No Build**					(40)	(20)	40	(20)	1,120	(880)	160	**400**

Alternative	LRT Alternative 1				LRT Alternative 2				LRT Alternative 3			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,241,100	1,166,310	1,237,140	3,644,550	1,241,090	1,166,340	1,237,120	3,644,550	1,241,120	1,166,310	1,237,090	3,644,520
SH-2	107,160	1,506,510	856,910	2,470,580	107,270	1,506,630	856,600	2,470,500	107,180	1,506,080	856,430	2,469,690
SH-3+	22,120	0	0	22,120	22,120	0	0	22,120	22,110	0	0	22,110
Total Auto	1,370,380	2,672,820	2,094,050	6,137,250	1,370,480	2,672,970	2,093,720	6,137,170	1,370,410	2,672,390	2,093,520	6,136,320
DRIVE	14,190	6,340	4,250	24,780	14,320	6,310	4,450	25,080	14,130	6,330	4,310	24,770
WLK-LOC	32,830	23,950	8,610	65,390	32,940	23,610	8,520	65,070	33,400	24,230	9,040	66,670
WLK-PRM	17,450	5,880	3,210	26,540	16,980	6,100	3,440	26,520	16,850	6,030	3,260	26,140
Total Transit	64,470	36,170	16,070	116,710	64,240	36,020	16,410	116,670	64,380	36,590	16,610	117,580
New Riders **Delta No Build**	2,230	(1,140)	160	**1,250**	2,000	(1,290)	500	**1,210**	2,140	(720)	700	**2,120**

Table V-III Boarding Summary by Company for Rail Alternatives

Year 2025 Average Weekday Boardings

	Alternative	No Build			TSM			DMU Alternative 1A			LRT Alternative 1			LRT Alternative 2			LRT Alternative 3		
	Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1	TTA Bus	5,210	5,880	11,090	7,130	5,780	12,910	2,940	2,780	5,720	3,020	2,730	5,750	3,160	2,680	5,840	3,040	2,700	5,740
2	CAT	15,860	13,880	29,740	15,850	13,860	29,710	15,990	13,870	29,860	15,920	13,910	29,830	15,900	13,940	29,840	15,890	13,880	29,770
3	CHT	14,610	17,130	31,740	13,440	17,150	30,590	13,760	16,620	30,380	13,660	15,450	29,110	13,590	15,170	28,760	13,560	15,600	29,160
4	DATA	23,870	19,400	43,270	22,720	19,610	42,330	22,050	18,430	40,480	19,520	17,750	37,270	19,730	17,630	37,360	20,170	18,330	38,500
5	NCSU	2,950	4,230	7,180	2,960	4,240	7,200	2,940	4,260	7,200	2,980	4,250	7,230	2,980	4,250	7,230	3,060	4,250	7,310
6	Duke	12,750	9,240	21,990	12,920	9,260	22,180	12,480	4,750	17,230	13,030	8,400	21,430	12,960	8,600	21,560	13,050	5,660	18,710
7	NCCU	660	240	900	660	230	890	600	270	870	540	280	820	520	250	770	560	270	830
8	OPT	80	510	590	150	520	670	150	450	600	150	520	670	70	530	600	150	510	660
9	TTA Rail	18,370	10,490	28,860	18,150	10,490	28,640	24,110	12,790	36,900	28,570	15,470	44,040	28,200	16,310	44,510	28,210	15,810	44,020
10	Cary	3,180	3,270	6,450	3,160	3,270	6,430	3,110	3,220	6,330	3,160	3,270	6,430	3,040	3,250	6,290	3,020	3,230	6,250
	Total	97,540	84,270	181,810	97,140	84,410	181,550	98,130	77,440	175,570	100,550	82,030	182,580	100,150	82,610	182,760	100,710	80,240	180,950

Table VI-IV. DMU Alternative 1A Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

DMU Alternative 1A							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	150	50	200	740
Millbrook	390	670	1,060	160	210	370	1,430
Six Forks/Highlands	280	700	980	140	160	300	1,280
State Government Ctr	330	460	790	300	380	680	1,470
Dtn Raleigh	930	750	1,680	970	520	1,490	3,170
NCSU	2,040	2,070	4,110	1,570	1,230	2,800	6,910
State Fairgrounds	280	290	570	130	180	310	880
West Raleigh	40	590	630	50	270	320	950
Cary Depot	280	300	580	130	130	260	840
Morrisville	230	80	310	120	130	250	560
South Park	180	190	370	110	150	260	630
North Park	320	230	550	240	240	480	1,030
Alston Ave	1,410	760	2,170	580	300	880	3,050
Dtn Durham	710	480	1,190	260	130	390	1,580
9th Street	1,880	800	2,680	800	510	1,310	3,990
Hillsborough Rd	380	50	430	120	20	140	570
Cameron Blvd	1,180	340	1,520	350	300	650	2,170
South Square Mall	600	420	1,020	140	250	390	1,410
Mt. Moriah Rd	20	10	30	80	20	100	130
Gateway	240	370	610	60	220	280	890
Ephesus Church	70	50	120	10	80	90	210
Friday Center	70	150	220	10	70	80	300
UNC Hospital	1,670	290	1,960	420	350	770	2,730
Total	13,970	10,150	24,120	6,900	5,900	12,800	**36,920**

Table VI-V. LRT Alternative 1 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

LRT Alternative 1							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	160	50	210	750
Millbrook	400	710	1,110	160	200	360	1,470
Six Forks/Highlands	290	700	990	140	170	310	1,300
State Government Ctr	330	460	790	290	380	670	1,460
Dtn Raleigh	920	740	1,660	970	510	1,480	3,140
NCSU	2,030	2,070	4,100	1,570	1,230	2,800	6,900
State Fairgrounds	270	280	550	130	170	300	850
West Raleigh	30	600	630	40	270	310	940
Cary Depot	290	320	610	130	130	260	870
Morrisville	220	80	300	130	140	270	570
South Park	160	160	320	110	130	240	560
North Park	320	220	540	230	230	460	1,000
Alston Ave	1,320	590	1,910	630	200	830	2,740
Dtn Durham	600	360	960	190	120	310	1,270
9th Street	2,100	610	2,710	950	390	1,340	4,050
Duke Med Ctr	670	80	750	250	40	290	1,040
Morreene Road	2,210	600	2,810	740	320	1,060	3,870
Pickett Road	170	230	400	160	70	230	630
South Square Mall	510	90	600	10	60	70	670
University Drive	320	60	380	350	60	410	790
Garrett Rd	500	160	660	120	140	260	920
Mt. Moriah Rd	20	10	30	160	30	190	220
Gateway	450	470	920	180	170	350	1,270
Ephesus Church	150	50	200	50	80	130	330
Meadowmont	40	0	40	110	0	110	150
Friday Center	130	130	260	70	60	130	390
UNC Hospital	2,220	400	2,620	1,030	470	1,500	4,120
Total	17,110	10,280	27,390	9,060	5,820	14,880	**42,270**

Table VI-VI. LRT Alternative 2 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

LRT Alternative 2							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	430	90	520	160	50	210	730
Millbrook	400	690	1,090	170	210	380	1,470
Six Forks/Highlands	280	690	970	140	160	300	1,270
State Government Ctr	330	480	810	280	380	660	1,470
Dtn Raleigh	910	740	1,650	980	520	1,500	3,150
NCSU	2,000	2,110	4,110	1,560	1,230	2,790	6,900
State Fairgrounds	290	290	580	130	170	300	880
West Raleigh	30	590	620	40	270	310	930
Cary Depot	270	300	570	130	130	260	830
Morrisville	210	200	410	130	140	270	680
South Park	170	170	340	120	140	260	600
North Park	290	240	530	230	240	470	1,000
Alston Ave	1,280	570	1,850	610	210	820	2,670
Dtn Durham	500	380	880	170	120	290	1,170
9th Street	2,050	620	2,670	960	420	1,380	4,050
Duke Med Ctr	400	50	450	190	30	220	670
Morreene Road	2,210	590	2,800	870	360	1,230	4,030
Pickett Road	170	230	400	190	90	280	680
South Square Mall	520	80	600	10	80	90	690
University Blvd	320	70	390	440	80	520	910
Garrett Blvd	500	120	620	140	130	270	890
Mt. Moriah Rd	20	10	30	180	60	240	270
Gateway	450	470	920	230	160	390	1,310
Ephesus Church	160	30	190	50	40	90	280
Meadowmont	40	0	40	130	10	140	180
Friday Center	130	150	280	110	90	200	480
UNC Hospital	2,210	380	2,590	1,210	510	1,720	4,310
Total	16,570	10,340	26,910	9,560	6,030	15,590	**42,500**

Table VI-VII. LRT Alternative 3 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

LRT Alternative 3							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	110	550	150	50	200	750
Millbrook	390	700	1,090	150	210	360	1,450
Six Forks/Highlands	280	700	980	140	160	300	1,280
State Government Ctr	330	470	800	290	390	680	1,480
Dtn Raleigh	920	750	1,670	970	500	1,470	3,140
NCSU	2,040	2,130	4,170	1,560	1,220	2,780	6,950
State Fairgrounds	300	270	570	130	170	300	870
West Raleigh	30	580	610	40	260	300	910
Cary Depot	260	300	560	130	130	260	820
Morrisville	210	200	410	130	130	260	670
South Park	170	180	350	110	140	250	600
North Park	290	220	510	240	240	480	990
Alston Ave	1,320	490	1,810	610	170	780	2,590
Dtn Durham	610	340	950	280	100	380	1,330
9th Street	2,180	550	2,730	1,060	450	1,510	4,240
Hillsborough Rd	710	270	980	320	200	520	1,500
Cameron Blvd	2,010	550	2,560	840	260	1,100	3,660
Pickett Road	160	230	390	160	70	230	620
South Square Mall	470	100	570	100	60	160	730
University Drive	310	70	380	280	70	350	730
Garrett Rd	490	120	610	120	120	240	850
Mt. Moriah Rd	20	10	30	150	50	200	230
Gateway	430	480	910	180	130	310	1,220
Ephesus Church	140	30	170	50	30	80	250
Meadowmont	40	0	40	110	0	110	150
Friday Center	120	150	270	70	70	140	410
UNC Hospital	2,170	390	2,560	1,010	440	1,450	4,010
Total	16,840	10,390	27,230	9,380	5,820	15,200	**42,430**

Table V-VIII. Highway Assignment Summary for Rail Alternatives
Year 2025 Average Weekday

Alternative	No Build	TSM	DMU Alternative 1A	LRT Alternative 1	LRT Alternative 2	LRT Alternative 3
Vehicle-Miles	60,580,466	60,663,730	60,669,682	60,660,567	60,626,498	60,624,876
Delta No Build		83,264	89,216	80,101	46,037	44,409
Vehicle-Hours	1,825,340	1,831,250	1,846,200	1,828,670	1,838,890	1,826,600
Delta No Build		5,910	20,860	3,320	13,550	1,260

Table V-VIX. Transit System Performance Summary for Rail Alternatives

Year 2025 Average Weekday Passenger-Miles

Alternative	**No Build**			**TSM**			**DMU Alternative 1A**			**LRT Alternative 1**			**LRT Alternative 2**			**LRT Alternative 3**		
Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1 TTA Bus	33,728	46,957	80,679	44,465	46,267	90,733	16,765	19,853	36,624	17,492	19,685	37,183	17,759	19,039	36,210	17,970	19,393	37,363
2 CAT	41,856	37,152	79,007	41,756	3,678	78,740	41,936	37,028	78,964	42,129	37,264	79,393	41,936	37,382	79,312	41,992	37,264	79,256
3 CHT	36,425	46,118	82,543	33,287	45,876	79,169	34,033	45,640	79,672	32,728	40,377	73,104	32,622	39,283	71,905	32,752	40,793	73,545
4 DATA	52,208	45,614	97,822	48,057	46,385	94,436	48,063	44,503	92,566	42,340	42,583	84,923	42,943	42,098	85,041	45,310	45,149	90,459
5 NCSU	3,722	5,610	9,333	3,709	5,629	9,339	3,685	5,636	9,321	3,716	5,648	9,358	3,716	5,642	9,358	3,790	5,636	9,420
6 Duke	16,199	12,452	28,645	15,652	12,384	28,036	16,734	8,389	25,122	14,664	9,880	24,544	14,565	10,035	24,600	18,504	10,079	28,577
7 NCCU	982	292	1,274	976	280	1,255	870	336	1,205	795	323	11,123	746	305	1,044	820	311	1,131
8 OPT	478	3,877	4,356	864	4,064	4,934	833	4,033	4,865	851	5,580	6,437	423	5,717	6,139	839	5,449	6,288
9 TTA Rail	135,316	63,671	198,987	135,559	63,410	198,963	219,586	97,356	316,937	225,831	108,175	334,006	222,358	114,481	336,833	237,451	116,855	6,288
10 Cary	8,289	9,594	17,883	8,103	9,606	17,709	8,016	9,513	17,529	8,115	9,557	17,666	7,891	9,613	17,510	7,804	9,463	17,268
Total	329,190	271,347	600,537	332,421	270,887	603,308	390,519	272,285	662,804	388,655	279,070	667,725	384,946	283,594	668,533	407,228	290,385	697,613
Delta No Build				*3237*	*460)*	*2,778*	*61,329*	*938*	*62,268*	*59,465*	*7,730*	*67,195*	*55,756*	*12,247*	*68,003*	*78,038*	*19,045*	*97,083*

Table V-X. Population Served by Transit
Year 2025 Projected Population

Total Population:	1,798,000
Population Served by Transit (estimated from transit walk percents):	836,275
Percentage Served by Transit: *Note: transit service coverage does not vary by alternative*	47%

3. *DMU Sensitivity Test*

For a more direct comparison between the DMU alternative and the three LRT alternatives, additional 15 minute peak/30 minute off-peak DMU service between UNC Hospital and 9th Street for DMU Alternative 1 was added; DMU Alternative 1B. This produced an effective 7.5 minute peak/15 minute off-peak rail headway consistent with the LRT alternatives for the US 15-501 Corridor. Tables X-I through V-XIV show the results of the new service with fixed guideway system boardings, mode choice summary, boardings by company, and boardings by company, respectively.

Table V-XI. DMU Alternative 1B Fixed Guideway System Boardings
Year 2025 Average Weekday Boardings (Unlinked Trips)

Alternative	No Build			TSM			DMU Alternative 1B		
	Peak	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
TTA Phase 1	18,380	10,490	28,870	18,150	10,490	28,640	21,880	11,880	33,760
New Service	0	0	0	0	0	0	3,920	1,720	**5,640**

Table V-XII. DMU Alternative 1B Modal Choice Summary
Year 2025 Average Weekday Linked Trips

Alternative	No Build				TSM				DMU Alternative 1B			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,680	1,166,170	1,237,140	3,645,990	1,242,790	1,166,120	1,237,110	3,646,020	1,241,720	1,166,420	1,237,190	3,645,330
SH-2	107,550	1,505,500	857,070	2,470,120	107,500	1,505,570	857,050	2,470,120	107,310	1,506,630	856,920	2,470,860
SH-3+	22,230	0	0	22,230	22,220	0	0	22,220	22,130	0	0	22,130
Total Auto	1,372,460	2,671,670	2,094,210	6,138,340	1,372,510	2,671,690	2,094,160	6,138,360	1,371,160	2,673,050	2,094,110	6,138,320
DRIVE	13,350	6,530	4,160	24,040	13,270	6,310	4,120	23,700	14,710	6,490	4,610	25,810
WLK-LOC	37,270	25,940	9,690	72,900	37,600	26,360	9,810	73,770	33,650	24,580	9,000	67,230
WLK-PRM	11,620	4,840	2,060	18,520	11,330	4,620	2,020	17,970	15,470	4,860	2,400	22,730
Total Transit	62,240	37,310	15,910	115,460	62,200	37,290	15,950	115,440	63,830	35,930	16,010	115,770
New Riders **delta No Build**					(40)	(20)	40	(20)	1,590	(1,380)	100	**310**

Table V-XIII. DMU Alternative 1B Boarding Summary by Company

Year 2025 Average Weekday Boardings

Alternative		No Build			TSM			DMU Alternative 1B		
Company		*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1	TTA Bus	5,210	5,880	11,090	7,130	5,780	12,910	2,900	2,720	5,620
2	CAT	15,860	13,880	29,740	15,850	13,860	29,710	16,050	13,810	29,860
3	CHT	14,610	17,130	31,740	13,440	17,150	30,590	13,390	15,430	28,820
4	DATA	23,870	19,400	43,270	22,720	19,610	42,330	20,950	18,220	39,170
5	NCSU	2,950	4,230	7,180	2,960	4,240	7,200	2,840	4,250	7,090
6	Duke	12,750	9,240	21,990	12,920	9,260	22,180	12,940	4,820	17,760
7	NCCU	660	240	900	660	230	890	610	280	890
8	OPT	80	510	590	150	520	670	150	430	580
9	TTA Rail	18,370	10,490	28,860	18,150	10,490	28,640	25,800	13,600	39,400
10	Cary	3,180	3,270	6,450	3,160	3,270	6,430	3,130	3,240	6,370
	Total	97,540	84,270	181,810	97,140	84,410	181,550	98,760	76,800	175,560

Table V-XIV. DMU Alternative 1B Fixed Guideway System Boardings
Year 2025 Average Weekday Boardings

DMU Alternative 1B							
Station Location	Peak			Off-Peak			Total Daily
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	120	560	150	50	200	760
Millbrook	390	670	1,060	160	200	360	1,420
Six Forks/Highlands	270	680	950	140	150	290	1,240
State Government Ctr	320	430	750	290	380	670	1,420
Dtn Raleigh	940	720	1,660	960	510	1,470	3,130
NCSU	2,030	2,010	4,040	1,570	1,240	2,810	6,850
State Fairgrounds	290	280	570	130	170	300	870
West Raleigh	30	620	650	40	260	300	950
Cary Depot	280	330	610	130	130	260	870
Morrisville	220	90	310	130	130	260	570
South Park	170	180	350	110	150	260	610
North Park	320	230	550	230	250	480	1,030
Alston Ave	1,360	630	1,990	600	190	790	2,780
Dtn Durham	630	460	1,090	250	140	390	1,480
9th Street	3,290	730	4,020	830	460	1,290	5,310
Hillsborough Rd	490	60	550	130	20	150	700
Cameron Blvd	240	600	840	390	400	790	1,630
South Square Mall	810	560	1,370	200	390	590	1,960
Mt. Moriah Rd	20	10	30	120	40	160	190
Gateway	330	610	940	120	290	410	1,350
Ephesus Church	100	70	170	30	150	180	350
Friday Center	130	230	360	30	90	120	480
UNC Hospital	1,970	440	2,410	540	530	1,070	3,480
Total	15,070	10,760	25,830	7,280	6,320	13,600	**39,430**

D. Bus Service Alternatives

There are two primary bus service types being considered for Phase II. The first is the development of an exclusive busway. The second is a busway / mixed traffic (BMT) scenario with designated bus lanes and limited sections of exclusive busway. Similar to the rail alternatives, these alternatives vary in alignment in the Durham segment.

- *Busway Alternative 1:* In Busway Alternative 1, the busway begins at the 9th Street Station. The Phase I rail extends along the coal spur to Duke Medical Center. The exclusive busway follows the Erwin Road alignment. Five busway routes are created to utilize this busway, with headways ranging from 10-30 minutes in the peak period and 15-30 minutes in the off-peak.

- *Busway Alternative 2:* Busway Alternative 2 follows the same alignment as Busway Alternative 1 with one exception. From UNC Hospital Station to the intersection of Fordham Boulevard and Manning Drive, the bus uses diamond lanes and then enters the exclusive busway at the intersection of Fordham Boulevard and Manning Drive. The remainder of the bus service patterns remains the same as in Busway Alternative 1.

- *BMT Alternative 1:* BMT Alternative 1 utilizes an exclusive busway segment between Friday Center and the intersection of Fordham Boulevard and Manning Drive. On Chapel Hill Road, SW Durham Drive and Manning Drive, the buses travel in one of two designated bus lanes. In BMT Alternative 1, the locations of South Square, University Drive, Garrett Road and Mt. Moriah Stations are shifted, compared to the other alternatives, to locate the stations closer to the bus route alignments. The headways for the busway buses range from 10-30 minutes in the peak period and 15-30 minutes in the off-peak period.

- *Busway Alternative 3:* Busway Alternative 3 has bus routes following the exclusive busway on the western alignment between Hillsborough Road (the end of the Phase I rail line) and UNC Hospitals Station as well as buses extending beyond Hillsborough Rd. to the Duke University Campus. In addition, some of the Chapel Hill local buses operate parts of their routes on the exclusive busway. The headways on the busway range from 15-30 minutes during both the peak and off-peak periods.

- *Busway Alternative 4:* Busway Alternative 4 is almost identical to Busway Alternative 3 except that from the intersection of Fordham Boulevard and Manning Drive to UNC Hospitals Station, the buses travel in diamond lanes on Manning Drive, as in Busway Alternative 2.

- *BMT Alternative 2:* BMT Alternative 2 has three segments of exclusive busway on which the five busway routes travel. The first segment begins near the intersection of Cornwallis Road and ends at the South Square Station. The second segment begins on University Drive near Snowcrest Terrace and ends at Southwest Durham Drive.

The final segment begins at Friday Center and ends at the intersection of Fordham Boulevard and Manning Drive. In addition to the segments of exclusive busway, there are also designated bus lanes on Erwin Road, Southwest Durham Drive, and Manning Drive. The buses operate with the same headways as in BMT Alternative 1.

1. Forecasts for Bus Service Alternatives

As with the rail service alternative, there are several ways to summarize the ridership forecasts. Table V-XVI shows 2025 average weekday person trips produced by the TRM modal choice model, listed by purpose (HBW, HBO, NHB) and mode of travel for both auto and transit modes. As in the results tables for the rail service alternatives, the transit person trips output by the modal choice model are *linked* trips, which is defined as a trip from the origin zone to the destination zone, regardless of the number of modes used. The difference in person trips between No Build and TSM and the build alternative is shown as an increase in transit trips (and the corresponding decrease in auto trips). This is the number of *new* transit riders the alternative generates.

Unlinked trips, or boardings, were reported in Table V-XV for the fixed guideway services and Table V-XVII by operating company. Peak trips are the HBW trips while off-peak trips include HBO and NHB trips. Please note that a decrease in boardings relative to another is not necessarily a sign of poor performance. In the bus service alternatives, fewer boardings can actually mean more “one seat rides” since there may be fewer transfers because of the bus circulating on local streets as the production or attraction end of the trip. The “new riders” measure in Table V-XIII is a more accurate measure of the alternative’s ability to attract riders.

In addition, boardings at the station level are summarized and presented in Tables V-XVIII through V-XXIII. Stations are included in this summary if they are on a busway route. These are reported as one half the average daily number of passengers boarding and alighting the train at each stop. The number of daily trips is halved to avoid “double counting” since transit trips are assigned in *production-attraction* format. This daily boarding summary is presented as Tables V-XVIII through V-XXIII for the alternatives and is stratified by mode of access or egress (i.e. walk/bus or drive). Please note that the Triangle Regional Model allows for drive access “drop off” or “kiss and ride” trips at stations with no parking provisions. In addition, the total in Table V-XV will not equal the total busway boardings because transfers between routes of the same mode are not reported.

Tables V-XXIV and V-XXV show additional measures of performance for each of the bus service alternatives. Table V-XXIV shows the vehicle-kilometers and vehicle-hours traveled by automobiles in each of the rail service alternatives. These measures can compare the amount of auto usage between the alternatives. Table X-XV shows the average weekday passenger-kilometers for each rail service alternative broken down by company.

Since, transit service coverage does not change by alternative (rail or bus) since the corridor is in area with transit coverage that is already established; the population served by transit can be found in Table V-X in the previous section.

Table V-XV. Busway System Boardings
Year 2025 Average Weekday Boardings

Alternative	No Build			TSM			Busway Alternative 1			Busway Alternative 2		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
TTA Phase 1	18,380	10,490	28,870	18,150	10,490	28,640	17,500	10,250	27,750	17,530	10,170	27,700
New Service	0	0	0	0	0	0	6,650	3,680	**10,330**	5,970	3,450	**9,420**

Alternative	BMT Alternative 1			Busway Alternative 3			Busway Alternative 4			BMT Alternative 2		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
TTA Phase 1	17,910	10,080	27,990	17,250	10,360	27,610	17,190	10,310	27,500	17,550	10,140	27,690
New Service	4,460	2,990	**7,450**	6,130	3,390	**9,520**	5,790	3,240	**9,030**	7,460	3,750	**11,210**

Table V-XVI. Modal Choice Summary for Bus Alternatives

Year 2025 Average Weekday Linked Trips

Alternative	**No Build**				**TSM**				**Busway Alternative 1**				**Busway Alternative 2**			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,680	1,166,170	1,237,140	3,645,990	1,242,790	1,166,120	1,237,110	3,646,020	1,240,710	1,166,350	1,237,080	3,644,140	1,240,790	1,166,310	1,237,060	3,644,160
SH-2	107,550	1,505,500	857,070	2,470,120	107,500	1,505,570	857,050	2,470,120	106,930	1,506,650	856,370	2,469,950	107,030	1,506,330	856,220	2,469,580
SH-3+	22,230	0	0	22,230	22,220	0	0	22,220	22,030	0	0	22,030	22,040	0	0	22,040
Total Auto	1,372,460	2,671,670	2,094,210	6,138,340	1,372,510	2,671,690	2,094,160	6,138,360	1,369,670	2,673,000	2,093,450	6,136,120	1,369,860	2,672,640	2,093,280	6,135,780
DRIVE	13,350	6,530	4,160	24,040	13,270	6,310	4,120	23,700	14,350	6,330	4,390	25,070	14,250	6,360	4,410	25,020
WLK-LOC	37,270	25,940	9,690	72,900	37,600	26,360	9,810	73,770	32,100	23,510	8,350	63,960	32,200	23,830	8,700	64,730
WLK-PRM	11,620	4,840	2,060	18,520	11,330	4,620	2,020	17,970	18,700	6,140	3,930	28,770	18,520	6,160	3,730	28,410
Total Transit	62,240	37,310	15,910	115,460	62,200	37,290	15,950	115,440	65,150	35,980	16,670	117,800	64,970	36,350	16,840	118,160
New Riders																
Delta No Build					(40)	(20)	40	(20)	2,910	(1,330)	760	**2,340**	2,730	(960)	930	**2,700**

Alternative	**BMT Alternative 1**				**Busway Alternative 3**				**Busway Alternative 4**				**BMT Alternative 2**			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,190	1,166,210	1,237,110	3,645,510	1,241,020	1,166,380	1,237,060	3,644,460	1,241,010	1,166,340	1,237,050	3,644,400	1,240,950	1,166,250	1,237,050	3,644,250
SH-2	107,380	1,506,200	856,750	2,470,330	107,110	1,506,450	856,160	2,469,720	107,180	1,506,170	856,000	2,469,350	107,260	1,506,220	856,400	2,469,880
SH-3+	22,130	0	0	22,130	22,080	0	0	22,080	22,120	0	0	22,120	22,150	0	0	22,150
Total Auto	1,371,700	2,672,410	2,093,860	6,137,970	1,370,210	2,672,830	2,093,220	6,136,260	1,370,310	2,672,510	2,093,050	6,135,870	1,370,360	2,672,470	2,093,450	6,136,280
DRIVE	13,950	6,370	4,220	24,540	13,520	6,250	4,230	24,000	13,550	6,290	4,240	24,080	14,470	6,380	4,330	25,180
WLK-LOC	34,540	24,540	8,960	68,040	32,970	23,340	8,560	64,870	33,250	23,740	8,910	65,900	33,080	24,220	8,780	66,080
WLK-PRM	14,690	5,670	3,090	23,450	18,140	6,560	4,120	28,820	17,610	6,450	3,920	27,980	16,820	5,920	3,580	26,320
Total Transit	63,180	36,580	16,270	116,030	64,630	36,150	16,910	117,690	64,410	36,480	17,070	117,960	64,370	36,520	16,690	117,580
New Riders																
Delta No Build	940	(730)	360	**570**	2,390	(1,160)	1,000	**2,230**	2,170	(830)	1,160	**2,500**	2,130	(790)	780	**2,120**

Table V-XVII. Boarding Summary by Company for Bus Alternatives

Year 2025 Average Weekday Boardings

Alternative		No Build			TSM			Busway Alternative 1			Busway Alternative 2		
	Company	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
1	TTA Bus	5,210	5,880	11,090	7,130	5,780	12,910	16,630	9,590	26,220	15,880	9,290	25,170
2	CAT	15,860	13,880	29,740	15,850	13,860	29,710	15,920	13,880	29,800	15,970	13,890	29,860
3	CHT	14,610	17,130	31,740	13,440	17,150	30,590	13,110	15,040	28,150	13,850	16,250	30,100
4	DATA	23,870	19,400	43,270	22,720	19,610	42,330	18,020	16,630	34,650	17,980	16,630	34,610
5	NCSU	2,950	4,230	7,180	2,960	4,240	7,200	2,980	4,290	7,270	2,980	4,260	7,240
6	Duke	12,750	9,240	21,990	12,920	9,260	22,180	7,330	6,400	13,730	7,350	6,410	13,760
7	NCCU	660	240	900	660	230	890	520	250	770	510	250	760
8	OPT	80	510	590	150	520	670	150	540	690	150	540	690
9	TTA Rail	18,370	10,490	28,860	18,150	10,490	28,640	17,500	10,250	27,750	17,530	10,170	27,700
10	Cary	3,180	3,270	6,450	3,160	3,270	6,430	3,050	3,250	6,300	3,140	3,240	6,380
	Total	97,540	84,270	181,810	97,140	84,410	181,550	95,210	80,120	175,330	95,340	80,930	176,270

Alternative		BMT Alternative 1			Busway Alternative 3			Busway Alternative 4			BMT Alternative 2		
	Company	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
1	TTA Bus	9,150	7,440	16,590	15,970	10,080	26,050	15,390	9,800	25,190	13,430	8,570	22,000
2	CAT	15,920	13,840	29,760	15,880	13,910	29,790	15,980	13,810	29,790	16,000	13,900	29,900
3	CHT	14,420	17,710	32,130	13,140	15,000	28,140	13,690	16,120	29,810	13,790	16,800	30,590
4	DATA	21,240	16,780	38,020	19,000	16,620	35,620	19,030	16,640	35,670	19,540	16,890	36,430
5	NCSU	3,050	4,250	7,300	2,990	4,220	7,210	2,950	4,260	7,210	2,910	4,250	7,160
6	Duke	12,410	8,060	20,470	8,520	4,230	12,750	8,700	4,230	12,930	12,590	7,820	20,410
7	NCCU	640	280	920	530	240	770	530	230	760	590	290	880
8	OPT	150	510	660	160	560	720	140	530	670	160	520	680
9	TTA Rail	17,910	10,080	27,990	17,250	10,360	27,610	17,190	10,310	27,500	17,550	10,140	27,690
10	Cary	3,120	3,210	6,330	3,210	3,210	6,420	3,050	3,250	6,300	3,130	3,250	6,380
	Total	98,010	82,160	180,170	96,650	78,430	175,080	96,650	79,180	175,830	99,690	82,430	182,120

Table V-XVIII. Busway Alternative 1 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 1							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	430	110	540	150	50	200	740
Millbrook	390	730	1,120	160	200	360	1,480
Six Forks/Highlands	280	690	970	140	170	310	1,280
State Government Ctr	330	470	800	290	380	670	1,470
Dtn Raleigh	910	700	1,610	970	510	1,480	3,090
NCSU	2,030	2,080	4,110	1,570	1,230	2,800	6,910
State Fairgrounds	290	290	580	140	170	310	890
West Raleigh	30	610	640	40	270	310	950
Cary Depot	270	270	540	140	140	280	820
Morrisville	210	190	400	120	130	250	650
South Park	160	180	340	120	140	260	600
North Park	310	230	540	230	250	480	1,020
Alston Ave	1,290	430	1,720	610	200	810	2,530
Dtn Durham	590	370	960	180	110	290	1,250
9th Street	2,050	520	2,570	990	470	1,460	4,030
Duke Med Ctr	510	80	590	160	30	190	780
Morreene Road	260	50	310	110	20	130	440
Pickett Road	120	80	200	110	30	140	340
South Square Mall	230	50	280	0	30	30	310
University Drive	160	50	210	160	30	190	400
Garrett Rd	190	60	250	60	50	110	360
Mt. Moriah Rd	20	10	30	80	30	110	140
Gateway	260	210	470	120	70	190	660
Ephesus Church	60	20	80	20	10	30	110
Meadowmont	20	0	20	40	10	50	70
Friday Center	70	70	140	60	30	90	230
UNC Hospital	530	180	710	330	190	520	1,230
Total	12,000	8,730	20,730	7,100	4,950	12,050	**32,780**

Table V-XIX. Busway Alternative 2 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 2							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	160	50	210	750
Millbrook	390	720	1,110	160	200	360	1,470
Six Forks/Highlands	280	690	970	140	160	300	1,270
State Government Ctr	330	470	800	290	390	680	1,480
Dtn Raleigh	920	760	1,680	970	510	1,480	3,160
NCSU	2,080	2,070	4,150	1,570	1,220	2,790	6,940
State Fairgrounds	290	300	590	130	170	300	890
West Raleigh	30	590	620	50	270	320	940
Cary Depot	280	310	590	120	140	260	850
Morrisville	230	80	310	130	130	260	570
South Park	160	180	340	120	130	250	590
North Park	320	230	550	230	240	470	1,020
Alston Ave	1,300	440	1,740	610	200	810	2,550
Dtn Durham	580	360	940	180	110	290	1,230
9th Street	2,040	550	2,590	1,000	490	1,490	4,080
Duke Med Ctr	440	70	510	140	20	160	670
Morreene Road	210	30	240	110	20	130	370
Pickett Road	110	70	180	90	20	110	290
South Square Mall	200	50	250	0	10	10	260
University Drive	120	40	160	110	30	140	300
Garrett Rd	160	30	190	30	20	50	240
Mt. Moriah Rd	20	10	30	60	10	70	100
Gateway	220	220	440	70	50	120	560
Ephesus Church	50	10	60	10	10	20	80
Meadowmont	20	0	20	10	0	10	30
Friday Center	30	90	120	20	30	50	170
Total	11,250	8,470	19,720	6,510	4,630	11,140	**30,860**

Table V-XX. BMT Alternative 1 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

BMT Alternative 1							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	110	550	150	60	210	760
Millbrook	380	730	1,110	160	200	360	1,470
Six Forks/Highlands	280	700	980	140	170	310	1,290
State Government Ctr	320	480	800	290	380	670	1,470
Dtn Raleigh	930	750	1,680	970	510	1,480	3,160
NCSU	2,080	2,110	4,190	1,560	1,230	2,790	6,980
State Fairgrounds	300	290	590	120	170	290	880
West Raleigh	40	630	670	50	270	320	990
Cary Depot	270	270	540	130	130	260	800
Morrisville	220	90	310	130	130	260	570
South Park	200	210	410	110	200	310	720
North Park	290	230	520	230	230	460	980
Alston Ave	1,430	750	2,180	600	210	810	2,990
Dtn Durham	390	310	700	160	100	260	960
9th Street	1,640	720	2,360	850	390	1,240	3,600
Duke Med Ctr	280	50	330	90	20	110	440
South Square Mall	10	30	40	30	20	50	90
University Drive	10	10	20	20	10	30	50
Garrett Rd	0	0	0	0	10	10	10
Friday Center	10	30	40	10	10	20	60
Total	9,520	8,500	18,020	5,800	4,450	10,250	**28,270**

Table V-XXI. Busway Alternative 3 Boarding Summary by Rail Station

Year 2025 Average Weekday Boardings

Busway Alternative 3							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	160	50	210	750
Millbrook	390	720	1,110	160	210	370	1,480
Six Forks/Highlands	280	660	940	140	160	300	1,240
State Government Ctr	330	430	760	290	390	680	1,440
Dtn Raleigh	930	720	1,650	960	510	1,470	3,120
NCSU	2,090	2,060	4,150	1,570	1,220	2,790	6,940
State Fairgrounds	310	280	590	130	180	310	900
West Raleigh	30	650	680	50	270	320	1,000
Cary Depot	270	320	590	120	140	260	850
Morrisville	230	80	310	130	120	250	560
South Park	150	170	320	120	130	250	570
North Park	310	220	530	240	240	480	1,010
Alston Ave	1,290	380	1,670	610	170	780	2,450
Dtn Durham	620	310	930	290	100	390	1,320
9^{th} Street	1,380	300	1,680	700	300	1,000	2,680
Hillsborough Rd	530	190	720	330	120	450	1,170
Cameron Blvd	140	490	630	150	220	370	1,000
Pickett Road	80	230	310	80	90	170	480
South Square Mall	240	70	310	110	40	150	460
University Drive	110	50	160	110	40	150	310
Garrett Rd	120	80	200	40	60	100	300
Mt. Moriah Rd	20	10	30	60	40	100	130
Gateway	330	440	770	90	110	200	970
Ephesus Church	30	20	50	20	10	30	80
Meadowmont	20	0	20	40	10	50	70
Friday Center	50	70	120	50	30	80	200
UNC Hospital	320	180	500	300	180	480	980
Total	11,040	9,230	20,270	7,050	5,140	12,190	**32,460**

Table V-XXII. Busway Alternative 4 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 4							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	430	100	530	150	50	200	730
Millbrook	390	670	1,060	160	210	370	1,430
Six Forks/Highlands	280	700	980	140	160	300	1,280
State Government Ctr	320	470	790	280	380	660	1,450
Dtn Raleigh	920	710	1,630	970	510	1,480	3,110
NCSU	2,050	2,050	4,100	1,570	1,230	2,800	6,900
State Fairgrounds	300	280	580	130	170	300	880
West Raleigh	40	590	630	40	260	300	930
Cary Depot	270	310	580	130	140	270	850
Morrisville	210	180	390	130	120	250	640
South Park	160	170	330	110	130	240	570
North Park	310	220	530	230	250	480	1,010
Alston Ave	1,290	420	1,710	600	180	780	2,490
Dtn Durham	600	320	920	290	100	390	1,310
9th Street	1,390	330	1,720	690	290	980	2,700
Hillsborough Rd	520	190	710	370	140	510	1,220
Cameron Blvd	120	500	620	150	210	360	980
Pickett Road	70	20	90	70	10	80	170
South Square Mall	230	210	440	100	90	190	630
University Drive	70	40	110	60	30	90	200
Garrett Rd	90	30	120	20	30	50	170
Mt. Moriah Rd	20	10	30	40	30	70	100
Gateway	350	500	850	60	100	160	1,010
Ephesus Church	30	0	30	10	10	20	50
Meadowmont	10	0	10	10	0	10	20
Friday Center	20	70	90	20	20	40	130
Total	10,490	9,090	19,580	6,530	4,850	11,380	**30,960**

Table V-XXIII. BMT Alternative 2 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

BMT Alternative 2							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	110	550	160	50	210	760
Millbrook	390	710	1,100	160	200	360	1,460
Six Forks/Highlands	280	700	980	150	160	310	1,290
State Government Ctr	320	460	780	290	380	670	1,450
Dtn Raleigh	920	710	1,630	970	500	1,470	3,100
NCSU	2,070	2,020	4,090	1,580	1,220	2,800	6,890
State Fairgrounds	290	290	580	130	170	300	880
West Raleigh	40	620	660	50	260	310	970
Cary Depot	290	320	610	120	130	250	860
Morrisville	220	70	290	130	130	260	550
South Park	170	170	340	100	130	230	570
North Park	310	220	530	230	230	460	990
Alston Ave	1,350	550	1,900	620	200	820	2,720
Dtn Durham	550	340	890	180	100	280	1,170
9th Street	1,890	660	2,550	940	490	1,430	3,980
Duke Med Ctr	30	0	30	10	0	10	40
Hillsborough Rd	240	20	260	70	10	80	340
South Square Mall	150	90	240	70	50	120	360
Garrett Rd	80	30	110	20	10	30	140
Mt. Moriah Rd	10	10	20	30	10	40	60
Gateway	130	120	250	50	40	90	340
Ephesus Church	30	10	40	10	0	10	50
Friday Center	20	40	60	10	20	30	90
Total	10,220	8,270	18,490	6,080	4,490	10,570	**29,060**

Table V-XXIV. Highway Assignment Summary for Bus Alternatives
Year 2025 Average Weekday

Alternative	No Build	TSM	Busway Alternative 1	Busway Alternative 2	BMT Alternative 1	Busway Alternative 3	Busway Alternative 4	BMT Alternative 2
Vehicle-Km	97,494,810	97,628,810	97,572,740	97,449,690	97,580,120	97,470,870	97,530,990	97,499,290
delta No Build		134,000	77,930	(45,120)	85,320	(23,930)	36,180	4,490
Vehicle-Hours	1,825,340	1,831,250	1,827,710	1,822,730	1,829,680	1,824,840	1,825,780	1,835,890
delta No Build		5,910	2,360	(2,610)	4,340	(500)	440	10,550

Table V-XXV. Transit System Performance Summary for Bus Alternatives

Year 2025 Average Weekday Passenger-Miles

Alternative	No Build			TSM			Busway Alternative 1			Busway Alternative 2		
Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1 TTA Bus	33,728	46,957	80,679	44,465	46,267	90,733	130,799	72,868	203,667	129,369	75,689	205,059
2 CAT	41,856	37,152	79,007	41,756	36,984	78,740	41,862	37,313	79,181	42,172	37,245	79,417
3 CHT	36,425	46,118	82,543	33,287	45,876	79,169	31,118	38,948	70,060	32,554	40,700	73,247
4 DATA	52,208	45,615	97,822	48,057	46,385	94,436	39,333	40,078	79,411	39,227	40,383	79,610
5 NCSU	3,722	5,611	9,333	3,710	5,630	9,339	3,728	5,679	9,408	3,710	5,648	9,358
6 Duke	16,199	12,452	28,645	15,652	12,384	28,036	9,737	8,351	18,088	9,805	8,370	18,175
7 NCCU	982	292	1,274	976	280	1,255	746	292	1,038	733	286	1,019
8 OPT	478	3,877	4,356	864	4,064	4,934	913	5,797	6,711	876	5,735	6,611
9 TTA Rail	135,316	63,672	198,988	135,558	63,411	198,963	134,850	66,014	200,864	134,390	65,120	199,504
10 Cary	8,289	9,594	17,883	8,103	9,606	17,709	7,898	9,544	17,442	8,022	9,488	17,504
Total	329,190	271,347	600,537	332,421	270,887	603,308	400,989	284,886	685,876	400,847	288,664	68,761
Delta No Build				*3,237*	*(460)*	*2,778*	*71,799*	*13,540*	*85,339*	*71,657*	*17,318*	*88,974*

Alternative	BMT Alternative 1			Busway Alternative 3			Busway Alternative 4			BMT Alternative 2		
Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1 TTA Bus	63,237	61,870	125,107	119,682	73,247	192,929	115,295	73,086	188,381	100,817	69,500	170,317
2 CAT	42,073	37,003	79,076	41,551	37,326	78,877	42,247	37,195	79,442	42,297	37,195	79,492
3 CHT	36,878	46,684	83,562	31,292	38,848	70,140	32,299	40,016	72,315	32,989	43,384	76,373
4 DATA	48,647	41,427	90,074	43,266	41,402	84,668	43,397	41,607	85,004	42,583	41,905	84,488
5 NCSU	3,790	5,654	9,445	3,734	5,636	9,364	3,703	5,654	9,357	3,679	5,648	9,327
6 Duke	15,429	9,805	25,234	10,681	7,463	18,150	10,980	7,469	18,449	14,403	9,495	23,898
7 NCCU	951	336	1,280	771	261	1,031	789	255	1,044	857	336	1,193
8 OPT	895	4,418	5,313	920	5,909	6,829	833	5,592	6,425	901	5,350	6,251
9 TTA Rail	133,346	63,125	196,471	133,538	66,710	200,249	133,763	66,623	200,386	132,166	64,716	196,882
10 Cary	7,972	9,439	17,411	8,258	9,476	17,734	7,835	9,519	17,354	8,084	9,575	17,659
Total	353,225	279,754	632,978	393,695	286,278	679,966	391,128	287,018	678,146	378,775	287,490	666,265
Delta No Build	*24,035*	*8,407*	*32,442*	*64,505*	*14,932*	*79,436*	*61,938*	*15,677*	*77,615*	*378,775*	*161,149*	*65,734*

E. Summary of Findings

A number of observations can be made about the US 15-501 MIS (Phase II) alternative forecasts:

- Busway Alternatives 1-4 attract the most new riders, each attracting over 2,200 average weekday linked trips, compared to the No-Build alternative. LRT Alternative 3 and BMT Alternative 2 both attract 2,120 new riders compared to the No Build Alternative. The other two LRT Alternatives gain approximately 1,200 riders. BMT Alternative 1 and DMU Alternative 1 both gain fewer than 600 new riders.

- The total number of linked trips is more indicative of the total number of person trips. Busway Alternative 2 had the highest number of average weekday linked trips with 118,160. It is followed closely by the other three busway alternatives.

- The three LRT Alternatives have the highest number of boardings for the new service with over 15,000 average weekday boardings. As stated previously, the four busway alternatives are expected to have fewer boardings because of the possibility of more "one seat rides." For the busway alternatives, average weekday boardings range from 9,000 to 10,300.

CHAPTER V
PATRONAGE FORECASTING METHODOLOGY AND RESULTS

A. Background

The patronage forecasts for the US 15-501 Major Investment Study (MIS) Phase II, to the greatest extent possible, were made using the *existing and currently available* (at the beginning of Phase II) Triangle Regional Model (TRM, Version 5). This chapter contains the following subsections:

- Patronage forecasting methodology;
- Rail service forecasts; and
- Bus service forecasts.

B. Patronage Forecasting Methodology

The elements or stages of a travel demand model are commonly called "steps." Most models have four steps.

In the first step, called " trip generation," the trips likely to originate and terminate in each zone are calculated.

In the second model step, called "trip distribution," trip productions and trip attractions are matched to produce a matrix of trips for the region. Travel between zones are represented as a function of trips produced in the origin zone, trips attracted to the destination zone, an approximate measure of the "cost" of travel between zones and the relative "attractiveness" of competing zones.

In the third model step, called "modal split," travel volumes are "split" among the available modes of travel (i.e., highway and transit). The "choice" of a travel mode is based on the costs of travel (e.g., cost of fuel, bus fare) and travel time (e.g., actual travel time plus time spent parking a car or waiting for a bus).

In the fourth step, called "trip assignment," mode-specific trips are assigned to paths in their respective infrastructure networks. Highway trips are assigned using an equilibrium assignment algorithm and transit trips to representative peak and off-peak networks.

Travel demand forecasting models attempt to answer the following question: Given the projected levels of travel activity for the region, where should additional infrastructure capacity be placed? To answer this question, model results can be summarized in a number of ways, including:

- Total Trips (zone to zone)

- Highway assignments

- Transit assignments
  - total unlinked transit trips
  - by trip purpose/time period
  - by route
  - by boarding/alighting station and mode of access

- Evaluation criteria
  - highway vehicle-miles
  - passenger-miles
  - travel time savings

The Triangle Regional Model generally follows the common "four step" procedure (trip generation, trip distribution, modal split, and assignment) described above. Important modifications include composite impedance and congestion feedback loops for the home-based work (HBW) trip purpose. Inputs for the base (1995) and horizon (2025) years were provided. The process utilizes the TRANPLAN transportation planning software package and special programs developed for the TRM. The Triangle Regional Model is discussed in detail in other documentation, including the *Triangle Regional Model User's Manual* (NCDOT, September 2000).

C. Rail Service Alternatives

Rail service alternatives for Phase II of the US 15-501 MIS extend the proposed TTA Phase I rail line from Durham southwest to Chapel Hill. The two rail technologies being modeled are LRT and DMU. The alternatives further vary in the alignment segment and the transfer point between the TTA Phase 1 service and the proposed rail lines.

1. Description of Rail Service Alternatives

The following rail service alternatives were simulated:

- *DMU Alternative 1A:* DMU Alternative 1A extends the Phase I rail line beyond the 9th Street Station to the UNC Hospitals Station, with stops at Phase II stations in the "Western" alignment. Both the Phase I and Phase II DMU lines operate at 15 minutes headways during the peak period and 30 minute headways in the off-peak period.

- *LRT Alternative 1:* In LRT Alternative 1, the Phase I rail extends on the "coal spur" to its termination at the Duke Medical Center Station. The LRT alignment begins at 9th Street and follows the Erwin Rd. alignment that includes the Morreene Rd. and Pickett Rd. Stations. The Phase I rail operates at 15-minute and 30-minute headways in the peak and off-peak period, respectively. The LRT operates at 7.5-minute headways in the peak and 15-minute headways in the off-peak. Several bus routes that operate in Chapel Hill and Durham are diverted in order to connect to rail stations and parts and/or entire routes that duplicate the LRT service are removed.

- *LRT Alternative 2:* LRT Alternative 2 is essentially identical to LRT Alternative 1 except that the Phase I rail ends at the 9th Street Station.

- *LRT Alternative 3:* In LRT Alternative 3, the Phase I rail extends to the Hillsborough Rd. Station. The LRT line runs between Hillsborough Rd. Station and UNC Hospitals Station along the western alignment. The headways for all rail is the same as in LRT Alternatives 1 and 2.

2. Rail System Forecast Summary

The forecasts can be summarized in a number of ways, including modal choice results and transit assignment results. Table V-II shows 2025 average weekday person trips produced by the TRM modal choice model. For each alternative, auto and transit trips are listed by purpose (home-based-work, home-based-other, and non-home-based) and mode of travel. The transit person trips output by the modal choice model are *linked* trips. A linked trip is defined as a trip from the origin zone to the destination zone, regardless of the number of modes used. The difference in person trips between No-Build and TSM and the build alternative is shown as an increase in transit trips (and the corresponding decrease in auto trips). This is the number of *new* transit riders the alternative generates.

Unlinked trips, or boardings, were reported in Table V-I for the rail services and in Table V-III by operating company. Peak trips are the home-based-work (HBW) trips while off-peak trips include home-based-other (HBO) and non-home-based (NHB) trips. Please note that a decrease in boardings relative to another is not necessarily a sign of poor performance. The "new riders" measure in Table V-II is a more accurate measure of the alternative's ability to attract riders.

In addition, boardings at the station level are summarized and presented in Tables V-IV through V-VII. These are reported as one half the average daily number of passengers boarding and alighting the train at each stop. The number of daily trips is halved to avoid "double counting" since transit trips are assigned in *production-attraction* format. This daily boarding summary is presented as Table V-IV for the alternatives and is stratified by mode of access or egress (i.e. walk/bus or drive). Please note that the Triangle Regional Model allows for drive access "drop-off" or "kiss-and-ride" trips at stations with no parking provisions. In addition, the totals in Tables V-IV through V-VII will not equal the total fixed guideway boardings because transfers between routes of the same mode are not reported.

Tables V-V and V-VI show additional measures of performance for each of the rail alternatives**.** Table V-V shows the vehicle-kilometers and vehicle-hours traveled by automobiles in each of the rail service alternatives. These measures can compare the amount of auto usage between the alternatives. Table V-VI shows the average weekday passenger-kilometers for each rail service alternative broken down by company.

The population served by transit, shown in Table V-VII was computed by multiplying the population in a TAZ by the percentage of the population in 1/2 mile of a transit line (the "long walk" percentage in the model). Transit service coverage does not change by alternative (rail or bus) since the corridor is in area with transit coverage that is already established.

Table V-I. Rail System Boardings

Year 2025 Average Weekday Boardings (Unlinked Trips)

Alternative	**No Build**			**TSM**			**DMU Alternative 1A**		
	Peak	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
TTA Phase 1 (1)	18,380	10,490	28,870	18,150	10,490	28,640	24,110	12,790	**36,900**

(1) Includes New Service in Alternative 1

Alternative	**LRT Alternative 1**			**LRT Alternative 2**			**LRT Alternative 3**		
	Peak	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
TTA Phase 1 (1)	17,830	10,260	28,090	17,400	10,200	27,600	17,770	10,420	28,190
New Service	10,740	5,210	**15,950**	10,800	6,110	**16,910**	10,440	5,390	**15,830**

Table V-II. Modal Choice Summary for Rail Alternatives

Year 2025 Average Weekday Linked Trips

Alternative	No Build				TSM				DMU Alternative 1A			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,680	1,166,170	1,237,140	3,645,990	1,242,790	1,166,120	1,237,110	3,646,020	1,241,680	1,166,340	1,237,170	3,645,190
SH-2	107,550	1,505,500	857,070	2,470,120	107,500	1,505,570	857,050	2,470,120	107,480	1,506,210	856,880	2,470,570
SH-3+	22,230	0	0	22,230	22,220	0	0	22,220	22,220	0	0	22,220
Total Auto	1,372,460	2,671,670	2,094,210	6,138,340	1,372,510	2,671,690	2,094,160	6,138,360	1,371,380	2,672,550	2,094,050	6,137,980
DRIVE	13,350	6,530	4,160	24,040	13,270	6,310	4,120	23,700	14,320	6,820	4,550	25,690
WLK-LOC	37,270	25,940	9,690	72,900	37,600	26,360	9,810	73,770	34,880	24,910	9,200	68,990
WLK-PRM	11,620	4,840	2,060	18,520	11,330	4,620	2,020	17,970	14,160	4,700	2,320	21,180
Total Transit	62,240	37,310	15,910	115,460	62,200	37,290	15,950	115,440	63,360	36,430	16,070	115,860
New Riders												
Delta No Build					(40)	(20)	40	(20)	1,120	(880)	160	**400**
	LRT Alternative 1				**LRT Alternative 2**				**LRT Alternative 3**			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,241,100	1,166,310	1,237,140	3,644,550	1,241,090	1,166,340	1,237,120	3,644,550	1,241,120	1,166,310	1,237,090	3,644,520
SH-2	107,160	1,506,510	856,910	2,470,580	107,270	1,506,630	856,600	2,470,500	107,180	1,506,080	856,430	2,469,690
SH-3+	22,120	0	0	22,120	22,120	0	0	22,120	22,110	0	0	22,110
Total Auto	1,370,380	2,672,820	2,094,050	6,137,250	1,370,480	2,672,970	2,093,720	6,137,170	1,370,410	2,672,390	2,093,520	6,136,320
DRIVE	14,190	6,340	4,250	24,780	14,320	6,310	4,450	25,080	14,130	6,330	4,310	24,770
WLK-LOC	32,830	23,950	8,610	65,390	32,940	23,610	8,520	65,070	33,400	24,230	9,040	66,670
WLK-PRM	17,450	5,880	3,210	26,540	16,980	6,100	3,440	26,520	16,850	6,030	3,260	26,140
Total Transit	64,470	36,170	16,070	116,710	64,240	36,020	16,410	116,670	64,380	36,590	16,610	117,580
New Riders												
Delta No Build	2,230	(1,140)	160	**1,250**	2,000	(1,290)	500	**1,210**	2,140	(720)	700	**2,120**

Table V-III Boarding Summary by Company for Rail Alternatives

Year 2025 Average Weekday Boardings

	Alternative	No Build			TSM			DMU Alternative 1A			LRT Alternative 1			LRT Alternative 2			LRT Alternative 3		
	Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1	TTA Bus	5,210	5,880	11,090	7,130	5,780	12,910	2,940	2,780	5,720	3,020	2,730	5,750	3,160	2,680	5,840	3,040	2,700	5,740
2	CAT	15,860	13,880	29,740	15,850	13,860	29,710	15,990	13,870	29,860	15,920	13,910	29,830	15,900	13,940	29,840	15,890	13,880	29,770
3	CHT	14,610	17,130	31,740	13,440	17,150	30,590	13,760	16,620	30,380	13,660	15,450	29,110	13,590	15,170	28,760	13,560	15,600	29,160
4	DATA	23,870	19,400	43,270	22,720	19,610	42,330	22,050	18,430	40,480	19,520	17,750	37,270	19,730	17,630	37,360	20,170	18,330	38,500
5	NCSU	2,950	4,230	7,180	2,960	4,240	7,200	2,940	4,260	7,200	2,980	4,250	7,230	2,980	4,250	7,230	3,060	4,250	7,310
6	Duke	12,750	9,240	21,990	12,920	9,260	22,180	12,480	4,750	17,230	13,030	8,400	21,430	12,960	8,600	21,560	13,050	5,660	18,710
7	NCCU	660	240	900	660	230	890	600	270	870	540	280	820	520	250	770	560	270	830
8	OPT	80	510	590	150	520	670	150	450	600	150	520	670	70	530	600	150	510	660
9	TTA Rail	18,370	10,490	28,860	18,150	10,490	28,640	24,110	12,790	36,900	28,570	15,470	44,040	28,200	16,310	44,510	28,210	15,810	44,020
10	Cary	3,180	3,270	6,450	3,160	3,270	6,430	3,110	3,220	6,330	3,160	3,270	6,430	3,040	3,250	6,290	3,020	3,230	6,250
	Total	97,540	84,270	181,810	97,140	84,410	181,550	98,130	77,440	175,570	100,550	82,030	182,580	100,150	82,610	182,760	100,710	80,240	180,950

Table VI-IV. DMU Alternative 1A Boarding Summary by Rail Station

Year 2025 Average Weekday Boardings

DMU Alternative 1A							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	150	50	200	740
Millbrook	390	670	1,060	160	210	370	1,430
Six Forks/Highlands	280	700	980	140	160	300	1,280
State Government Ctr	330	460	790	300	380	680	1,470
Dtn Raleigh	930	750	1,680	970	520	1,490	3,170
NCSU	2,040	2,070	4,110	1,570	1,230	2,800	6,910
State Fairgrounds	280	290	570	130	180	310	880
West Raleigh	40	590	630	50	270	320	950
Cary Depot	280	300	580	130	130	260	840
Morrisville	230	80	310	120	130	250	560
South Park	180	190	370	110	150	260	630
North Park	320	230	550	240	240	480	1,030
Alston Ave	1,410	760	2,170	580	300	880	3,050
Dtn Durham	710	480	1,190	260	130	390	1,580
9th Street	1,880	800	2,680	800	510	1,310	3,990
Hillsborough Rd	380	50	430	120	20	140	570
Cameron Blvd	1,180	340	1,520	350	300	650	2,170
South Square Mall	600	420	1,020	140	250	390	1,410
Mt. Moriah Rd	20	10	30	80	20	100	130
Gateway	240	370	610	60	220	280	890
Ephesus Church	70	50	120	10	80	90	210
Friday Center	70	150	220	10	70	80	300
UNC Hospital	1,670	290	1,960	420	350	770	2,730
Total	13,970	10,150	24,120	6,900	5,900	12,800	**36,920**

Table VI-V. LRT Alternative 1 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

LRT Alternative 1							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	160	50	210	750
Millbrook	400	710	1,110	160	200	360	1,470
Six Forks/Highlands	290	700	990	140	170	310	1,300
State Government Ctr	330	460	790	290	380	670	1,460
Dtn Raleigh	920	740	1,660	970	510	1,480	3,140
NCSU	2,030	2,070	4,100	1,570	1,230	2,800	6,900
State Fairgrounds	270	280	550	130	170	300	850
West Raleigh	30	600	630	40	270	310	940
Cary Depot	290	320	610	130	130	260	870
Morrisville	220	80	300	130	140	270	570
South Park	160	160	320	110	130	240	560
North Park	320	220	540	230	230	460	1,000
Alston Ave	1,320	590	1,910	630	200	830	2,740
Dtn Durham	600	360	960	190	120	310	1,270
9th Street	2,100	610	2,710	950	390	1,340	4,050
Duke Med Ctr	670	80	750	250	40	290	1,040
Morreene Road	2,210	600	2,810	740	320	1,060	3,870
Pickett Road	170	230	400	160	70	230	630
South Square Mall	510	90	600	10	60	70	670
University Drive	320	60	380	350	60	410	790
Garrett Rd	500	160	660	120	140	260	920
Mt. Moriah Rd	20	10	30	160	30	190	220
Gateway	450	470	920	180	170	350	1,270
Ephesus Church	150	50	200	50	80	130	330
Meadowmont	40	0	40	110	0	110	150
Friday Center	130	130	260	70	60	130	390
UNC Hospital	2,220	400	2,620	1,030	470	1,500	4,120
Total	17,110	10,280	27,390	9,060	5,820	14,880	**42,270**

Table VI-VI. LRT Alternative 2 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

LRT Alternative 2							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	430	90	520	160	50	210	730
Millbrook	400	690	1,090	170	210	380	1,470
Six Forks/Highlands	280	690	970	140	160	300	1,270
State Government Ctr	330	480	810	280	380	660	1,470
Dtn Raleigh	910	740	1,650	980	520	1,500	3,150
NCSU	2,000	2,110	4,110	1,560	1,230	2,790	6,900
State Fairgrounds	290	290	580	130	170	300	880
West Raleigh	30	590	620	40	270	310	930
Cary Depot	270	300	570	130	130	260	830
Morrisville	210	200	410	130	140	270	680
South Park	170	170	340	120	140	260	600
North Park	290	240	530	230	240	470	1,000
Alston Ave	1,280	570	1,850	610	210	820	2,670
Dtn Durham	500	380	880	170	120	290	1,170
9th Street	2,050	620	2,670	960	420	1,380	4,050
Duke Med Ctr	400	50	450	190	30	220	670
Morreene Road	2,210	590	2,800	870	360	1,230	4,030
Pickett Road	170	230	400	190	90	280	680
South Square Mall	520	80	600	10	80	90	690
University Blvd	320	70	390	440	80	520	910
Garrett Blvd	500	120	620	140	130	270	890
Mt. Moriah Rd	20	10	30	180	60	240	270
Gateway	450	470	920	230	160	390	1,310
Ephesus Church	160	30	190	50	40	90	280
Meadowmont	40	0	40	130	10	140	180
Friday Center	130	150	280	110	90	200	480
UNC Hospital	2,210	380	2,590	1,210	510	1,720	4,310
Total	16,570	10,340	26,910	9,560	6,030	15,590	**42,500**

Table VI-VII. LRT Alternative 3 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

LRT Alternative 3							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	110	550	150	50	200	750
Millbrook	390	700	1,090	150	210	360	1,450
Six Forks/Highlands	280	700	980	140	160	300	1,280
State Government Ctr	330	470	800	290	390	680	1,480
Dtn Raleigh	920	750	1,670	970	500	1,470	3,140
NCSU	2,040	2,130	4,170	1,560	1,220	2,780	6,950
State Fairgrounds	300	270	570	130	170	300	870
West Raleigh	30	580	610	40	260	300	910
Cary Depot	260	300	560	130	130	260	820
Morrisville	210	200	410	130	130	260	670
South Park	170	180	350	110	140	250	600
North Park	290	220	510	240	240	480	990
Alston Ave	1,320	490	1,810	610	170	780	2,590
Dtn Durham	610	340	950	280	100	380	1,330
9th Street	2,180	550	2,730	1,060	450	1,510	4,240
Hillsborough Rd	710	270	980	320	200	520	1,500
Cameron Blvd	2,010	550	2,560	840	260	1,100	3,660
Pickett Road	160	230	390	160	70	230	620
South Square Mall	470	100	570	100	60	160	730
University Drive	310	70	380	280	70	350	730
Garrett Rd	490	120	610	120	120	240	850
Mt. Moriah Rd	20	10	30	150	50	200	230
Gateway	430	480	910	180	130	310	1,220
Ephesus Church	140	30	170	50	30	80	250
Meadowmont	40	0	40	110	0	110	150
Friday Center	120	150	270	70	70	140	410
UNC Hospital	2,170	390	2,560	1,010	440	1,450	4,010
Total	16,840	10,390	27,230	9,380	5,820	15,200	**42,430**

Table V-VIII. Highway Assignment Summary for Rail Alternatives
Year 2025 Average Weekday

Alternative	No Build	TSM	DMU Alternative 1A	LRT Alternative 1	LRT Alternative 2	LRT Alternative 3
Vehicle-Miles	60,580,466	60,663,730	60,669,682	60,660,567	60,626,498	60,624,876
Delta No Build		83,264	89,216	80,101	46,037	44,409
Vehicle-Hours	1,825,340	1,831,250	1,846,200	1,828,670	1,838,890	1,826,600
Delta No Build		5,910	20,860	3,320	13,550	1,260

Table V-VIX. Transit System Performance Summary for Rail Alternatives

Year 2025 Average Weekday Passenger-Miles

Alternative	No Build			TSM			DMU Alternative 1A			LRT Alternative 1			LRT Alternative 2			LRT Alternative 3		
Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1 TTA Bus	33,728	46,957	80,679	44,465	46,267	90,733	16,765	19,853	36,624	17,492	19,685	37,183	17,759	19,039	36,210	17,970	19,393	37,363
2 CAT	41,856	37,152	79,007	41,756	3,678	78,740	41,936	37,028	78,964	42,129	37,264	79,393	41,936	37,382	79,312	41,992	37,264	79,256
3 CHT	36,425	46,118	82,543	33,287	45,876	79,169	34,033	45,640	79,672	32,728	40,377	73,104	32,622	39,283	71,905	32,752	40,793	73,545
4 DATA	52,208	45,614	97,822	48,057	46,385	94,436	48,063	44,503	92,566	42,340	42,583	84,923	42,943	42,098	85,041	45,310	45,149	90,459
5 NCSU	3,722	5,610	9,333	3,709	5,629	9,339	3,685	5,636	9,321	3,716	5,648	9,358	3,716	5,642	9,358	3,790	5,636	9,420
6 Duke	16,199	12,452	28,645	15,652	12,384	28,036	16,734	8,389	25,122	14,664	9,880	24,544	14,565	10,035	24,600	18,504	10,079	28,577
7 NCCU	982	292	1,274	976	280	1,255	870	336	1,205	795	323	11,123	746	305	1,044	820	311	1,131
8 OPT	478	3,877	4,356	864	4,064	4,934	833	4,033	4,865	851	5,580	6,437	423	5,717	6,139	839	5,449	6,288
9 TTA Rail	135,316	63,671	198,987	135,559	63,410	198,963	219,586	97,356	316,937	225,831	108,175	334,006	222,358	114,481	336,833	237,451	116,855	6,288
10 Cary	8,289	9,594	17,883	8,103	9,606	17,709	8,016	9,513	17,529	8,115	9,557	17,666	7,891	9,613	17,510	7,804	9,463	17,268
Total	329,190	271,347	600,537	332,421	270,887	603,308	390,519	272,285	662,804	388,655	279,070	667,725	384,946	283,594	668,533	407,228	290,385	697,613
Delta No Build				*3237*	*460)*	*2,778*	*61,329*	*938*	*62,268*	*59,465*	*7,730*	*67,195*	*55,756*	*12,247*	*68,003*	*78,038*	*19,045*	*97,083*

Table V-X. Population Served by Transit
Year 2025 Projected Population

Total Population:	1,798,000
Population Served by Transit (estimated from transit walk percents):	836,275
Percentage Served by Transit:	47%
Note: transit service coverage does not vary by alternative	

3. *DMU Sensitivity Test*

For a more direct comparison between the DMU alternative and the three LRT alternatives, additional 15 minute peak/30 minute off-peak DMU service between UNC Hospital and 9th Street for DMU Alternative 1 was added; DMU Alternative 1B. This produced an effective 7.5 minute peak/15 minute off-peak rail headway consistent with the LRT alternatives for the US 15-501 Corridor. Tables X-I through V-XIV show the results of the new service with fixed guideway system boardings, mode choice summary, boardings by company, and boardings by company, respectively.

Table V-XI. DMU Alternative 1B Fixed Guideway System Boardings
Year 2025 Average Weekday Boardings (Unlinked Trips)

Alternative	No Build			TSM			DMU Alternative 1B		
	Peak	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
TTA Phase 1	18,380	10,490	28,870	18,150	10,490	28,640	21,880	11,880	33,760
New Service	0	0	0	0	0	0	3,920	1,720	**5,640**

Table V-XII. DMU Alternative 1B Modal Choice Summary
Year 2025 Average Weekday Linked Trips

Alternative	No Build				TSM				DMU Alternative 1B			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,680	1,166,170	1,237,140	3,645,990	1,242,790	1,166,120	1,237,110	3,646,020	1,241,720	1,166,420	1,237,190	3,645,330
SH-2	107,550	1,505,500	857,070	2,470,120	107,500	1,505,570	857,050	2,470,120	107,310	1,506,630	856,920	2,470,860
SH-3+	22,230	0	0	22,230	22,220	0	0	22,220	22,130	0	0	22,130
Total Auto	1,372,460	2,671,670	2,094,210	6,138,340	1,372,510	2,671,690	2,094,160	6,138,360	1,371,160	2,673,050	2,094,110	6,138,320
DRIVE	13,350	6,530	4,160	24,040	13,270	6,310	4,120	23,700	14,710	6,490	4,610	25,810
WLK-LOC	37,270	25,940	9,690	72,900	37,600	26,360	9,810	73,770	33,650	24,580	9,000	67,230
WLK-PRM	11,620	4,840	2,060	18,520	11,330	4,620	2,020	17,970	15,470	4,860	2,400	22,730
Total Transit	62,240	37,310	15,910	115,460	62,200	37,290	15,950	115,440	63,830	35,930	16,010	115,770
New Riders **delta No Build**					(40)	(20)	40	(20)	1,590	(1,380)	100	**310**

Table V-XIII. DMU Alternative 1B Boarding Summary by Company
Year 2025 Average Weekday Boardings

Alternative		No Build			TSM			DMU Alternative 1B		
Company		*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1	TTA Bus	5,210	5,880	11,090	7,130	5,780	12,910	2,900	2,720	5,620
2	CAT	15,860	13,880	29,740	15,850	13,860	29,710	16,050	13,810	29,860
3	CHT	14,610	17,130	31,740	13,440	17,150	30,590	13,390	15,430	28,820
4	DATA	23,870	19,400	43,270	22,720	19,610	42,330	20,950	18,220	39,170
5	NCSU	2,950	4,230	7,180	2,960	4,240	7,200	2,840	4,250	7,090
6	Duke	12,750	9,240	21,990	12,920	9,260	22,180	12,940	4,820	17,760
7	NCCU	660	240	900	660	230	890	610	280	890
8	OPT	80	510	590	150	520	670	150	430	580
9	TTA Rail	18,370	10,490	28,860	18,150	10,490	28,640	25,800	13,600	39,400
10	Cary	3,180	3,270	6,450	3,160	3,270	6,430	3,130	3,240	6,370
	Total	97,540	84,270	181,810	97,140	84,410	181,550	98,760	76,800	175,560

Table V-XIV. DMU Alternative 1B Fixed Guideway System Boardings
Year 2025 Average Weekday Boardings

DMU Alternative 1B							
Station Location	Peak			Off-Peak			Total Daily
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	120	560	150	50	200	760
Millbrook	390	670	1,060	160	200	360	1,420
Six Forks/Highlands	270	680	950	140	150	290	1,240
State Government Ctr	320	430	750	290	380	670	1,420
Dtn Raleigh	940	720	1,660	960	510	1,470	3,130
NCSU	2,030	2,010	4,040	1,570	1,240	2,810	6,850
State Fairgrounds	290	280	570	130	170	300	870
West Raleigh	30	620	650	40	260	300	950
Cary Depot	280	330	610	130	130	260	870
Morrisville	220	90	310	130	130	260	570
South Park	170	180	350	110	150	260	610
North Park	320	230	550	230	250	480	1,030
Alston Ave	1,360	630	1,990	600	190	790	2,780
Dtn Durham	630	460	1,090	250	140	390	1,480
9th Street	3,290	730	4,020	830	460	1,290	5,310
Hillsborough Rd	490	60	550	130	20	150	700
Cameron Blvd	240	600	840	390	400	790	1,630
South Square Mall	810	560	1,370	200	390	590	1,960
Mt. Moriah Rd	20	10	30	120	40	160	190
Gateway	330	610	940	120	290	410	1,350
Ephesus Church	100	70	170	30	150	180	350
Friday Center	130	230	360	30	90	120	480
UNC Hospital	1,970	440	2,410	540	530	1,070	3,480
Total	15,070	10,760	25,830	7,280	6,320	13,600	**39,430**

D. Bus Service Alternatives

There are two primary bus service types being considered for Phase II. The first is the development of an exclusive busway. The second is a busway / mixed traffic (BMT) scenario with designated bus lanes and limited sections of exclusive busway. Similar to the rail alternatives, these alternatives vary in alignment in the Durham segment.

- *Busway Alternative 1:* In Busway Alternative 1, the busway begins at the 9th Street Station. The Phase I rail extends along the coal spur to Duke Medical Center. The exclusive busway follows the Erwin Road alignment. Five busway routes are created to utilize this busway, with headways ranging from 10-30 minutes in the peak period and 15-30 minutes in the off-peak.

- *Busway Alternative 2:* Busway Alternative 2 follows the same alignment as Busway Alternative 1 with one exception. From UNC Hospital Station to the intersection of Fordham Boulevard and Manning Drive, the bus uses diamond lanes and then enters the exclusive busway at the intersection of Fordham Boulevard and Manning Drive. The remainder of the bus service patterns remains the same as in Busway Alternative 1.

- *BMT Alternative 1:* BMT Alternative 1 utilizes an exclusive busway segment between Friday Center and the intersection of Fordham Boulevard and Manning Drive. On Chapel Hill Road, SW Durham Drive and Manning Drive, the buses travel in one of two designated bus lanes. In BMT Alternative 1, the locations of South Square, University Drive, Garrett Road and Mt. Moriah Stations are shifted, compared to the other alternatives, to locate the stations closer to the bus route alignments. The headways for the busway buses range from 10-30 minutes in the peak period and 15-30 minutes in the off-peak period.

- *Busway Alternative 3:* Busway Alternative 3 has bus routes following the exclusive busway on the western alignment between Hillsborough Road (the end of the Phase I rail line) and UNC Hospitals Station as well as buses extending beyond Hillsborough Rd. to the Duke University Campus. In addition, some of the Chapel Hill local buses operate parts of their routes on the exclusive busway. The headways on the busway range from 15-30 minutes during both the peak and off-peak periods.

- *Busway Alternative 4:* Busway Alternative 4 is almost identical to Busway Alternative 3 except that from the intersection of Fordham Boulevard and Manning Drive to UNC Hospitals Station, the buses travel in diamond lanes on Manning Drive, as in Busway Alternative 2.

- *BMT Alternative 2:* BMT Alternative 2 has three segments of exclusive busway on which the five busway routes travel. The first segment begins near the intersection of Cornwallis Road and ends at the South Square Station. The second segment begins on University Drive near Snowcrest Terrace and ends at Southwest Durham Drive.

The final segment begins at Friday Center and ends at the intersection of Fordham Boulevard and Manning Drive. In addition to the segments of exclusive busway, there are also designated bus lanes on Erwin Road, Southwest Durham Drive, and Manning Drive. The buses operate with the same headways as in BMT Alternative 1.

1. *Forecasts for Bus Service Alternatives*

As with the rail service alternative, there are several ways to summarize the ridership forecasts. Table V-XVI shows 2025 average weekday person trips produced by the TRM modal choice model, listed by purpose (HBW, HBO, NHB) and mode of travel for both auto and transit modes. As in the results tables for the rail service alternatives, the transit person trips output by the modal choice model are *linked* trips, which is defined as a trip from the origin zone to the destination zone, regardless of the number of modes used. The difference in person trips between No Build and TSM and the build alternative is shown as an increase in transit trips (and the corresponding decrease in auto trips). This is the number of *new* transit riders the alternative generates.

Unlinked trips, or boardings, were reported in Table V-XV for the fixed guideway services and Table V-XVII by operating company. Peak trips are the HBW trips while off-peak trips include HBO and NHB trips. Please note that a decrease in boardings relative to another is not necessarily a sign of poor performance. In the bus service alternatives, fewer boardings can actually mean more "one seat rides" since there may be fewer transfers because of the bus circulating on local streets as the production or attraction end of the trip. The "new riders" measure in Table V-XIII is a more accurate measure of the alternative's ability to attract riders.

In addition, boardings at the station level are summarized and presented in Tables V-XVIII through V-XXIII. Stations are included in this summary if they are on a busway route. These are reported as one half the average daily number of passengers boarding and alighting the train at each stop. The number of daily trips is halved to avoid "double counting" since transit trips are assigned in *production-attraction* format. This daily boarding summary is presented as Tables V-XVIII through V-XXIII for the alternatives and is stratified by mode of access or egress (i.e. walk/bus or drive). Please note that the Triangle Regional Model allows for drive access "drop off" or "kiss and ride" trips at stations with no parking provisions. In addition, the total in Table V-XV will not equal the total busway boardings because transfers between routes of the same mode are not reported.

Tables V-XXIV and V-XXV show additional measures of performance for each of the bus service alternatives. Table V-XXIV shows the vehicle-kilometers and vehicle-hours traveled by automobiles in each of the rail service alternatives. These measures can compare the amount of auto usage between the alternatives. Table X-XV shows the average weekday passenger-kilometers for each rail service alternative broken down by company.

Since, transit service coverage does not change by alternative (rail or bus) since the corridor is in area with transit coverage that is already established; the population served by transit can be found in Table V-X in the previous section.

Table V-XV. Busway System Boardings
Year 2025 Average Weekday Boardings

Alternative	**No Build**			**TSM**			**Busway Alternative 1**			**Busway Alternative 2**		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
TTA Phase 1	18,380	10,490	28,870	18,150	10,490	28,640	17,500	10,250	27,750	17,530	10,170	27,700
New Service	0	0	0	0	0	0	6,650	3,680	**10,330**	5,970	3,450	**9,420**

Alternative	**BMT Alternative 1**			**Busway Alternative 3**			**Busway Alternative 4**			**BMT Alternative 2**		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
TTA Phase 1	17,910	10,080	27,990	17,250	10,360	27,610	17,190	10,310	27,500	17,550	10,140	27,690
New Service	4,460	2,990	**7,450**	6,130	3,390	**9,520**	5,790	3,240	**9,030**	7,460	3,750	**11,210**

Table V-XVI. Modal Choice Summary for Bus Alternatives

Year 2025 Average Weekday Linked Trips

Alternative	**No Build**				**TSM**				**Busway Alternative 1**				**Busway Alternative 2**			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,680	1,166,170	1,237,140	3,645,990	1,242,790	1,166,120	1,237,110	3,646,020	1,240,710	1,166,350	1,237,080	3,644,140	1,240,790	1,166,310	1,237,060	3,644,160
SH-2	107,550	1,505,500	857,070	2,470,120	107,500	1,505,570	857,050	2,470,120	106,930	1,506,650	856,370	2,469,950	107,030	1,506,330	856,220	2,469,580
SH-3+	22,230	0	0	22,230	22,220	0	0	22,220	22,030	0	0	22,030	22,040	0	0	22,040
Total Auto	1,372,460	2,671,670	2,094,210	6,138,340	1,372,510	2,671,690	2,094,160	6,138,360	1,369,670	2,673,000	2,093,450	6,136,120	1,369,860	2,672,640	2,093,280	6,135,780
DRIVE	13,350	6,530	4,160	24,040	13,270	6,310	4,120	23,700	14,350	6,330	4,390	25,070	14,250	6,360	4,410	25,020
WLK-LOC	37,270	25,940	9,690	72,900	37,600	26,360	9,810	73,770	32,100	23,510	8,350	63,960	32,200	23,830	8,700	64,730
WLK-PRM	11,620	4,840	2,060	18,520	11,330	4,620	2,020	17,970	18,700	6,140	3,930	28,770	18,520	6,160	3,730	28,410
Total Transit	62,240	37,310	15,910	115,460	62,200	37,290	15,950	115,440	65,150	35,980	16,670	117,800	64,970	36,350	16,840	118,160
New Riders **Delta No Build**					(40)	(20)	40	(20)	2,910	(1,330)	760	**2,340**	2,730	(960)	930	**2,700**

Alternative	**BMT Alternative 1**				**Busway Alternative 3**				**Busway Alternative 4**				**BMT Alternative 2**			
	HBW	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*	*HBW*	*HBO*	*NHB*	*Total*
DA	1,242,190	1,166,210	1,237,110	3,645,510	1,241,020	1,166,380	1,237,060	3,644,460	1,241,010	1,166,340	1,237,050	3,644,400	1,240,950	1,166,250	1,237,050	3,644,250
SH-2	107,380	1,506,200	856,750	2,470,330	107,110	1,506,450	856,160	2,469,720	107,180	1,506,170	856,000	2,469,350	107,260	1,506,220	856,400	2,469,880
SH-3+	22,130	0	0	22,130	22,080	0	0	22,080	22,120	0	0	22,120	22,150	0	0	22,150
Total Auto	1,371,700	2,672,410	2,093,860	6,137,970	1,370,210	2,672,830	2,093,220	6,136,260	1,370,310	2,672,510	2,093,050	6,135,870	1,370,360	2,672,470	2,093,450	6,136,280
DRIVE	13,950	6,370	4,220	24,540	13,520	6,250	4,230	24,000	13,550	6,290	4,240	24,080	14,470	6,380	4,330	25,180
WLK-LOC	34,540	24,540	8,960	68,040	32,970	23,340	8,560	64,870	33,250	23,740	8,910	65,900	33,080	24,220	8,780	66,080
WLK-PRM	14,690	5,670	3,090	23,450	18,140	6,560	4,120	28,820	17,610	6,450	3,920	27,980	16,820	5,920	3,580	26,320
Total Transit	63,180	36,580	16,270	116,030	64,630	36,150	16,910	117,690	64,410	36,480	17,070	117,960	64,370	36,520	16,690	117,580
New Riders **Delta No Build**	940	(730)	360	**570**	2,390	(1,160)	1,000	**2,230**	2,170	(830)	1,160	**2,500**	2,130	(790)	780	**2,120**

Table V-XVII. Boarding Summary by Company for Bus Alternatives
Year 2025 Average Weekday Boardings

Alternative		No Build			TSM			Busway Alternative 1			Busway Alternative 2		
	Company	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
1	TTA Bus	5,210	5,880	11,090	7,130	5,780	12,910	16,630	9,590	26,220	15,880	9,290	25,170
2	CAT	15,860	13,880	29,740	15,850	13,860	29,710	15,920	13,880	29,800	15,970	13,890	29,860
3	CHT	14,610	17,130	31,740	13,440	17,150	30,590	13,110	15,040	28,150	13,850	16,250	30,100
4	DATA	23,870	19,400	43,270	22,720	19,610	42,330	18,020	16,630	34,650	17,980	16,630	34,610
5	NCSU	2,950	4,230	7,180	2,960	4,240	7,200	2,980	4,290	7,270	2,980	4,260	7,240
6	Duke	12,750	9,240	21,990	12,920	9,260	22,180	7,330	6,400	13,730	7,350	6,410	13,760
7	NCCU	660	240	900	660	230	890	520	250	770	510	250	760
8	OPT	80	510	590	150	520	670	150	540	690	150	540	690
9	TTA Rail	18,370	10,490	28,860	18,150	10,490	28,640	17,500	10,250	27,750	17,530	10,170	27,700
10	Cary	3,180	3,270	6,450	3,160	3,270	6,430	3,050	3,250	6,300	3,140	3,240	6,380
	Total	97,540	84,270	181,810	97,140	84,410	181,550	95,210	80,120	175,330	95,340	80,930	176,270
Alternative		**BMT Alternative 1**			**Busway Alternative 3**			**Busway Alternative 4**			**BMT Alternative 2**		
	Company	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off-Peak	Total
1	TTA Bus	9,150	7,440	16,590	15,970	10,080	26,050	15,390	9,800	25,190	13,430	8,570	22,000
2	CAT	15,920	13,840	29,760	15,880	13,910	29,790	15,980	13,810	29,790	16,000	13,900	29,900
3	CHT	14,420	17,710	32,130	13,140	15,000	28,140	13,690	16,120	29,810	13,790	16,800	30,590
4	DATA	21,240	16,780	38,020	19,000	16,620	35,620	19,030	16,640	35,670	19,540	16,890	36,430
5	NCSU	3,050	4,250	7,300	2,990	4,220	7,210	2,950	4,260	7,210	2,910	4,250	7,160
6	Duke	12,410	8,060	20,470	8,520	4,230	12,750	8,700	4,230	12,930	12,590	7,820	20,410
7	NCCU	640	280	920	530	240	770	530	230	760	590	290	880
8	OPT	150	510	660	160	560	720	140	530	670	160	520	680
9	TTA Rail	17,910	10,080	27,990	17,250	10,360	27,610	17,190	10,310	27,500	17,550	10,140	27,690
10	Cary	3,120	3,210	6,330	3,210	3,210	6,420	3,050	3,250	6,300	3,130	3,250	6,380
	Total	98,010	82,160	180,170	96,650	78,430	175,080	96,650	79,180	175,830	99,690	82,430	182,120

Table V-XVIII. Busway Alternative 1 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 1							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	430	110	540	150	50	200	740
Millbrook	390	730	1,120	160	200	360	1,480
Six Forks/Highlands	280	690	970	140	170	310	1,280
State Government Ctr	330	470	800	290	380	670	1,470
Dtn Raleigh	910	700	1,610	970	510	1,480	3,090
NCSU	2,030	2,080	4,110	1,570	1,230	2,800	6,910
State Fairgrounds	290	290	580	140	170	310	890
West Raleigh	30	610	640	40	270	310	950
Cary Depot	270	270	540	140	140	280	820
Morrisville	210	190	400	120	130	250	650
South Park	160	180	340	120	140	260	600
North Park	310	230	540	230	250	480	1,020
Alston Ave	1,290	430	1,720	610	200	810	2,530
Dtn Durham	590	370	960	180	110	290	1,250
9th Street	2,050	520	2,570	990	470	1,460	4,030
Duke Med Ctr	510	80	590	160	30	190	780
Morreene Road	260	50	310	110	20	130	440
Pickett Road	120	80	200	110	30	140	340
South Square Mall	230	50	280	0	30	30	310
University Drive	160	50	210	160	30	190	400
Garrett Rd	190	60	250	60	50	110	360
Mt. Moriah Rd	20	10	30	80	30	110	140
Gateway	260	210	470	120	70	190	660
Ephesus Church	60	20	80	20	10	30	110
Meadowmont	20	0	20	40	10	50	70
Friday Center	70	70	140	60	30	90	230
UNC Hospital	530	180	710	330	190	520	1,230
Total	12,000	8,730	20,730	7,100	4,950	12,050	**32,780**

Table V-XIX. Busway Alternative 2 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 2							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	160	50	210	750
Millbrook	390	720	1,110	160	200	360	1,470
Six Forks/Highlands	280	690	970	140	160	300	1,270
State Government Ctr	330	470	800	290	390	680	1,480
Dtn Raleigh	920	760	1,680	970	510	1,480	3,160
NCSU	2,080	2,070	4,150	1,570	1,220	2,790	6,940
State Fairgrounds	290	300	590	130	170	300	890
West Raleigh	30	590	620	50	270	320	940
Cary Depot	280	310	590	120	140	260	850
Morrisville	230	80	310	130	130	260	570
South Park	160	180	340	120	130	250	590
North Park	320	230	550	230	240	470	1,020
Alston Ave	1,300	440	1,740	610	200	810	2,550
Dtn Durham	580	360	940	180	110	290	1,230
9th Street	2,040	550	2,590	1,000	490	1,490	4,080
Duke Med Ctr	440	70	510	140	20	160	670
Morreene Road	210	30	240	110	20	130	370
Pickett Road	110	70	180	90	20	110	290
South Square Mall	200	50	250	0	10	10	260
University Drive	120	40	160	110	30	140	300
Garrett Rd	160	30	190	30	20	50	240
Mt. Moriah Rd	20	10	30	60	10	70	100
Gateway	220	220	440	70	50	120	560
Ephesus Church	50	10	60	10	10	20	80
Meadowmont	20	0	20	10	0	10	30
Friday Center	30	90	120	20	30	50	170
Total	11,250	8,470	19,720	6,510	4,630	11,140	**30,860**

Table V-XX. BMT Alternative 1 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

BMT Alternative 1							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	110	550	150	60	210	760
Millbrook	380	730	1,110	160	200	360	1,470
Six Forks/Highlands	280	700	980	140	170	310	1,290
State Government Ctr	320	480	800	290	380	670	1,470
Dtn Raleigh	930	750	1,680	970	510	1,480	3,160
NCSU	2,080	2,110	4,190	1,560	1,230	2,790	6,980
State Fairgrounds	300	290	590	120	170	290	880
West Raleigh	40	630	670	50	270	320	990
Cary Depot	270	270	540	130	130	260	800
Morrisville	220	90	310	130	130	260	570
South Park	200	210	410	110	200	310	720
North Park	290	230	520	230	230	460	980
Alston Ave	1,430	750	2,180	600	210	810	2,990
Dtn Durham	390	310	700	160	100	260	960
9th Street	1,640	720	2,360	850	390	1,240	3,600
Duke Med Ctr	280	50	330	90	20	110	440
South Square Mall	10	30	40	30	20	50	90
University Drive	10	10	20	20	10	30	50
Garrett Rd	0	0	0	0	10	10	10
Friday Center	10	30	40	10	10	20	60
Total	9,520	8,500	18,020	5,800	4,450	10,250	**28,270**

Table V-XXI. Busway Alternative 3 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 3							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	100	540	160	50	210	750
Millbrook	390	720	1,110	160	210	370	1,480
Six Forks/Highlands	280	660	940	140	160	300	1,240
State Government Ctr	330	430	760	290	390	680	1,440
Dtn Raleigh	930	720	1,650	960	510	1,470	3,120
NCSU	2,090	2,060	4,150	1,570	1,220	2,790	6,940
State Fairgrounds	310	280	590	130	180	310	900
West Raleigh	30	650	680	50	270	320	1,000
Cary Depot	270	320	590	120	140	260	850
Morrisville	230	80	310	130	120	250	560
South Park	150	170	320	120	130	250	570
North Park	310	220	530	240	240	480	1,010
Alston Ave	1,290	380	1,670	610	170	780	2,450
Dtn Durham	620	310	930	290	100	390	1,320
9th Street	1,380	300	1,680	700	300	1,000	2,680
Hillsborough Rd	530	190	720	330	120	450	1,170
Cameron Blvd	140	490	630	150	220	370	1,000
Pickett Road	80	230	310	80	90	170	480
South Square Mall	240	70	310	110	40	150	460
University Drive	110	50	160	110	40	150	310
Garrett Rd	120	80	200	40	60	100	300
Mt. Moriah Rd	20	10	30	60	40	100	130
Gateway	330	440	770	90	110	200	970
Ephesus Church	30	20	50	20	10	30	80
Meadowmont	20	0	20	40	10	50	70
Friday Center	50	70	120	50	30	80	200
UNC Hospital	320	180	500	300	180	480	980
Total	11,040	9,230	20,270	7,050	5,140	12,190	**32,460**

Table V-XXII. Busway Alternative 4 Boarding Summary by Rail Station
Year 2025 Average Weekday Boardings

Busway Alternative 4							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	430	100	530	150	50	200	730
Millbrook	390	670	1,060	160	210	370	1,430
Six Forks/Highlands	280	700	980	140	160	300	1,280
State Government Ctr	320	470	790	280	380	660	1,450
Dtn Raleigh	920	710	1,630	970	510	1,480	3,110
NCSU	2,050	2,050	4,100	1,570	1,230	2,800	6,900
State Fairgrounds	300	280	580	130	170	300	880
West Raleigh	40	590	630	40	260	300	930
Cary Depot	270	310	580	130	140	270	850
Morrisville	210	180	390	130	120	250	640
South Park	160	170	330	110	130	240	570
North Park	310	220	530	230	250	480	1,010
Alston Ave	1,290	420	1,710	600	180	780	2,490
Dtn Durham	600	320	920	290	100	390	1,310
9th Street	1,390	330	1,720	690	290	980	2,700
Hillsborough Rd	520	190	710	370	140	510	1,220
Cameron Blvd	120	500	620	150	210	360	980
Pickett Road	70	20	90	70	10	80	170
South Square Mall	230	210	440	100	90	190	630
University Drive	70	40	110	60	30	90	200
Garrett Rd	90	30	120	20	30	50	170
Mt. Moriah Rd	20	10	30	40	30	70	100
Gateway	350	500	850	60	100	160	1,010
Ephesus Church	30	0	30	10	10	20	50
Meadowmont	10	0	10	10	0	10	20
Friday Center	20	70	90	20	20	40	130
Total	10,490	9,090	19,580	6,530	4,850	11,380	**30,960**

Table V-XXIII. BMT Alternative 2 Boarding Summary by Rail Station

Year 2025 Average Weekday Boardings

BMT Alternative 2							
Station Location	**Peak**			**Off-Peak**			**Total Daily**
	Walk/ Bus	Drive	Total	Walk/ Bus	Drive	Total	
Spring Forest	440	110	550	160	50	210	760
Millbrook	390	710	1,100	160	200	360	1,460
Six Forks/Highlands	280	700	980	150	160	310	1,290
State Government Ctr	320	460	780	290	380	670	1,450
Dtn Raleigh	920	710	1,630	970	500	1,470	3,100
NCSU	2,070	2,020	4,090	1,580	1,220	2,800	6,890
State Fairgrounds	290	290	580	130	170	300	880
West Raleigh	40	620	660	50	260	310	970
Cary Depot	290	320	610	120	130	250	860
Morrisville	220	70	290	130	130	260	550
South Park	170	170	340	100	130	230	570
North Park	310	220	530	230	230	460	990
Alston Ave	1,350	550	1,900	620	200	820	2,720
Dtn Durham	550	340	890	180	100	280	1,170
9th Street	1,890	660	2,550	940	490	1,430	3,980
Duke Med Ctr	30	0	30	10	0	10	40
Hillsborough Rd	240	20	260	70	10	80	340
South Square Mall	150	90	240	70	50	120	360
Garrett Rd	80	30	110	20	10	30	140
Mt. Moriah Rd	10	10	20	30	10	40	60
Gateway	130	120	250	50	40	90	340
Ephesus Church	30	10	40	10	0	10	50
Friday Center	20	40	60	10	20	30	90
Total	10,220	8,270	18,490	6,080	4,490	10,570	**29,060**

Table V-XXIV. Highway Assignment Summary for Bus Alternatives
Year 2025 Average Weekday

Alternative	No Build	TSM	Busway Alternative 1	Busway Alternative 2	BMT Alternative 1	Busway Alternative 3	Busway Alternative 4	BMT Alternative 2
Vehicle-Km	97,494,810	97,628,810	97,572,740	97,449,690	97,580,120	97,470,870	97,530,990	97,499,290
delta No Build		134,000	77,930	(45,120)	85,320	(23,930)	36,180	4,490
Vehicle-Hours	1,825,340	1,831,250	1,827,710	1,822,730	1,829,680	1,824,840	1,825,780	1,835,890
delta No Build		5,910	2,360	(2,610)	4,340	(500)	440	10,550

Table V-XXV. Transit System Performance Summary for Bus Alternatives
Year 2025 Average Weekday Passenger-Miles

Alternative	**No Build**			**TSM**			**Busway Alternative 1**			**Busway Alternative 2**		
Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1 TTA Bus	33,728	46,957	80,679	44,465	46,267	90,733	130,799	72,868	203,667	129,369	75,689	205,059
2 CAT	41,856	37,152	79,007	41,756	36,984	78,740	41,862	37,313	79,181	42,172	37,245	79,417
3 CHT	36,425	46,118	82,543	33,287	45,876	79,169	31,118	38,948	70,060	32,554	40,700	73,247
4 DATA	52,208	45,615	97,822	48,057	46,385	94,436	39,333	40,078	79,411	39,227	40,383	79,610
5 NCSU	3,722	5,611	9,333	3,710	5,630	9,339	3,728	5,679	9,408	3,710	5,648	9,358
6 Duke	16,199	12,452	28,645	15,652	12,384	28,036	9,737	8,351	18,088	9,805	8,370	18,175
7 NCCU	982	292	1,274	976	280	1,255	746	292	1,038	733	286	1,019
8 OPT	478	3,877	4,356	864	4,064	4,934	913	5,797	6,711	876	5,735	6,611
9 TTA Rail	135,316	63,672	198,988	135,558	63,411	198,963	134,850	66,014	200,864	134,390	65,120	199,504
10 Cary	8,289	9,594	17,883	8,103	9,606	17,709	7,898	9,544	17,442	8,022	9,488	17,504
Total	329,190	271,347	600,537	332,421	270,887	603,308	400,989	284,886	685,876	400,847	288,664	68,761
Delta No Build				*3,237*	*(460)*	*2,778*	*71,799*	*13,540*	*85,339*	*71,657*	*17,318*	*88,974*

Alternative	**BMT Alternative 1**			**Busway Alternative 3**			**Busway Alternative 4**			**BMT Alternative 2**		
Company	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*	*Peak*	*Off-Peak*	*Total*
1 TTA Bus	63,237	61,870	125,107	119,682	73,247	192,929	115,295	73,086	188,381	100,817	69,500	170,317
2 CAT	42,073	37,003	79,076	41,551	37,326	78,877	42,247	37,195	79,442	42,297	37,195	79,492
3 CHT	36,878	46,684	83,562	31,292	38,848	70,140	32,299	40,016	72,315	32,989	43,384	76,373
4 DATA	48,647	41,427	90,074	43,266	41,402	84,668	43,397	41,607	85,004	42,583	41,905	84,488
5 NCSU	3,790	5,654	9,445	3,734	5,636	9,364	3,703	5,654	9,357	3,679	5,648	9,327
6 Duke	15,429	9,805	25,234	10,681	7,463	18,150	10,980	7,469	18,449	14,403	9,495	23,898
7 NCCU	951	336	1,280	771	261	1,031	789	255	1,044	857	336	1,193
8 OPT	895	4,418	5,313	920	5,909	6,829	833	5,592	6,425	901	5,350	6,251
9 TTA Rail	133,346	63,125	196,471	133,538	66,710	200,249	133,763	66,623	200,386	132,166	64,716	196,882
10 Cary	7,972	9,439	17,411	8,258	9,476	17,734	7,835	9,519	17,354	8,084	9,575	17,659
Total	353,225	279,754	632,978	393,695	286,278	679,966	391,128	287,018	678,146	378,775	287,490	666,265
Delta No Build	*24,035*	*8,407*	*32,442*	*64,505*	*14,932*	*79,436*	*61,938*	*15,677*	*77,615*	*378,775*	*161,149*	*65,734*

E. Summary of Findings

A number of observations can be made about the US 15-501 MIS (Phase II) alternative forecasts:

- Busway Alternatives 1-4 attract the most new riders, each attracting over 2,200 average weekday linked trips, compared to the No-Build alternative. LRT Alternative 3 and BMT Alternative 2 both attract 2,120 new riders compared to the No Build Alternative. The other two LRT Alternatives gain approximately 1,200 riders. BMT Alternative 1 and DMU Alternative 1 both gain fewer than 600 new riders.

- The total number of linked trips is more indicative of the total number of person trips. Busway Alternative 2 had the highest number of average weekday linked trips with 118,160. It is followed closely by the other three busway alternatives.

- The three LRT Alternatives have the highest number of boardings for the new service with over 15,000 average weekday boardings. As stated previously, the four busway alternatives are expected to have fewer boardings because of the possibility of more "one seat rides." For the busway alternatives, average weekday boardings range from 9,000 to 10,300.

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.
Auto (from west)	Via Erwin (RIRO)*	Via improved Pettigrew St. or Main St.	Via Main St. to Buchanan Blvd.
Auto (from north)	Via 9th Street (RIRO)*	Via Swift Ave. to Pettigrew St. or Broad St. to Main Street	Via Buchanan Blvd.
Auto (from east)	Via Main (RIRO)*	Via Main St. or Main St. to Swift Ave. to Pettigrew	Via Main St. to Buchanan Blvd.
Auto 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*	*$11.5 5*	*$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

<u>**Legend**</u>

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

<u>Notes:</u>
* (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 <u>exclude</u> 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.

CHAPTER VIII
PUBLIC INVOLVEMENT AND AGENCY COORDINATION

A. Technical Committee

A technical committee was appointed with representatives from the following:

- NCDOT Public Transportation Division
- NCDOT Project Development & Environmental Analysis Branch
- City of Durham Department of Transportation
- Town of Chapel Hill Planning Department
- Triangle Transit Authority (TTA)
- Duke University
- UNC - Chapel Hill
- Federal Highway Administration

The project team met with the technical committee monthly or more frequently as needed during the course of the project. The technical committee provided project input and direction on all aspects of the project.

B. Policy Oversight Committee

The Policy Oversight Committee's function on the project was one of approval and oversight. Representatives of this committee include:

- NC Board of Transportation (1 member)
- NCDOT, Deputy Secretary
- NCDOT, Chief Planning and Environmental Officer
- Mayor of Durham
- Durham City Manager
- Mayor of Chapel Hill
- Town of Chapel Hill Manager
- Triangle Transit Authority Board (1 member)
- Triangle Transit Authority General Manager
- Duke University President & Vice President
- UNC - Chapel Hill Associate Vice Chancellor & Assistant to Chancellor

Generally after meeting with the technical committee, the project team met with the Policy Oversight Committee to seek approvals at key milestone points in the study, before proceeding forward on the project. Meeting minutes from the policy oversight committee meetings during the Phase II MIS are provided in Appendix G.

C. Public Workshops

Two (2) public workshop series were held throughout the duration of the Phase II study. For each series, two (2) public workshops, one in Durham and one in Chapel Hill, were convened as an informational outreach to citizens of the study area and to encourage public participation in the study process.

The first workshop series was held in September 2000 and its purpose was to present the types of technology being considered for transit and to obtain input from the public. Additionally, the study process was outlined and presented for the public's information and comment. The second public workshop series was held in January 2001. At these workshops, the results of the Duke and UNC-Chapel Hill station area workshops were presented and preliminary alternative alignments from South Square to the Friday Center were presented. Brief presentations were made by the Mayors of the respective cities during the course of the workshops, followed by a brief question and answer period.

For each of the above workshops, postcards were mailed out beforehand to citizens on the mailing list and letters were mailed out to local public officials announcing the workshop and outlining the information to be presented. Each of the workshops was also announced via the local news media and posted on several websites including TTA's and the Town of Chapel Hill's. During the week of the second workshop series, NCDOT provided flashing variable message signs on US 15-501 informing drivers of the meeting times and locations. Handouts with graphics and comment cards were distributed at the workshop to solicit input on a broad range of project issues. Comment cards received during and after the workshops were reviewed and summarized a copy of this summary is provided in Appendix G.

Throughout the project a mailing list of interested citizens was developed and maintained. Over 1,800 citizens were on the mailing list at the end of Phase II. In addition to the efforts of the project team to involve and inform the public, several newspaper articles were published in local newspapers giving the project exposure. Copies of select newspaper articles regarding the project are provided in Appendix G.

D. Resource Agency Coordination

Formal resource agency coordination was not included in the Phase II MIS because the alternatives and corridors were substantially reviewed during Phase 1 and further coordination would occur during the project development/environmental studies stage of the project. However, at the request of the Policy Oversight Committee, in March 2001, a meeting with the US Army Corps of Engineers, US Fish and Wildlife, NC Division of Water Quality, NC Wildlife Resources Commission, NC Division of Parks and Recreation Natural Heritage Program, and NC Department of Transportation was held. The purpose of the meeting was to discuss the status of the project, identify any "fatal flaws", and to provide a forum for receiving input from the resource agencies. The agencies did not identify any "fatal flaws" in either the Phase I MIS /

Corridor A Alignment or the "Southern UNC" Alignment. The general consensus of those present was that there will have to be further justification, avoidance, minimization, and mitigation for any future crossing of New Hope Creek. All alignments, including an alignment adjacent to the existing US 15-501 New Hope Creek crossing, will need to be studied during the next phase of the project, the Environmental Impact Statement (EIS).

CHAPTER IX
RECOMMENDED TRANSIT TECHNOLOGY AND ALIGNMENT

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A. Background

The primary objective of Phase II of this Major Investment Study is to identify a transit corridor and technology to be studied further Environmental Impact Statement (EIS) phase of the project. Through the evaluation process, the study team and a diverse group of stakeholders heard, considered and debated the merits and disadvantages of all the alternatives considered. Although a broad array of evaluation criteria was considered during Phase II, not all stakeholders shared the same emphasis on each evaluation factor. The resulting recommendations represent the consensus reached in Phase II.
Under the Transportation Equity Act for the 21st Century (TEA-21), transportation projects seeking Section 5309 New Starts funding must undergo an evaluation and ratings process with FTA (Federal Transit Administration). These New Starts projects must receive FTA approval through a project rating justification process to advance from alternative analysis to preliminary engineering. FTA considers the following evaluation criteria for project justification:

- *Mobility improvements* as measured by travel times savings and the number of low income households served in comparison to the No-Build and TSM alternative;
- *Environmental benefits* as measured by the net change in air pollutant emissions, greenhouse gas emissions and regional energy consumption;
- *Operating efficiencies* as measured by the change in systemwide operating costs per passenger mile in the forecast year (2025) by comparing the New Start alternative to the No-Build and TSM alternatives;
- *Cost effectiveness* as measured by the incremental cost per incremental passenger in the forecast year in comparison with the No-Build and the TSM alternative; and
- *Transit supportive land use*, which considers the existing land use, containment of sprawl, transit-supportive corridor policies, and supportive zoning regulations near transit stations.

FTA also considers other factors such as the degree to which policies and programs are in place as assumed in the ridership forecasts, project management capability of the applicant, and factors relevant to local and national priorities (i.e., Brownfields, local economic development initiatives, etc). If these other factors are significant, FTA may increase the initial project justification summary rating to reflect this significance.

It was never intended for the Phase II MIS study to address all of FTA's New Starts project justification criteria. The goal of the Phase II study was to determine both a vehicle technology and a transit corridor alignment to be carried forward into the NEPA documentation phase of the project, the Environmental Impact Statement (EIS).

B. Preferred Transit Alignment and Alternative

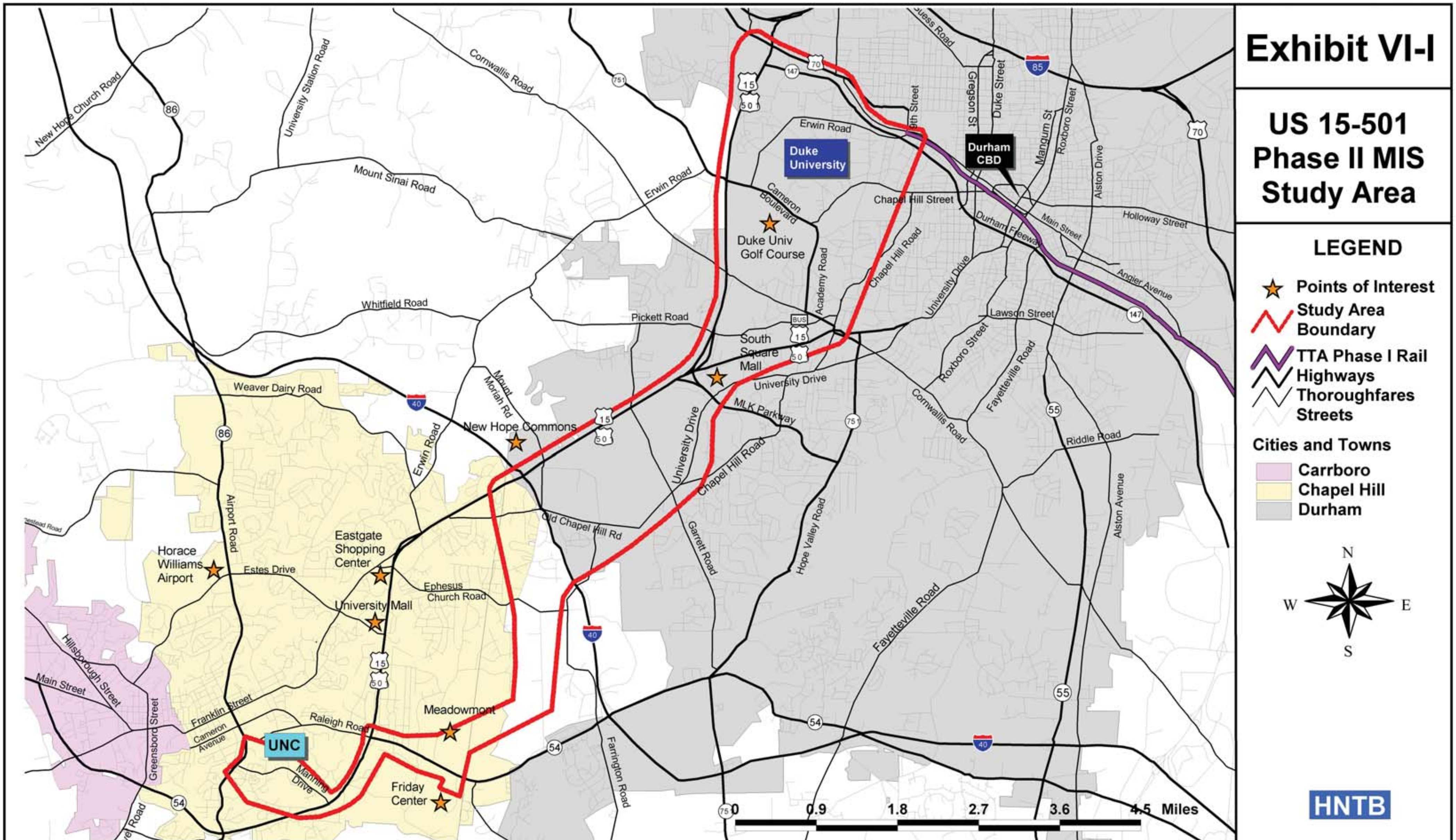
The merits and disadvantages of various technologies were explored, considered and debated as part of Phase II. All build alternatives were similar with respect to environmental and community impacts, physical characteristics (miles of improvements, structure length, number of stations).

Although the DMU and LRT alternatives presented higher overall transit ridership, it was the exclusive busway options that attracted the highest number of a "new transit" riders attributing to a corresponding decrease in auto trips. In determining the cost effectiveness of all the alternatives in comparison with the No-Build, (incremental cost per incremental new rider, i.e., transit cost per new rider), the Busway and Busway / BMT alternatives proved more cost effective than the other alternatives. The flexibility of constructing a future exclusive busway system with incremental segments of BMT also made these alternatives more attractive in comparison to rail alternatives. The Policy Oversight Committee decided that a decision on the specific technology cannot be made at this time, however, it appears that based on cost effectiveness criteria both the Busway and Busway / mixed traffic (BMT) technologies appear to be the most promising.

These limited conclusions and recommendations on vehicle technology were based in part on modeling forecast results from the new Triangle Regional Model (Version 5.0). Predicting transit ridership through modeling forecasts requires an iterative process of analyzing results, reassessing assumptions, and additional model runs. The modeling forecast results of the Phase II study reflect only a single cursory model run, the results should be viewed as a indication of potential ridership and not as the final projected ridership. The study team also recommends that further refinement of the regional model should be done prior to commencing the EIS phase of the project.

The Phase I MIS Corridor "A" was further refined in Phase II to encourage transit friendly development consistent with future land use plans and projected development. As all the exclusive guideway alternatives shared the same transit corridor alignment in the area between Cameron Boulevard and Fordham Boulevard; the fixed guideway alignment varies only at both Universities. In the Duke area, the consensus of the Policy Oversight and Technical Committee determined that the benefits of a transit corridor along Erwin Road directly serving the University and Duke Medical Center was more desirable than a "Western Alignment" along the NC 147 / NCRR corridor in which two cemeteries would be impacted. The 9th Street Station was also confirmed as a technology transfer point after several other potential sites were studied within the project area. The Policy Oversight Committee also felt that the determination of transit corridor alignment within the UNC campus awaits the cooperative process between the Town of Chapel Hill and University to resolve the alignment on the UNC campus.

The study team recommends adding the Phase II transit corridor to the thoroughfare plan and recommends that the local governments consider this corridor when implementing local land use policies (i.e., zoning changes, establishment of public facilities, planning of parks and recreational areas, and issuing building permits).



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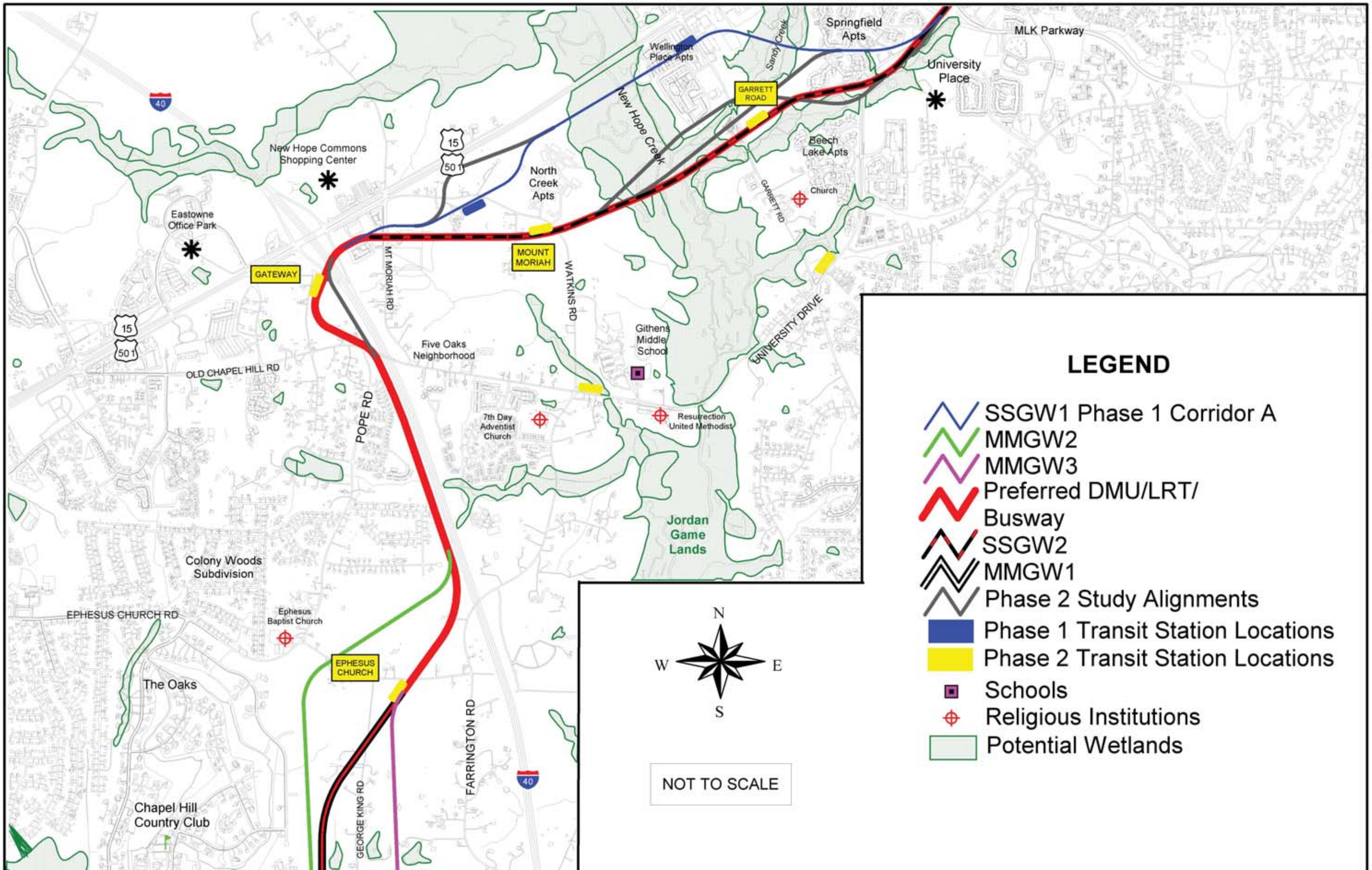

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Exhibit VI-II
Initial Rail & Busway Middle Alignments

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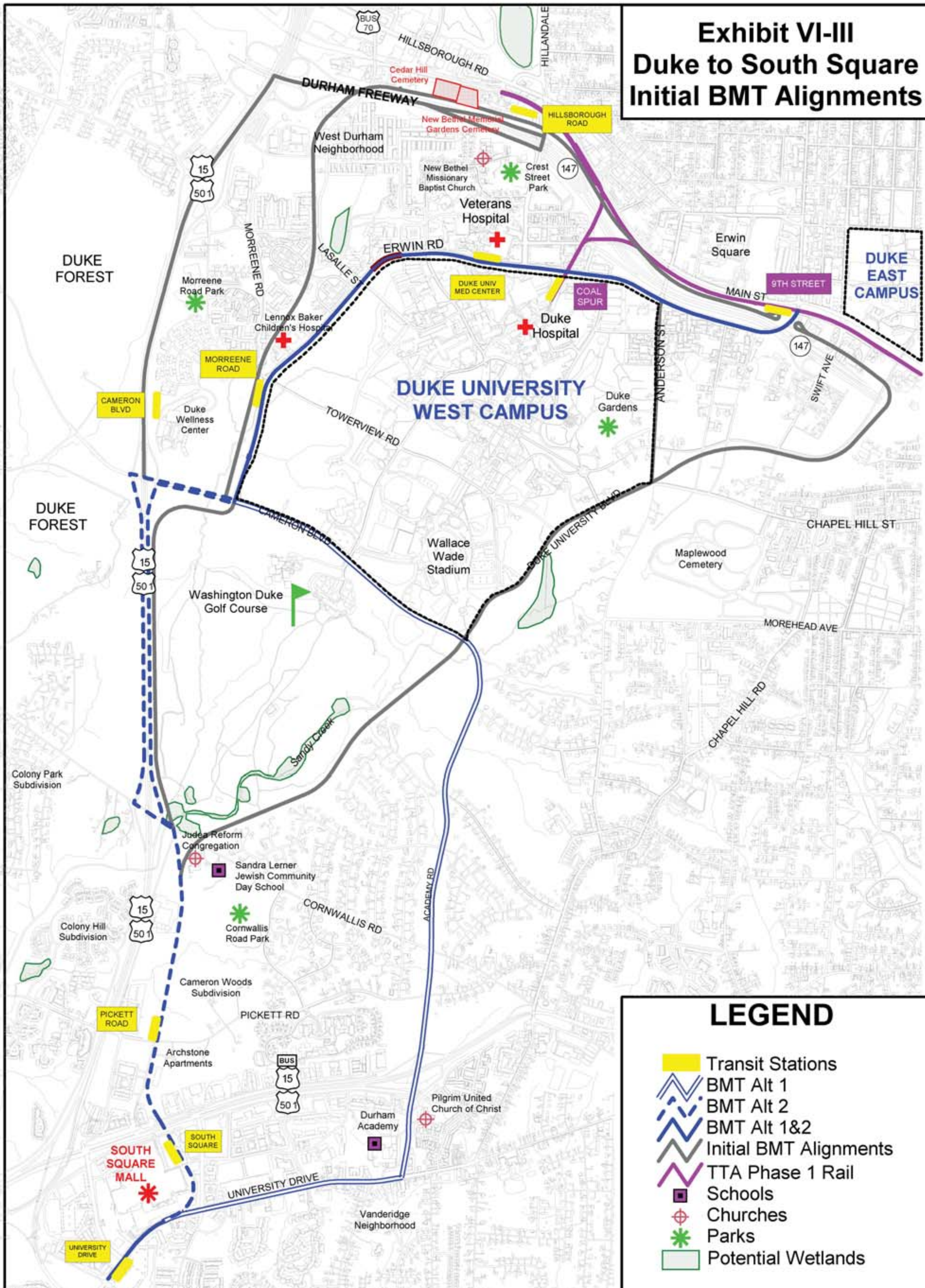
Exhibit VI-III
Duke to South Square Initial BMT Alignments



LEGEND

- Transit Stations
- BMT Alt 1
- BMT Alt 2
- BMT Alt 1&2
- Initial BMT Alignments
- TTA Phase 1 Rail
- Schools
- Churches
- Parks
- Potential Wetlands

NOT TO SCALE

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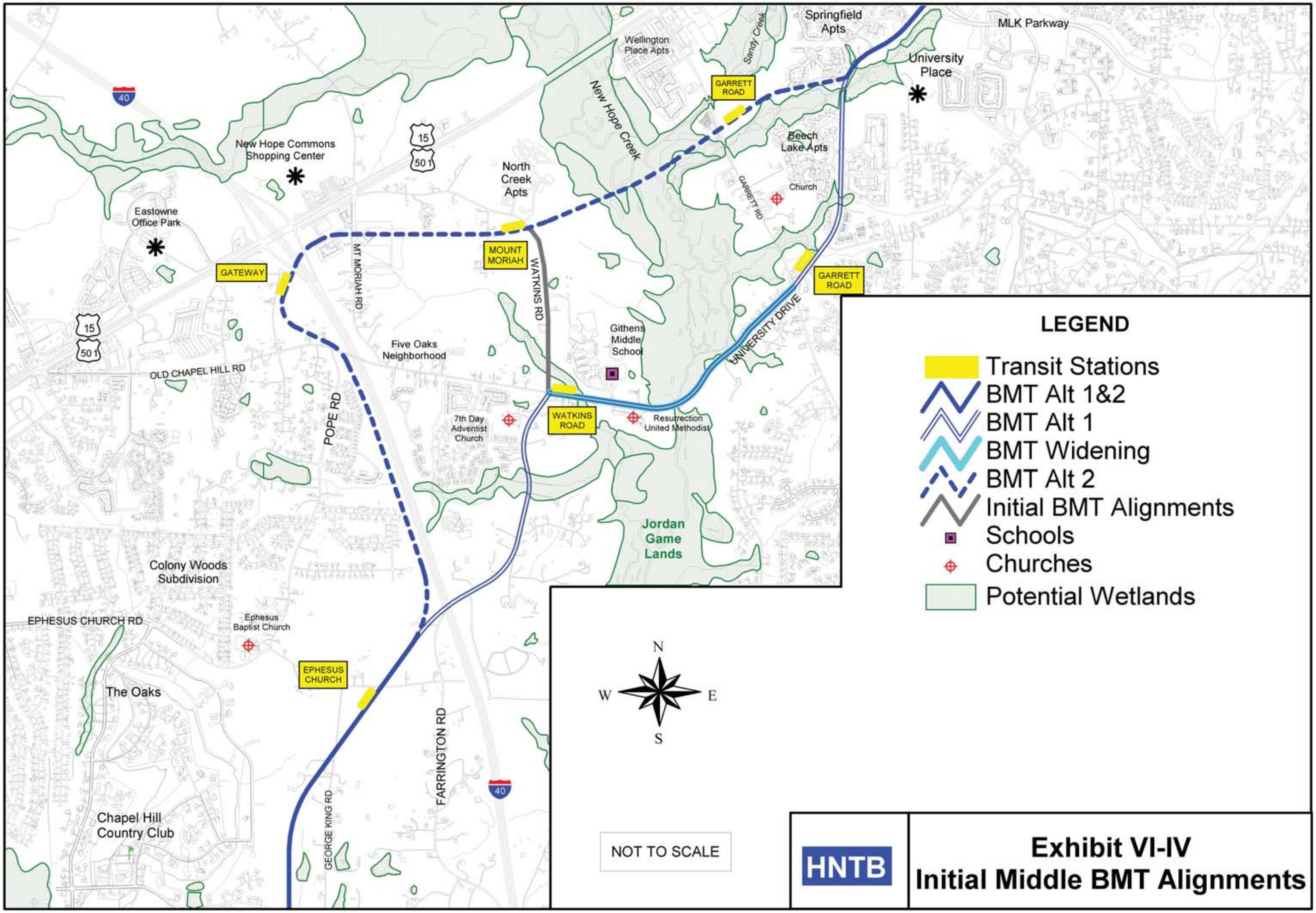

Exhibit VI-IV
Initial Middle BMT Alignments

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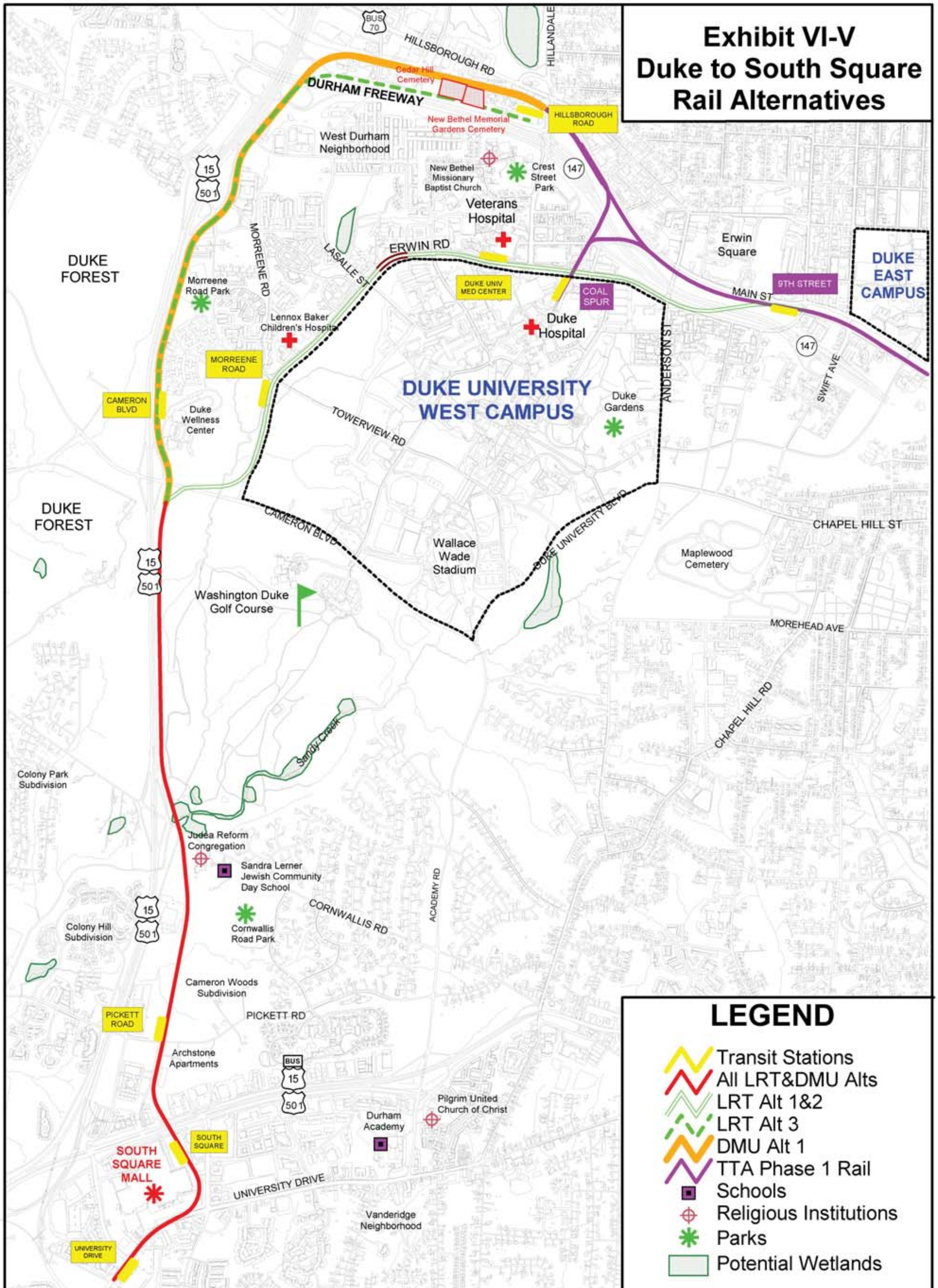
Exhibit VI-V
Duke to South Square Rail Alternatives



LEGEND

- Transit Stations
- All LRT&DMU Alts
- LRT Alt 1&2
- LRT Alt 3
- DMU Alt 1
- TTA Phase 1 Rail
- Schools
- Religious Institutions
- Parks
- Potential Wetlands

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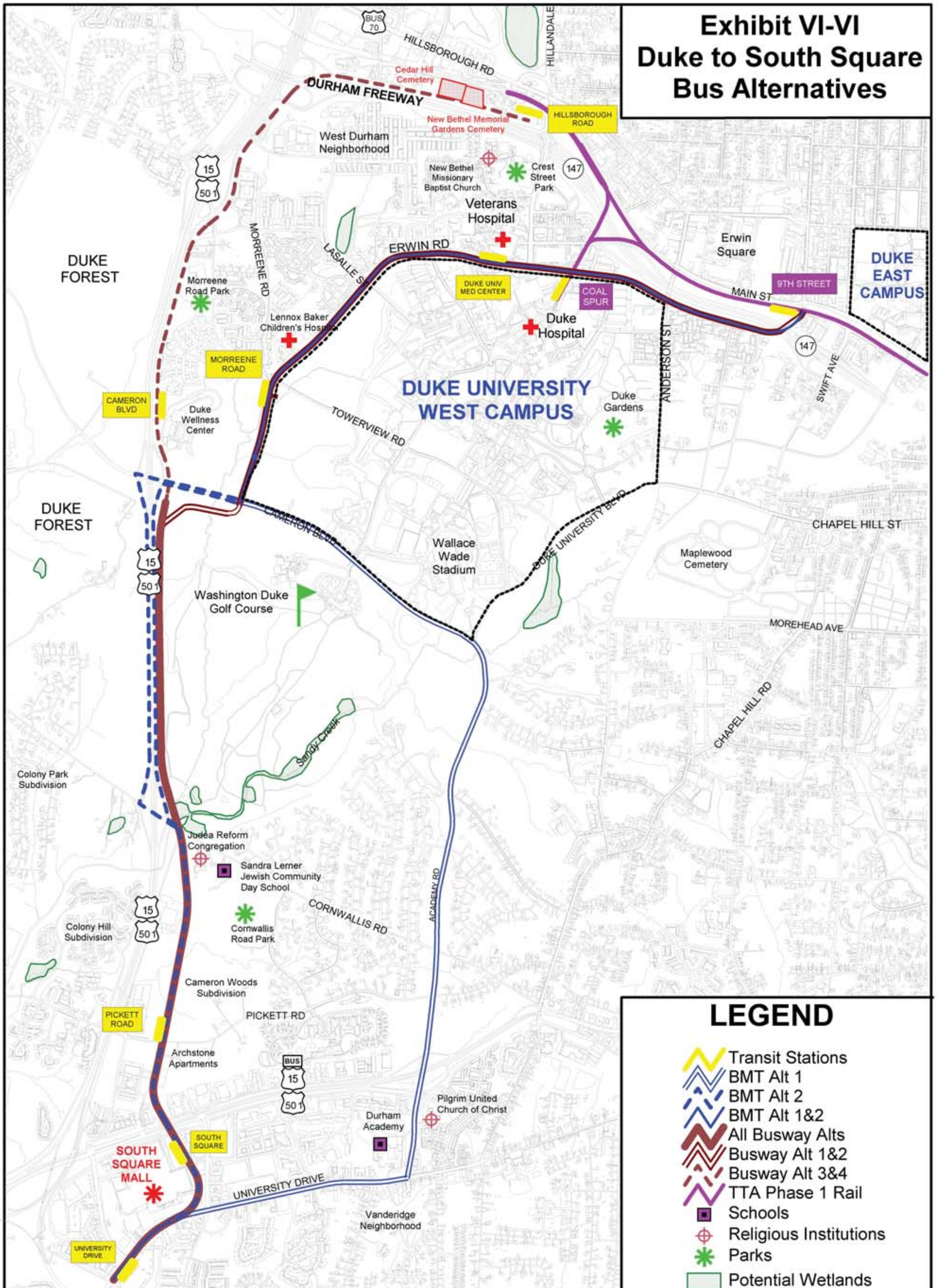
Exhibit VI-VI
Duke to South Square Bus Alternatives



LEGEND

- Transit Stations
- BMT Alt 1
- BMT Alt 2
- BMT Alt 1&2
- All Busway Alts
- Busway Alt 1&2
- Busway Alt 3&4
- TTA Phase 1 Rail
- Schools
- Religious Institutions
- Parks
- Potential Wetlands

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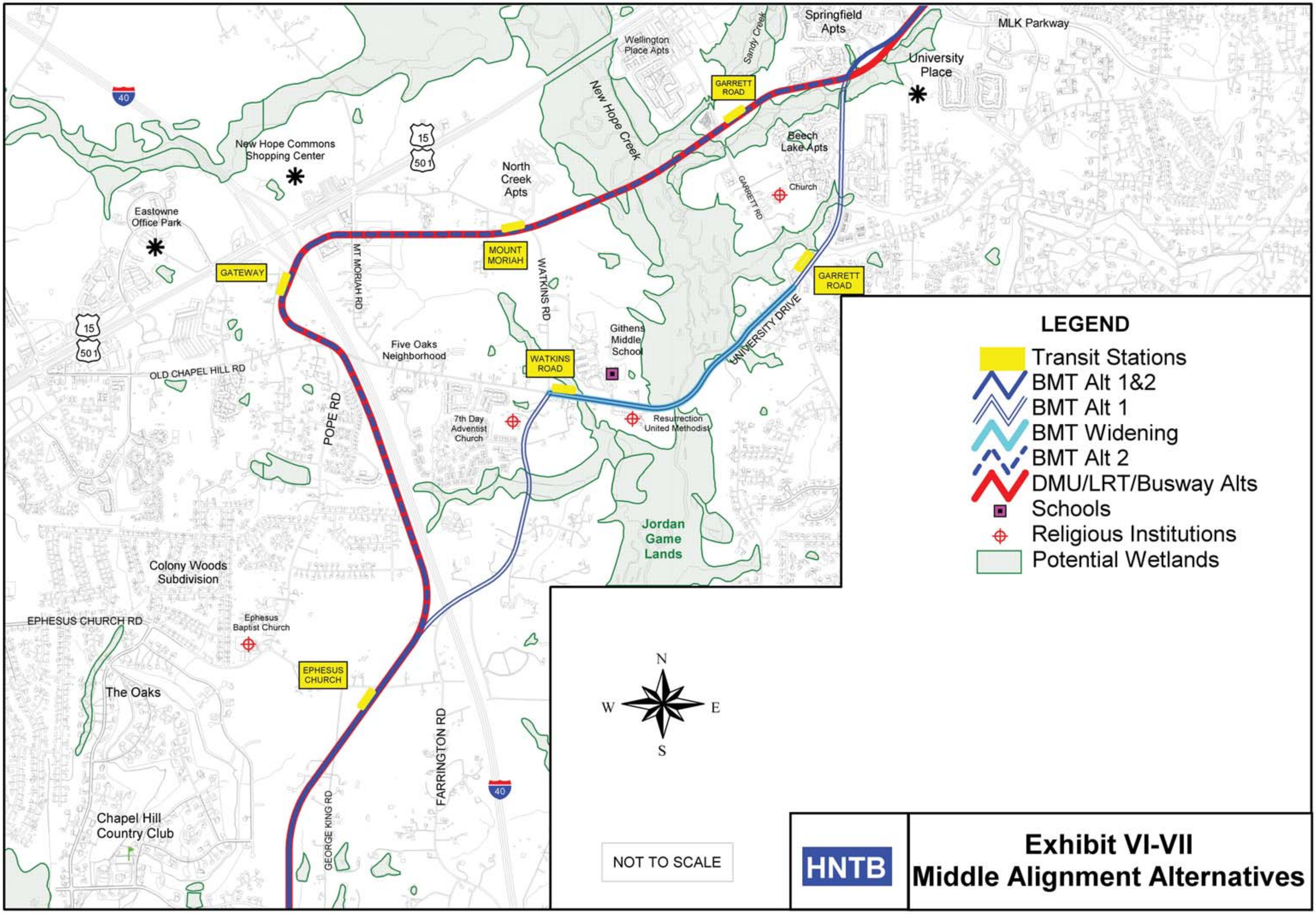

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Exhibit VI-VII
Middle Alignment Alternatives

Exhibit VI-VIII
UNC Area Transit Alternatives

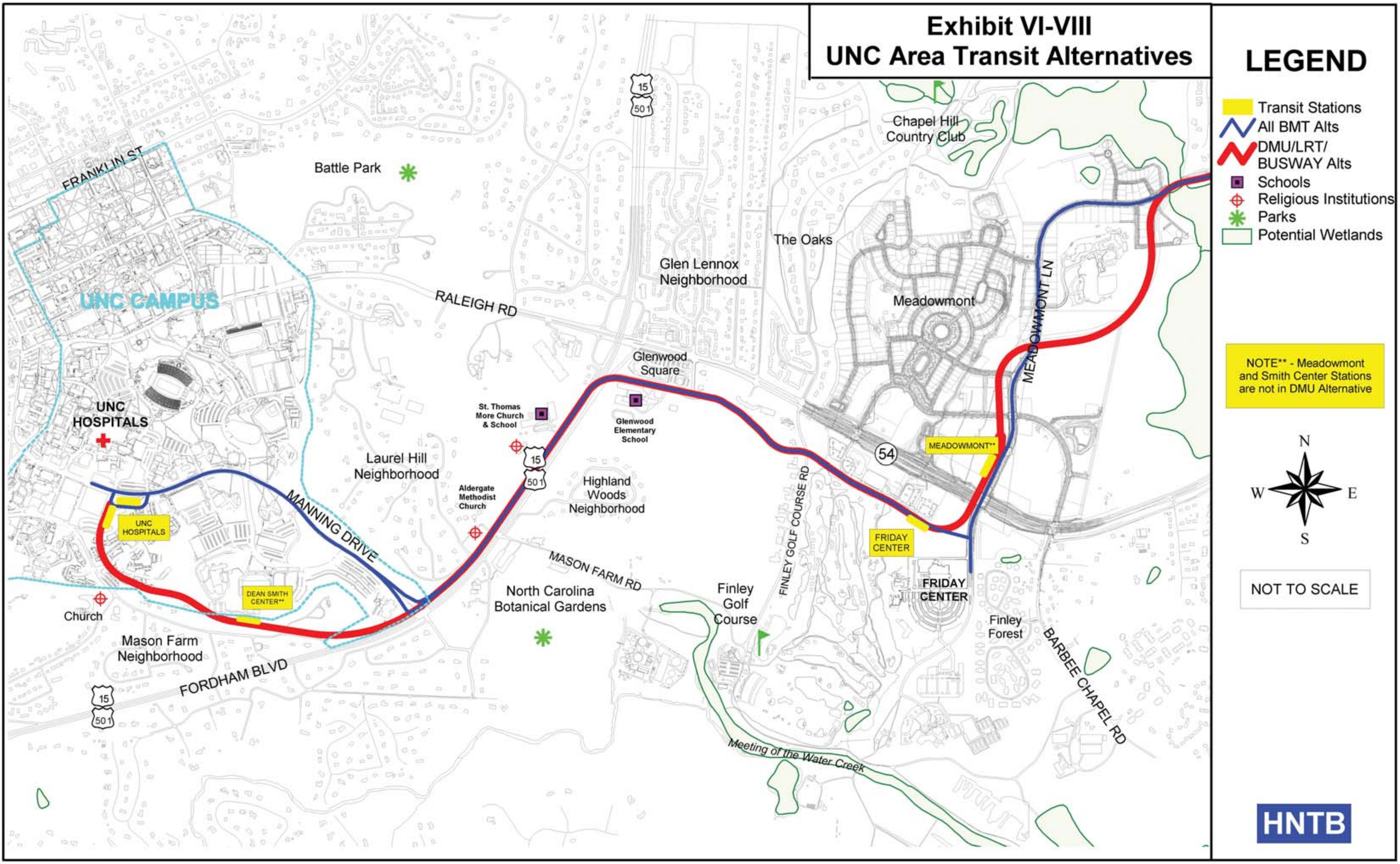

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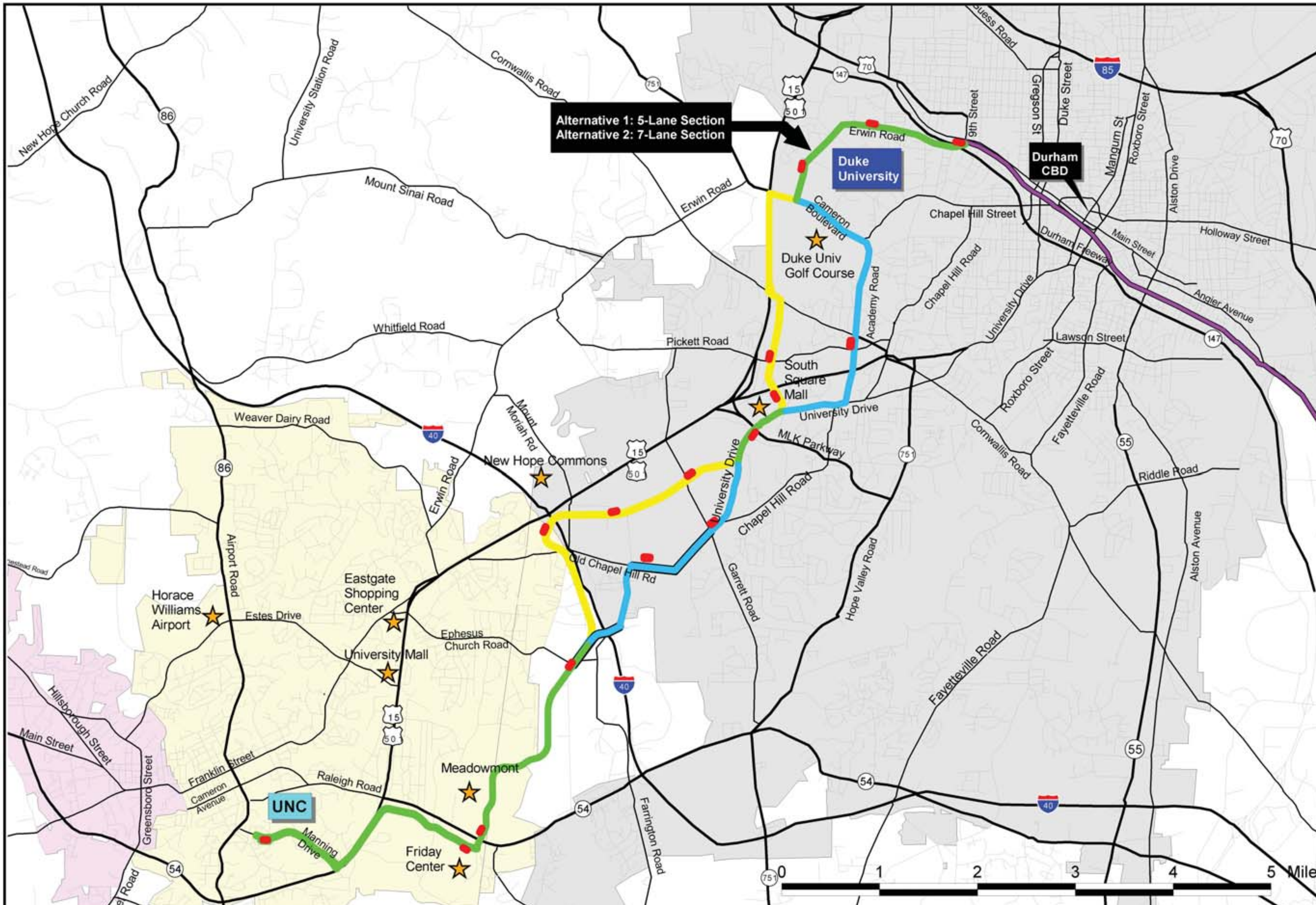
Exhibit VI-IX BMT Alternatives



LEGEND

- BMT Stations
- Alt 1&2 Alignment
- Alternative 1 Alignment
- BMT Widening
- Alternative 2 Alignment
- Points of Interest
- TTA Phase I Rail
- Highways
- Thoroughfares
- Streets

Cities and Towns

- Carrboro
- Chapel Hill
- Durham

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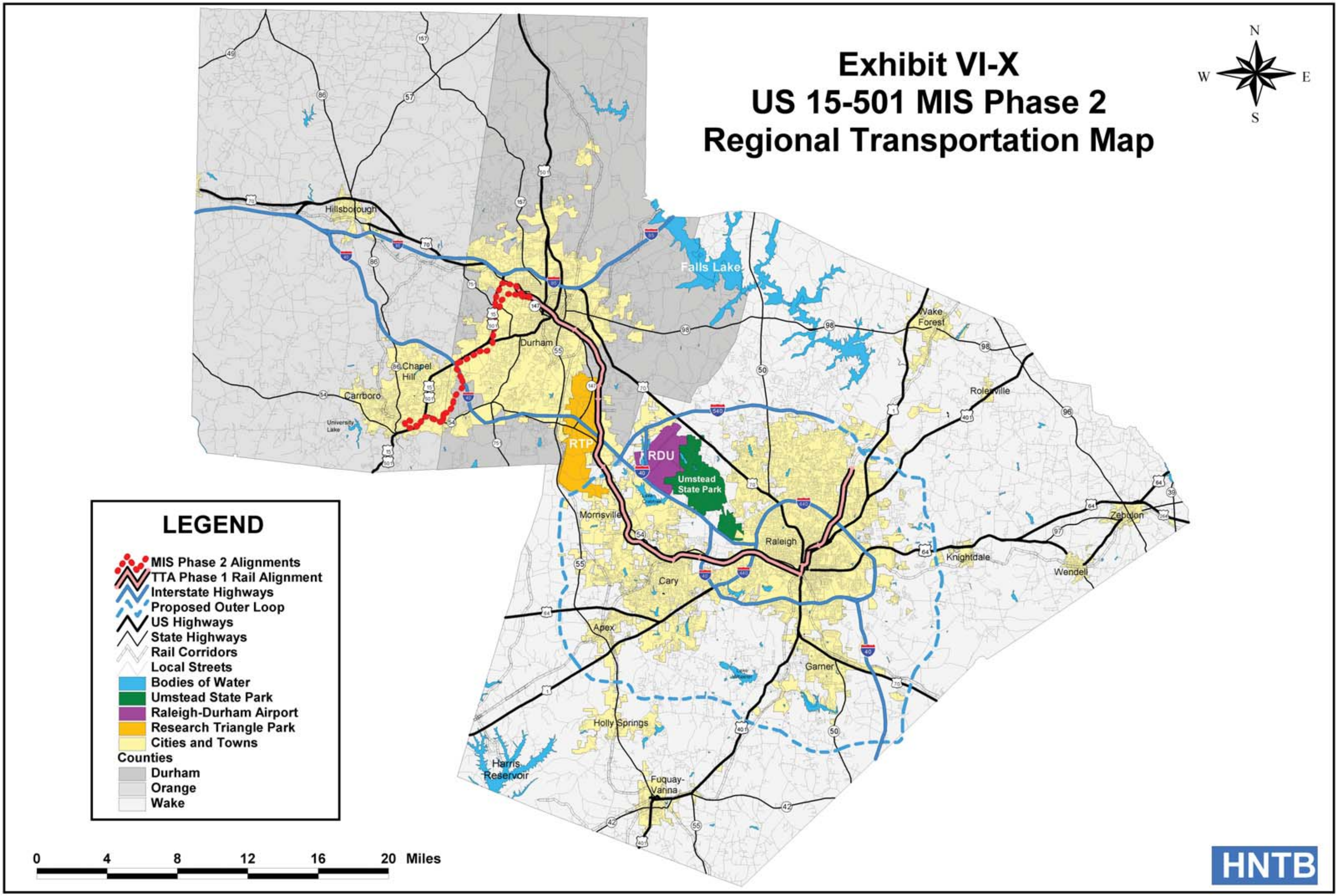
Exhibit VI-X
US 15-501 MIS Phase 2
Regional Transportation Map



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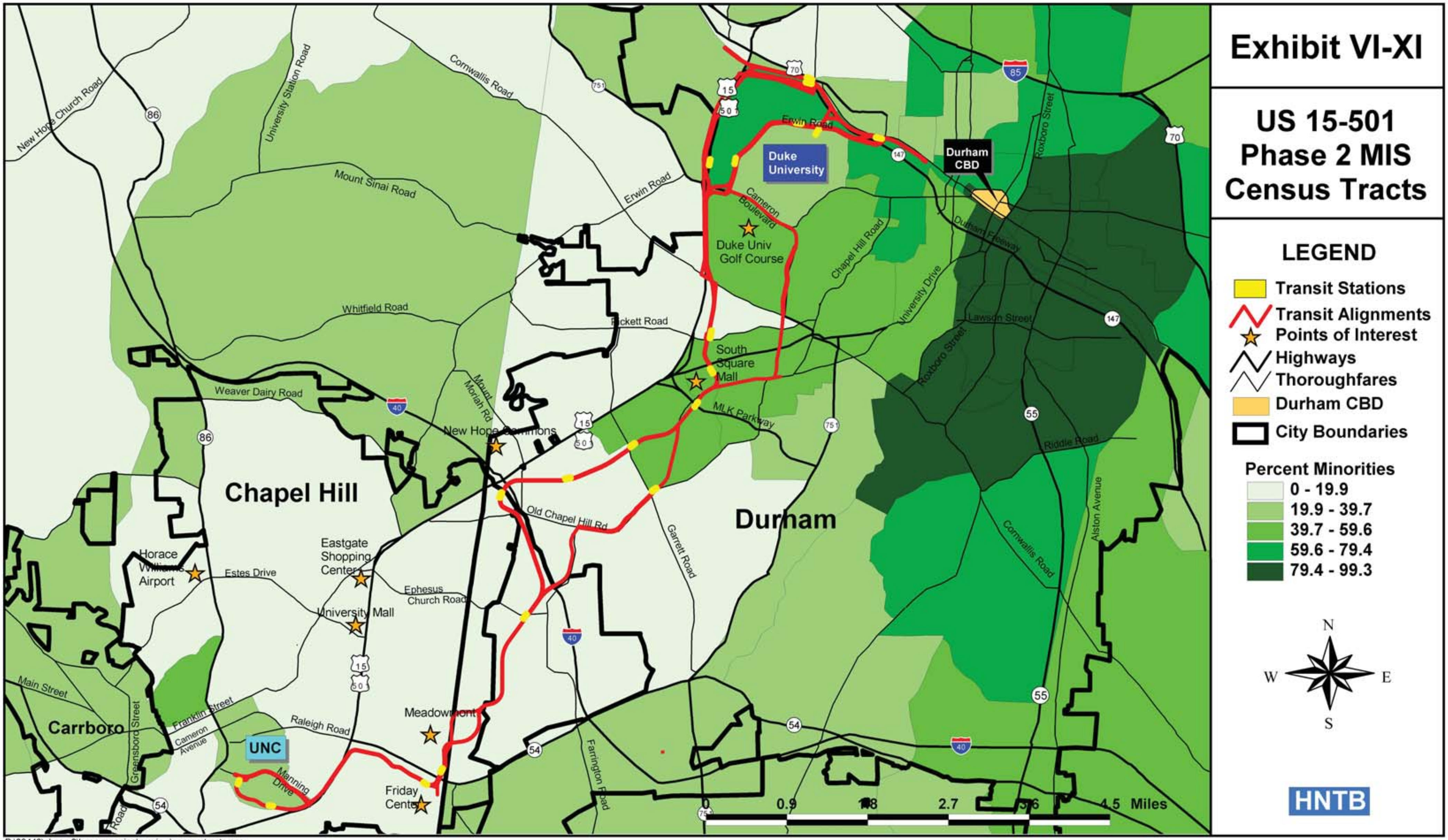

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