URS DIN 01566 Rev 2

Operations and Maintenance Cost Methodology Report

Durham-Orange Light Rail Transit Project

July 24, 2015

The NEPA Preferred Alternative for the D-O LRT Project would generally follow NC 54, I-40, US 15-501, and the North Carolina Railroad (NCRR) Corridor in downtown Durham and east Durham. The alignment would begin at UNC Hospitals, parallel Fordham Boulevard, proceed east on NC 54, travel north on I-40, parallel US 15-501 before it turns east toward the Duke University campus along Erwin Road, and then follow the NCRR Corridor parallel to NC 147 through downtown Durham, before reaching its eastern terminus near Alston Avenue. The alignment would consist of at-grade alignment, fill and cut sections, and elevated structures. In two sections of the alignment, Little Creek and New Hope Creek, multiple Light Rail Alternatives are evaluated in the DEIS.

This technical report contains information for all alternatives analyzed in the DEIS. However, pursuant to MAP 21, the Moving Ahead for Progress in the 21st Century Act (P.L. 112-141), a NEPA Preferred Alternative has been developed, which recommends C2A in the Little Creek section of the alignment, NHC 2 in the New Hope Creek section of the alignment, the Trent/Flowers Drive station, and the Farrington Road Rail Operations and Maintenance Facility.

Table of Contents

List of Tables

List of Figures

List of Acronyms and Abbreviations

Acronym/Abbreviation	Definition
AA	alternatives analysis
CAMPO	Capital Area Metropolitan Planning Organization
CAT	Capital Area Transit
CHT	Chapel Hill Transit
CNG	compressed natural gas
CPI	consumer price index
CPI-U	consumer price index for all urban consumers
DATA	Durham Area Transit Authority
DBBS	Designing Better Bus Service
DCHC	Durham/Chapel Hill/Carrboro
DEIS	Draft Environmental Impact Statement
D-O	Durham-Orange
D-O LRT	Durham-Orange Light Rail Transit
DTCC	Durham Technical Community College
DUMC	Duke University Medical Centers
FTA	Federal Transit Administration
I-40	Interstate 40
LPA	locally preferred alternative
LRT	light rail transit
MPO	metropolitan planning organization
MTP	metropolitan transportation plan
NC	North Carolina
NCCU	North Carolina Central University
NCRR	North Carolina Railroad
NTD	National Transit Database
O&M	operations and maintenance
ROMF	rail operations maintenance facility
RTC	regional transit center
TSM	transportation system management
UNC	University of North Carolina
US	United States

Acronym/Abbreviation	Definition
VA	Veteran Affairs

1. Introduction

Triangle Transit, in cooperation with the Federal Transit Administration (FTA), has prepared a Draft Environmental Impact Statement (DEIS) to evaluate a potential high-capacity transit improvement in the Triangle region, within the Durham-Orange (D-O) Corridor, between Chapel Hill and Durham.

This report presents the methodology used to develop the bus and rail operations and maintenance costs. The report begins with a brief description of existing transit services in the project study area, and how these existing services were modified to become the No-Build network. This No-Build network is the basis on which the other project alternatives have been defined. The report also includes a brief description of the Light Rail Alternatives considered in the DEIS.

The report then presents how the operating and maintenance cost model was constructed using data from the four transit systems currently operating in the project area, as well data from peer light rail systems. The report ends with a description of the line item detail that will be used to calculate the operating and maintenance costs of the various project alternatives.

1.1 Description of Study Corridor

The D-O Corridor is located within the Triangle region. It extends roughly 17 miles from southwest Chapel Hill to east Durham, and includes several educational, medical, and other key activity centers which generate a large number of trips each day. The land uses in the D-O Corridor are supported by a network of major highways including NC 54, I-40, US 15-501, Erwin Road, and NC 147. Additional detail regarding the study corridor is included in the *Durham-Orange Light Rail Transit Project DEIS*, chapters 1 and 2.

1.2 Alternatives Considered

- No-Build Alternative
- Light Rail Alternatives

In addition to the Light Rail Alternatives, the DEIS considers a No-Build Alternative comprised of the existing and programmed transportation network improvements without the planned rail improvements and associated bus network modifications. Additional detail regarding the alternatives considered is included in the *Durham-Orange Light Rail Transit Project DEIS*, chapter 2.

1.2.1 No-Build Alternative

The No-Build Alternative includes the existing and planned transportation programs and projects scheduled to be built and implemented before forecast year 2040 and contained in the 2040 Metropolitan Transportation Plan (MTP), excluding only the proposed Light Rail Alternatives, rail transit improvements and related bus transit modifications that would be associated with the proposed D-O LRT Project.

1.2.2 Light Rail Alternatives

Through the Alternatives Analysis and Scoping process, a majority of the proposed D-O LRT Project alignment was identified. However, there are a few areas where different alternatives were retained for further evaluation. As a result, multiple alignments crossing Little Creek and New Hope Creek are evaluated in the DEIS.

- Four potential crossings of Little Creek between Hamilton Road and the proposed Leigh Village Station (Alternatives C1, C1A, C2,and C2A)
- Three potential crossings of New Hope Creek and Sandy Creek between Patterson Place and South Square (Alternatives NHC LPA, NHC 1, and NHC 2)
- Station alternatives at Duke/VA Medical Centers (i.e., Duke Eye Center and Trent/Flowers Drive)
- Five proposed locations for the ROMF (i.e., Leigh Village ROMF, Farrington Road ROMF, Patterson Place ROMF, Cornwallis Road ROMF, and Alston Avenue ROMF)

The Light Rail Alternatives would generally follow North Carolina (NC) Highway 54 (NC 54), Interstate 40 (I-40), United States (US) 15-501, and the North Carolina Railroad (NCRR) Corridor in downtown Durham and east Durham. The alignment would begin in Chapel Hill at UNC Hospitals, parallel Fordham Boulevard, proceed eastward adjacent to NC 54, travel north along I-40, parallel US 15-501 before it would turn east toward Duke University and run within Erwin Road, and then follow the NCRR Corridor that parallels NC Highway 147 (NC 147) through downtown Durham, before reaching its eastern terminus in Durham near Alston Avenue. The alignment would consist of at-grade alignment, fill and cut sections, and elevated structures. A total of 17 stations are planned, and up to 5,100 parking spaces would be provided along the Light Rail Alternatives. In addition, a rail operations and maintenance facility (ROMF) would be constructed to accommodate the D-O LRT fleet (initially 17 vehicles, with the ability to accommodate up to 26 vehicles without needing expansion).

Bus routes would be modified to feed into the D-O LRT stations, and headways would be adjusted to provide more frequent bus service and minimize transfer waiting times. These services would also connect light rail passengers with other area transportation hubs, including park-and-ride lots and transfer centers.

1.3 Purpose of This Report

This report presents methodology for developing annual operations and maintenance (O&M) cost estimates for the proposed D-O LRT Project alternatives.

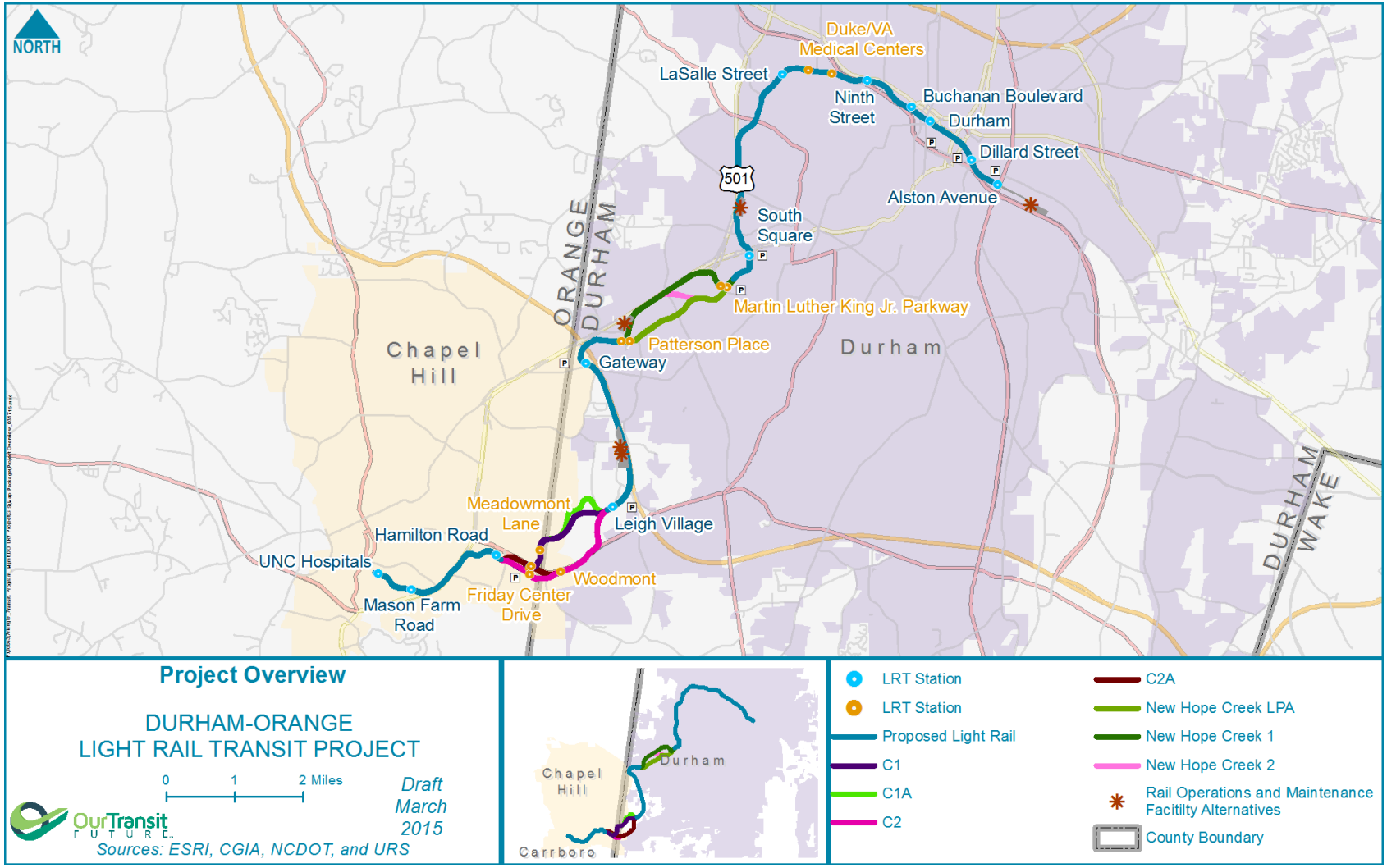
As noted by the Federal Transit Administration (FTA) in *Procedures and Technical Methods for Transit Project Planning (Draft)*, dated November 2006, estimating O&M costs is an important part of planning New Starts projects for three reasons:

- Cost-effectiveness measures: The projection of annual O&M costs is a critical input to the determination of the New Starts measures of cost effectiveness.
- Environmental benefits measure: The projection of annual O&M costs is a critical input to the determination of the New Starts measures of environmental benefits.
- Financial planning: Annual O&M cost projections are vital to the development of financial plans that cover multiple years of construction and operation of New Starts projects.

The FTA requires the use of a resource-driven, fully-allocated cost model for O&M projections in a New Starts project. Resource-driven models connect specific expenses to specific service or system characteristics. Once expense items are assigned their driving variable(s), resource-driven models produce cost estimates accordingly. For example, after mathematically connecting bus operator wages/salaries to annual revenue bus-hours, a model would estimate the future annual cost of this expense item based on a study alternative's revenue bus-hours of service.

This report continues with a brief description of the project alternatives in Section 2 and a summary of the methodology used to estimate O&M costs in Section 3. Sections 4 through 7 of this report present specific O&M cost methodology for Triangle Transit, Durham Area Transit Authority (DATA), Chapel Hill Transit (CHT) and for the proposed light rail service.

Figure 1-1: Proposed D-O LRT Project



2. Project Alternatives

The Light Rail Alternatives for the current phase of the project are being compared to a No-Build Alternative. Full descriptions of the service plans for each alternative are provided in the project's *Transit Operating Plan (Draft)* dated March 2015. Brief highlights of the operating plan assumptions for each alternative are provided below.

2.1 No-Build Alternative

A No-Build Alternative establishes a reference point for the environmental impacts of the alternatives and the financial condition of the transit operator(s).

For the D-O LRT Project, the definition of the No-Build Alternative began with incorporating planned improvements from the region's long-range plan. The 2040 Metropolitan Transportation Plan (MTP) was adopted by the DCHC MPO and Capital Area Metropolitan Planning Organization (CAMPO). The MTP assumes significant expansion of the region's transit network with revenues from the recently passed sales tax referendum and vehicle registration fees; the MTP includes the D-O LRT Project in its transit network and regional commuter rail between Raleigh and Durham. The following modifications were made to the MTP transit network in defining this project's No-Build Alternative:

- The D-O LRT line was removed from the 2040 MTP network.
- Triangle Transit Routes 400A and 400B were included in the No-Build network. These proposed routes are similar to the existing Routes 400 and 405 that presently operate in the D-O LRT Corridor (from downtown Durham to downtown Chapel Hill). They were not included in the 2040 MTP network because LRT was assumed in this corridor.
- Existing Triangle Transit Routes 700 and the DRX were added back into the No-Build network. Both routes were excluded from the 2040 MTP network because the network assumed commuter rail in this corridor.
- Triangle Transit recently began operating a short-turn pattern for Route 800. The new pattern was added to the 2040 network.
- After consultation with Triangle Transit and CHT service planning staff, several more Triangle Transit routes were eliminated from the 2040 MTP network including the Butner-Durham Express, the New Hope-RTP Express, and Triangle Transit Circulators; Research Triangle, Southport, and Purple.
- The Bull City Connector was added into the No-Build Alternative. This is an existing local route that operates in Durham and was not included in the 2040 MTP network because it operates in parallel to the MTP's D-O LRT line.
- The 2040 MTP network assumed several new feeder routes associated with the D-O LRT line. Since this No-Build network does not include this LRT line, these feeder routes were removed.
- Service improvements identified in Scenario 3 of DATA's *Designing Better Bus Service* (DBBS) study were also assumed in the 2040 No-Build network. This plan was developed by DATA in May of 2012 with service recommendations based across four fronts; Safety, Service Quality, Fiscal Responsibility, and Community Benefits. DATA has already implemented many of the service improvements identified in Scenarios 1 and 2 of the DBBS project.

2.2 Light Rail Alternatives

The Light Rail Alternatives consist of LRT service from UNC Hospitals in Chapel Hill to Alston Avenue in Durham. Summarizing the alignment, it begins near the Dogwood Parking Deck on the southern side of the UNC campus and proceeds to Friday Center, Leigh Village, South Square, Duke Medical Center, Durham Station, and terminates just west of Alston Avenue along Pettigrew Street on the south side of the railroad tracks. The proposed LRT alignment includes 17 stations and eight of the sites include park-and-ride facilities.

For project definition and project design purposes, the alignment has been broken into six segments (A through F). Four alignment alternatives are still under consideration for Segment C (C1, C1A, C2 and C2A). Three alignment options are still under consideration for Segment D (NHC LPA, NHC 1 and NHC 2). In Segment E, two alternative stations are still being considered (Trent/Flowers Drive vs. Duke Eye Center Stations).

Operating hours for the new LRT service are proposed to be from 5:30 a.m. to midnight on weekdays and Saturdays, and 6:30 a.m. to midnight on Sundays. Proposed service frequencies on weekdays would be 10 minutes during peak periods, 20 minutes during the midday, and 30 minutes in the evening. Saturday service would operate every 20 minutes until 7:00 p.m., when the frequency would be reduced to every half hour. Sunday service would operate at 30-minute intervals before 9:00 a.m. and after 7:00 p.m., with 20-minute service during the day.

2.3 Supporting Background Bus Service for Light Rail Alternatives

With the introduction of new premium bus or LRT service in the D-O LRT Corridor, several changes would be made to existing Triangle Transit, DATA, and CHT routes in the corridor. These changes can be categorized as the following:

- Elimination of duplicative bus service: Two Triangle Transit routes (Routes 400A, 400B), four CHT routes (Routes DX, FCX, HU, and S) and one DATA route (Bull City Connector) are eliminated from the transit network.
- Changes to the background bus network: Several DATA, CHT, and Triangle Transit route alignments are modified to include connections to nearby stations.
- Introduction of new feeder bus routes: New feeder routes are proposed along the alignment to improve connectivity to the LRT service.

As noted at the beginning of this section, the project's *Transit Operating Plans* documents proposed changes to the local bus networks.

3. Operations and Maintenance Costing Overview

Operations and maintenance (O&M) cost estimates are important in the planning process for New Starts projects because design-year projections are one of the input variables required in determining New Starts measures of cost effectiveness. An O&M cost model estimates the annual cost to operate, maintain, and administer a transit system for a given set of service indicators. O&M costs are expressed as the annual total of employee earnings and fringe benefits, contract services, materials and supplies, utilities, and other day-to-day expenses incurred in the operation and maintenance of a transit system.

In general, steps of the O&M cost estimating process are as follows:

- Develop methodology for estimating O&M costs.
- Develop appropriate cost model(s) to evaluate alternatives.
- Calibrate the model for current year operations.
- Generate operating plans and statistics for each study alternative.
- Estimate annual O&M costs for each study alternative.

This report documents the first three steps as they have been applied to the proposed D-O LRT Project. The operating plans and cost estimates referred to in the last two steps will be documented separately, after completion and review of ridership forecasts, to determine appropriate adjustments to each alternative's service plan definition. Capital cost estimates, for construction and equipment purchases, are not part of the O&M cost estimating process.

Paraphrasing from the Federal Transit Administration's (FTA's) Procedures and Technical Methods for Transit Project Planning, Chapter 4, Operating and Maintenance Costs (Draft Version 3), page 1 and 2, a fully-allocated cost model is the best approach to O&M costing because it is: a) able to reflect cost differences by mode and service type; b) structured based on actual operating experience; and c) sensitive to future changes in cost factors. The FTA has issued guidelines that specify the following methodology for calculating O&M costs:

- Estimate labor and materials needed to provide a specific level of service and then apply current unit costs to the estimated future labor and non-labor items.
- Calculate costs based on operating characteristics by mode (e.g., LRT train-hours) rather than for all modes combined (e.g., system-wide passengers).
- Model each reported labor and non-labor expense separately to ensure that equations are mutually exclusive and cover all operating costs.
- Model expense items as variable, so that cost estimates will change with projected changes in service.

A cost allocation model assumes that each expense incurred by a transit system is driven by a key supply variable such as revenue-hours, revenue-miles, or the number of vehicles operated during peak periods. Combining recent actual O&M costs with the quantity of relevant supply variables establishes unit costs and productivity ratios that can then be applied to a different set of service indicators (such as projected future expansions or cut-backs). The result is an estimated annual O&M cost estimate that is specific for a test scenario.

3.1 General Model Structure

The structure of the D-O LRT Project's O&M cost models is consistent with the spreadsheets presented in *Chapter 4, Operating and Maintenance Costs,* of the FTA's *Procedures and Technical Methods for Transit Project Planning (Draft Version 3)*. The model's data and calculations progress from the base year expense items and amounts on the left side of the spreadsheet, through the assignment of driving variables, to productivity and inflation, and end with the estimated incremental cost of a study alternative on the right side of the spreadsheet.

3.2 Line Items and Calibration Expenses

The first few columns of a cost model spreadsheet lists O&M line item expenses, a recent annual cost for each item, and a column for noting whether a line item's existing unit cost is adjusted in the model or a new unit cost has been added. The ability to adjust a current annual expense or add a new one enables a cost model to factor into future projections certain changes an agency is in the process of implementing, such as new compressed natural gas (CNG) buses to replace an aging diesel fleet or a railcar maintenance campaign that will effectively make an older fleet perform as if it were years younger.

3.3 Calibration Unit Costs

As pointed out in the FTA guidelines, O&M costs are related to (or "driven" by) different supply variables. Supply variables can be considered causal because as they increase, so do the related expense items. The second section of a spreadsheet model is for the supply variable unit cost rates. One column is designated for each variable used as a driver for estimating the cost of a project alternative. Usually, unit rates are calculated by dividing the actual annual expense for the line item by the value of the relevant supply variable.

3.4 Productivity Ratios

Line item productivity ratios are calculated in the third section of a cost model with columns that display the resource variable used for the calculation (may be the line item's supply variable, or it may be something else related to the supply variable, such as work hours for salary and wage expenses), the value of the resource variable, and the factor that results from dividing the resource value by the supply value.

3.5 Estimated Cost of a Test Scenario

For each line item expense, the last columns in the spreadsheet contain the base year resource unit cost (supply variable unit cost divided by resource/supply factor), an inflation factor, and the model estimates of resource unit cost and annual cost. The D-O LRT Project models are based on actual 2012 expenses, inflated to represent 2015 dollars for the study alternatives.

3.6 Project Operations and Maintenance Cost Models

Four models were developed for this project in order to estimate O&M costs for each of three existing bus service providers (Triangle Transit, DATA, and CHT) and for LRT as a new mode of transit.

3.7 Background Bus Cost Models

The D-O LRT Project alternatives require bus O&M costs to be estimated for Triangle Transit, DATA and CHT. All three agencies operate bus service in the study corridor and project alternatives reflect various modifications to bus service for each of these service providers. The cost model for each provider has been developed with actual expenses, system characteristics, and service statistics as reported to the National Transit Database (NTD) for the 2012 report year. In some instances, the agencies have been able to provide additional cost data beyond what is reported in NTD. Demand response has not been modeled because these operations in the project corridor are not expected to change from one study alternative to another.

3.8 Light Rail Cost Model

Since LRT is not currently operated in the region, O&M cost estimates for the Light Rail Alternatives have been based on the actual cost experience of several LRT systems elsewhere in the United States. The LRT section of this report describes selection of the project's "peer" LRT systems and how the rail cost model has been structured for use on the D-O LRT Project.

The models are described in the following sections of this document.

4. Triangle Transit Bus Operations and Maintenance Cost Model

Triangle Transit's bus O&M cost model is based on the agency's 2012 NTD report for directly-operated motor bus service. Triangle Transit's FY 2012 overall cost per revenue bus-hour averaged $129. In accordance with FTA New Starts guidance, costs have been identified by function with one or more variables assigned to each line item cost. Expenses, service statistics, and supplemental information on contracted services were provided by Triangle Transit staff.

4.1 Key Supply Variables

After collection of financial and service data, preparation of the spreadsheet cost model began with the selection of key supply variables for the existing bus system. Variables selected were as follows:

- ***Annual Revenue Bus-Hours:*** The hours that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-hours include layover and schedule recovery but exclude time for deadhead, operator training, and maintenance testing. For modeling purposes, revenue bus-hours have been divided between Triangle Transit's directly-operated service and service contracted out. Triangle Transit has contracts with Capital Area Transit (CAT), Raleigh's public transit service provider, and CHT to operate select Triangle Transit bus routes.
- ***Annual Revenue Bus-Miles:*** The miles that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-miles include layover and schedule recovery but exclude miles for deadhead, operator training, and maintenance testing. For modeling purposes, revenue bus-miles have been divided between Triangle Transit's directly-operated service and service contracted out to CAT and CHT.
- ***Garages:*** The number of garages from which buses are dispatched into service. These garages also serve as general purpose maintenance facilities for inspecting, servicing, and maintaining buses. For a bus system with one garage, it also functions as a heavy maintenance facility.
- ***Regional Transit Centers:*** The number of bus passenger facilities that provide more amenities than a conventional, on-street bus stop. Triangle Transit is responsible for the operation and maintenance of the Regional Transit Center (RTC), located in Research Triangle Park.
- ***Peak Buses:*** The maximum number of passenger service vehicles actually operated simultaneously on an average weekday. In some cases, peak buses may be used as a supply variable when the model needs to base line item expenses on overall bus system size.

Table 4-1 shows the key supply variables and values used to represent the model's calibration (FY 2012 base year) input. Once again, bus-hours, bus-miles, and peak buses were obtained directly from Triangle Transit's 2012 NTD report.

Table 4-1: Triangle Transit Bus Cost Model: Supply Variable Input

Supply Variable Inputs	2012 Calibration
Annual Revenue Triangle Transit Bus-Hours	97,555
Annual Revenue Contractor Bus-Hours	10,183
Annual Revenue Triangle Transit Bus-Miles	1,978,235
Annual Revenue Contractor Bus-Miles	228,833
Garages	1
Regional Transit Centers	1
Peak Buses	59

4.2 Line Item Expenses

After selecting the key supply variables, the next step in model development was to record Triangle Transit's bus expenses as a series of line items. The NTD report format categorizes operating expenses within the four functional areas of Vehicle Operations, Vehicle Maintenance, Non-Vehicle Maintenance, and General Administration. For each functional area, line item expenses are further classified as salaries/wages, fringe benefits, services, materials/supplies, utilities, casualty and liability, taxes/fees, and miscellaneous. Triangle Transit's finance staff provided some additional break-out of costs beyond what is required to be reported for the NTD.

After the list of line items was established, each was assigned a key supply variable as its most relevant cost driver and a few expenses that were strongly influenced by more than one of the model's supply variables were split between them. Split line items include the following:

- ***Vehicle Operations: Non-Operator Salaries and Wages*** have been split with 70 percent of non-operator work hours driven by revenue bus-hours and 30 percent driven by the number of garages. Fringe benefits are allocated proportionally to the same driving variables.
- ***Vehicle Operations: Professional and Technical Services*** are driven by a combination of contractor revenue bus-hours and peak buses. The portion assigned to contractor revenue bus-hours is based on actual expense detail provided by Triangle Transit staff.
- ***Vehicle Maintenance: Professional and Technical Services*** are driven by Triangle Transit directly-operated and contractor revenue bus-miles. The portion assigned to contractor revenue bus-miles is based on actual expense detail provided by Triangle Transit staff.

In addition to the supply variables listed in Table 4-1, from which line item unit costs are derived, the model also incorporates resource variables specifically to provide labor productivity and fuel consumption ratios.

- NTD-reported employee work hours are included as a resource variable for estimating salaries and wages by functional area for the project alternatives. For Vehicle Operations, NTD does not subdivide total work hours reported by operator and non-operator so the 2012 model maintains the same ratio of operator and non-operator work hours that was provided by Triangle Transit

staff for the 2011 version of the cost model. Fringe benefit cost estimates pivot off labor work hours.

- The Triangle Transit bus O&M cost model uses gallons of fuel as the resource variable for estimating those fuel costs for the future.

For all other line items, the model calculates productivity using supply variable input.

Table 4-2 summarizes the dollar impact that each of the bus model's key supply variables has on the calibration (FY 2012 base year) system. The unit costs in this table reflect the dollar amount the model will adjust for each added or deleted unit of a supply variable – in other words, the incremental change from the calibration system. For example, for each Triangle Transit-operated revenue bus-mile added, the model will increase its total estimate by $1.74; for each revenue bus-hour deleted the model will subtract $49.12 from its estimate, and so forth.

Table 4-2: Triangle Transit Bus Cost Model Supply Variable Impacts for the 2012 Calibration Bus System (in 2012 dollars)

Key Supply Variable	Share of Total O&M Cost		Unit Cost
	Dollar Amount	Percentage	
Annual Revenue Triangle Transit Bus-Hours	$4,791,538	38.1%	$49.12
Annual Revenue Contractor Bus-Hours	$654,983	5.2%	$64.32
Annual Revenue Triangle Transit Bus-Miles	$3,450,601	27.4%	$1.74
Annual Revenue Contractor Bus-Miles	$215,573	1.7%	$0.94
Garages	$406,393	3.2%	$406,393
Regional Transit Centers	$126,284	1.0%	$126,284
Peak Buses	$2,927,198	23.3%	$49,614
Total	**$12,572,570**	**100.0%**	

Table 4-3 presents the Triangle Transit bus O&M cost model for the 2012 calibration (base year), created with the supply variables shown in Table 4-2.

Model results will be inflated to 2015 dollars using the Bureau of Labor Statistics consumer price index (CPI), specifically the consumer price index for all urban consumers (CPI-U), South Region. The average of the two most recent annual periods (2012 to 2013, and 2013 to 2014) was used as a proxy for an additional 12 months of inflation so that project O&M cost estimates will represent 2015 dollars.

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Table 4-3: Triangle Transit Bus Line Item Detail

Durham-Orange County Corridor
Triangle Regional Transit Program
O&M Cost Models
TRIANGLE TRANSIT AUTHORITY BUS LINE ITEM DETAIL

																Calibration		
																Inflation Factor:		1.049
				Bus Supply Variable Unit Cost Rate ($2012)							Productivity Ratio			Base Year		Results in:		2015$
Expense Line Item	2012 Bus Expenses	Existing Unit Cost Adjusted	New Unit Cost Added	TTA Revenue Bus-Hours	Contracted Bus-Hours	TTA Revenue Bus-Miles	Contracted Bus-Miles	Garages	Regional Transit Ctrs	Peak Buses	Resource Variable	Resource Value	Resource/ Supply	Resource Unit Cost	Inflation Factor	Resource Unit Cost	Estimated Annual Cost
VEHICLE OPERATIONS																	
OPERATORS' SALARIES & WAGES	*$3,246,438*			$33.28							Work Hours	147,985	1.517	$21.94	1.049	$23.02	$3,405,894
OTHER SALARIES & WAGES - Rev-Hours Driven (70%)	*$346,191*			$3.55							Work Hours	9,007	0.092	$38.44	1.049	$40.32	$363,195
OTHER SALARIES & WAGES - Garage Driven (30%)	*$148,368*							$148,368			Work Hours	3,860	3,860	$38.44	1.049	$40.32	$155,655
FRINGE BENEFITS - Rev-Hours Driven	*$1,198,909*			$12.29							Work Hours	156,992	1.609	$7.64	1.049	$8.01	$1,257,796
FRINGE BENEFITS - Garage Driven	*$49,512*							$49,512			Work Hours	3,860	3,860	$12.83	1.049	$13	$51,944
PROFESSIONAL & TECH SVCS - Peak Buses Driven	*$90,395*									$1,532	Peak Buses	59	1.000	$1,532	1.049	$1,607	$94,835
PROFESSIONAL & TECH SVCS - Contract-Hours Driven	*$654,983*				$64.32						Contracted Hours	10,183	1.000	$64.32	1.049	$67.48	$687,154
FUEL & LUBRICANTS	*$1,679,008*					$0.85					Gallons	525,241	0.266	$3.20	1.049	$3.35	$1,761,476
TIRES & TUBES	*$99,712*					$0.05					Revenue Miles	1,978,235	1.000	$0.05	1.049	$0.05	$104,610
OTHER MATERIALS & SUPPLIES	*$7,760*							$7,760			Garages	1	1.000	$7,760	1.049	$8,141	$8,141
MISCELLANEOUS EXPENSES	*$55,794*							$55,794			Garages	1	1.000	$55,794	1.049	$58,534	$58,534
VEHICLE MAINTENANCE																	
SALARIES & WAGES - Mechanics	*$775,992*					$0.39					Work Hours	28,548	0.014	$27.18	1.049	$28.52	$814,106
FRINGE BENEFITS	*$258,189*					$0.13					Work Hours	28,548	0.014	$9.04	1.049	$9.49	$270,870
PROFESSIONAL & TECH SVCS - TTA Rev-Miles Driven	*$120,566*					$0.06					Revenue Miles	1,978,235	1.000	$0.06	1.049	$0.06	$126,488
PROFESSIONAL & TECH SVCS - Contract-Miles Driven	*$215,573*						$0.94				Contracted Miles	228,833	22.472	$0.00	1.049	$0.00	$0
FUEL & LUBRICANTS	*$0*									$0.00	Peak Buses	59	1.000	$0.00	1.049	$0	$0
TIRES & TUBES	*$3,084*									$52.27	Peak Buses	59	1.000	$52.27	1.049	$54.84	$3,235
OTHER MATERIALS & SUPPLIES	*$481,098*					$0.24					Revenue Miles	1,978,235	1.000	$0.24	1.049	$0.26	$504,728
CASUALTY & LIABILITY	*$36,036*					$0.02					Revenue Miles	1,978,235	1.000	$0.02	1.049	$0.02	$37,806
MISCELLANEOUS EXPENSES	*$30,928*							$30,928			Garages	1	1.000	$30,928	1.049	$32,447	$32,447
NON-VEHICLE MAINTENANCE																	
SALARIES & WAGES	*$0*							$0			Garages	1	1.000	$0.00	1.049	$0.00	$0
FRINGE BENEFITS	*$0*							$0			Garages	1	1.000	$0.00	1.049	$0.00	$0
PROFESSIONAL & TECH SERVICES	*$126,284*								$126,284		Transit Centers	1	1.000	$126,284	1.049	$132,487	$132,487
GENERAL ADMINISTRATION																	
SALARIES & WAGES	*$1,278,335*									$21,667	Work Hours	30,553	517.8	$41.84	1.049	$43.89	$1,341,123
FRINGE BENEFITS	*$423,262*									$7,174	Work Hours	30,553	517.8	$13.85	1.049	$14.53	$444,051
PROFESSIONAL & TECHNICAL SERVICES	*$256,950*									$4,355	Peak Buses	59	1.000	$4,355	1.049	$4,569	$269,571
MATERIALS & SUPPLIES	*$34,556*							$34,556			Garages	1	1.000	$34,556	1.049	$36,253	$36,253
UTILITIES	*$79,475*							$79,475			Garages	1	1.000	$79,475	1.049	$83,379	$83,379
CASUALTY & LIABILITY	*$733,957*									$12,440	Peak Buses	59	1.000	$12,440	1.049	$13,051	$770,007
MISCELLANEOUS EXPENSES	*$141,215*									$2,393	Peak Buses	59	1.000	$2,393	1.049	$2,511	$148,151
TOTALS	***$12,572,570***			**$49.12**	**$64.32**	**$1.74**	**$0.94**	**$406,393**	**$126,284**	**$49,614**							**$12,963,937**
2012 Resource Variable Values				**97,555**	**10,183**	**1,978,235**	**228,833**	**1**	**1**	**59**						TT Rev Hours	97,555
																Contract Hours	10,183
																TT Rev Miles	1,978,235
																Contract Miles	228,833
																Garages	1
																Transit Centers	1
																Peak Buses	59

Notes:
1. NTD Fringe Benefit Rate for Vehicle Ops = 33.4%
2. NTD Fringe Benefit Rate for Vehicle Maint = 33.1%
3. NTD Fringe Benefit Rate for General Admin = 33.1%

5. Durham Area Transit Authority Bus Operations and Maintenance Cost Model

The DATA bus O&M cost model is based on the agency's 2012 NTD report for directly-operated motor bus service where the overall cost per revenue bus-hour averaged $88.72. DATA is unique from the other area operators in that its service provision is contracted to Triangle Transit which means that nearly all of DATA's O&M expenses are reported simply as "Purchased Transportation" to the NTD. For the prior (FY 2011) calibration of the cost model, DATA and Triangle Transit staff provided supplemental financial detail on Purchased Transportation expenses that enabled a break-out of these costs for use in this project. Since the corresponding 2012 expense break-out was not available as of this report update, the recalibrated model uses 2011 ratios of line item expense to total cost, by functional area, to be as consistent as possible with the prior cost estimating process.

5.1 Key Supply Variables

After collection of financial and service data, preparation of the spreadsheet cost model continued with selection of key supply variables for the existing bus system. Variables selected were as follows:

- ***Annual Revenue Bus-Hours:*** The hours that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-hours include layover and schedule recovery but exclude time for deadhead, operator training, and maintenance testing.
- ***Annual Revenue Bus-Miles:*** The miles that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-miles include layover and schedule recovery but exclude miles for deadhead, operator training, and maintenance testing.
- ***Garages:*** The number of garages from which buses are dispatched into service. These garages also serve as general purpose maintenance facilities for inspecting, servicing, and maintenance work on buses. For a system with one garage, it also functions as a heavy maintenance facility.
- ***Transit Centers:*** The number of bus passenger facilities that provide more amenities than a conventional, on-street bus stop. DATA's primary transit hub is Durham Station, located in downtown Durham.
- ***Peak Buses:*** The maximum number of passenger service vehicles actually operated simultaneously on an average weekday. In some cases, peak buses may be used as a supply variable when the model needs to baseline item expenses on overall bus system size.

Table 5-1 shows the key supply variables and values used to represent the model's recalibration (FY 2012) input.

Table 5-1: Durham Area Transit Authority: Supply Variable Input

Supply Variable Inputs	2012 Calibration
Annual Revenue Bus-Hours	190,551
Annual Revenue Bus-Miles	2,694,208
Garages	1
Regional Transit Centers	1
Peak Buses	38

5.2 Line Item Expenses

After selecting the key supply variables, the next step in model development was recording DATA's bus expenses as a series of line items. The agency's NTD report categorizes operating expenses within the four functional areas of Vehicle Operations, Vehicle Maintenance, Non-Vehicle Maintenance, and General Administration. As noted above, in lieu of actual 2012 line item expenses for Purchased Transportation, the known 2012 cost totals were allocated to line items according to 2011 proportions.

As was the case noted with Triangle Transit, some line item expenses typically are influenced by more than one of the model's supply variables. Accordingly, it is appropriate to divide these costs between relevant supply variables. Split line items in the DATA O&M cost model are as follows:

- ***Non-Vehicle Maintenance: Salaries and Wages*** are 75 percent driven by garages and 25 percent driven by regional transit centers. Fringe benefits are allocated proportionally to the same driving variables.
- ***General Administration: Professional and Technical Services*** are driven by both peak buses and the number of garages. The percentage split between supply variables was based on prior expense data provided by DATA and Triangle Transit staff.

The model incorporates employee work hours as a resource variable for estimating salaries and wages by functional area for the project alternatives. Work hours used in the 2012 recalibration are the same as those in the prior version of the model. Fringe benefit cost estimates in the model also pivot off labor work hours. After the line items were established, each one was assigned a key supply variable as its most relevant cost driver then unit costs and productivity ratios were calculated.

Table 5-2 summarizes the dollar impact that each of the bus model's key supply variables has on the calibration (FY 2012) system. The unit costs in this table reflect the dollar amount the model will adjust for each added or deleted unit of a supply variable – the incremental change from the calibration bus system. In other words, for each DATA revenue bus-mile added, the model will increase its total estimate by $1.64; for each revenue bus-hour deleted, the model will subtract $41.13 from its estimate, and so forth.

Table 5-2: Durham Area Transit Authority Bus Cost Model Supply Variable Impacts for the 2012 Calibration Bus System (in 2012 dollars)

Key Supply Variable	Share of Total O&M Cost		Unit Cost
	Dollar Amount	Percentage	
Annual Revenue Bus-Hours	$7,837,771	46.4%	$41.13
Annual Revenue Bus-Miles	$4,422,673	26.2%	$1.64
Garages	$779,920	4.6%	$779,920
Regional Transit Centers	$67,168	0.4%	$67,168
Peak Buses	$3,798,471	22.5%	$99,960
Total	**$16,906,003**	**100.0%**	

Table 5-3 presents the DATA bus O&M cost model worksheet for the 2012 calibration (base year), created with the supply variables shown in Table 5-1. Model results are inflated to 2015 dollars using the same CPI-U factor as the Triangle Transit bus model.

Table 5-3: Durham Area Transit Authority Bus Line Item Detail

Durham-Orange County Corridor
Triangle Regional Transit Program
O&M Cost Models
DURHAM AREA TRANSIT AUTHORITY BUS LINE ITEM DETAIL

													Calibration		
													Inflation Factor:		1.049
	2012	Existing	New	Bus Supply Variable Unit Cost Rate ($2012)					Productivity Ratio			Base Year		Results in:	2015$
Expense Line Item	Estim. Bus Expenses	Unit Cost Adjusted	Unit Cost Added	Revenue Bus-Hours	Revenue Bus-Miles	Garages	Transit Ctrs	Peak Buses	Resource Variable	Resource Value	Resource/ Supply	Resource Unit Cost	Inflation Factor	Resource Unit Cost	Estimated Annual Cost
VEHICLE OPERATIONS - PURCHASED TRANSP.															
OPERATORS' SALARIES & WAGES	*$4,876,800*			$25.59					Work Hours	220,480	1.157	$22.12	1.049	$23.21	$5,116,335
FRINGE BENEFITS	*$2,960,971*			$15.54					Work Hours	220,480	1.157	$13.43	1.049	$14.09	$3,106,405
PROFESSIONAL & TECHNICAL SERVICES	*$391,359*							$10,299	Peak Buses	38	1.000	$10,299	1.049	$10,805	$410,581
FUEL & LUBRICANTS	*$1,935,584*				$0.72				Revenue Miles	2,694,208	1.000	$0.718	1.049	$0.754	$2,030,654
TIRES & TUBES	*$215,608*				$0.08				Revenue Miles	2,694,208	1.000	$0.080	1.049	$0.084	$226,198
MISCELLANEOUS EXPENSES	*$30,110*					$30,110			Garages	1	1.000	$30,110	1.049	$31,588	$31,588
VEHICLE MAINTENANCE - PURCHASED TRANSP.															
SALARIES & WAGES	*$917,510*				$0.34				Work Hours	39,520	0.015	$23.22	1.049	$24.36	$962,576
FRINGE BENEFITS	*$445,559*				$0.17				Work Hours	39,520	0.015	$11.27	1.049	$11.83	$467,443
PROFESSIONAL & TECHNICAL SERVICES	*$189,673*				$0.07				Revenue Miles	2,694,208	1.000	$0.070	1.049	$0.074	$198,989
FUEL & LUBRICANTS	*$69,387*							$1,826	Peak Buses	38	1.000	$1,826	1.049	$1,916	$72,795
TIRES & TUBES	*$3,006*							$79.10	Peak Buses	38	1.000	$79	1.049	$82.98	$3,153
OTHER MATERIALS & SUPPLIES	*$708,604*				$0.26				Revenue Miles	2,694,208	1.000	$0.263	1.049	$0.276	$743,408
CASUALTY & LIABILITY	*$10,134*				$0.004				Revenue Miles	2,694,208	1.000	$0.004	1.049	$0.004	$10,632
NON-VEHICLE MAINTENANCE - PURCHASED TRANSP.															
SALARIES & WAGES - Garage Driven (75%)	*$142,273*					$142,273			Work Hours	18,720	18,720	$7.60	1.049	$7.97	$149,261
SALARIES & WAGES - Passenger Facility Driven (25%)	*$47,424*						$47,424		Work Hours	6,240	6,240	$7.60	1.049	$7.97	$49,754
FRINGE BENEFITS - Garage Driven	*$59,232*					$59,232			Work Hours	18,720	18,720	$3.16	1.049	$3.32	$62,141
FRINGE BENEFITS - Passenger Facility Driven	*$19,744*						$19,744		Work Hours	6,240	6,240	$3.16	1.049	$3.32	$20,714
PROFESSIONAL & TECH SERVICES	*$58,193*					$58,193			Garages	1	1.000	$58,193	1.049	$61,051	$61,051
MATERIALS & SUPPLIES	*$24,570*					$24,570			Garages	1	1.000	$24,570	1.049	$25,777	$25,777
MISCELLANEOUS EXPENSES	*$214,694*					$214,694			Garages	1	1.000	$214,694	1.049	$225,239	$225,239
GENERAL ADMINISTRATION - PURCHASED TRANSP.															
SALARIES & WAGES	*$646,945*							$17,025	Work Hours	11,900	313	$54.37	1.049	$57.04	$678,721
FRINGE BENEFITS	*$213,696*							$5,624	Work Hours	11,900	313	$17.96	1.049	$18.84	$224,192
PROF & TECHNICAL SERVICES - Garage Driven	*$66,422*					$66,422			Garages	1	1.000	$66,422	1.049	$69,684	$69,684
PROF & TECHNICAL SERVICES - Pk Bus Driven	*$614,093*							$16,160	Peak Buses	38	1.000	$16,160	1.049	$16,954	$644,255
MATERIALS & SUPPLIES	*$50,249*					$50,249			Garages	1	1.000	$50,249	1.049	$52,717	$52,717
UTILITIES	*$116,761*					$116,761			Garages	1	1.000	$116,761	1.049	$122,496	$122,496
CASUALTY & LIABILITY	*$893,113*							$23,503	Peak Buses	38	1.000	$23,503	1.049	$24,657	$936,980
TAXES & FEES	*$55,863*							$1,470	Peak Buses	38	1.000	$1,470	1.049	$1,542	$58,607
MISCELLANEOUS EXPENSES	*$287,295*							$7,560	Peak Buses	38	1.000	$7,560	1.049	$7,932	$301,406
GENERAL ADMINISTRATION - DIRECTLY OPERATED															
SALARIES & WAGES	*$483,893*							$12,734	Work Hours	8,900	234	$54.37	1.049	$57.04	$507,660
FRINGE BENEFITS	*$139,821*							$3,680	Work Hours	8,900	234	$15.71	1.049	$16.48	$146,689
UTILITIES	*$17,416*					$17,416			Garages	1	1.000	$17,416	1.049	$18,271	$18,271
TOTALS	***$16,906,003***			**$41.13**	**$1.64**	**$779,920**	**$67,168**	**$99,960**							**$17,736,377**
2012 Resource Variable Values				**190,551**	**2,694,208**	**1**	**1**	**38**						Revenue Hours	190,551
														Revenue Miles	2,694,208
														Garages	1
														Transit Centers	1
														Peak Buses	38

Notes:
1. NTD Fringe Benefit Rate for Vehicle Ops = 60.7%
2. NTD Fringe Benefit Rate for Vehicle Maint = 48.6%
3. NTD Fringe Benefit Rate for Non-Veh Maint = 41.6%
4. NTD Fringe Benefit Rate for General Admin = 33.0%
5. 2012 line item costs based on 2011 ratios applied to 2012 NTD totals by functional area.

6. Chapel Hill Transit Bus Operations and Maintenance Cost Model

CHT's bus O&M cost model is based on the agency's 2012 NTD report for directly-operated motor bus service. CHT's FY 2012 overall cost per revenue bus-hour averaged $92. However, per FTA New Starts guidance, line item expenses have been identified by function with supply variables representing service and facilities assigned to each item.

6.1 Key Supply Variables

After collection of financial and service data, preparation of the spreadsheet cost model began with the selection of key supply variables for the existing bus system. Variables selected were as follows:

- ***Annual Revenue Bus-Hours:*** The hours that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-hours include layover and schedule recovery but exclude time for deadhead, operator training, and maintenance testing.
- ***Annual Revenue Bus-Miles:*** The miles that vehicles travel while in revenue service over the entire fiscal year. Revenue bus-miles include layover and schedule recovery but exclude miles for deadhead, operator training, and maintenance testing.
- ***Garages:*** The number of garages from which buses are dispatched into service. These garages also serve as general purpose maintenance facilities for inspecting, servicing, and maintenance work on buses. For a bus system with one garage, it is assumed to function as a heavy maintenance facility as well.
- ***Peak Buses:*** The maximum number of passenger service vehicles actually operated simultaneously on an average weekday. In some cases, peak buses may be used as a supply variable when the model needs to base line item expenses on overall bus system size.

Table 6-1 shows the key supply variables and values used to represent the model's calibration (FY 2012 base year) input.

Table 6-1: Chapel Hill Transit: Supply Variable Input

Supply Variable Inputs	2012 Calibration
Annual Revenue Bus-Hours	157,768
Annual Revenue Bus-Miles	1,799,539
Garages	1
Peak Buses	73

6.2 Line Item Expenses

After selecting the key supply variables, the next step in model development was to record CHT's bus expenses as a series of line items. The agency's NTD report format categorizes operating expenses within the four functional areas of Vehicle Operations, Vehicle Maintenance, Non-Vehicle Maintenance, and General Administration. For each functional area, line item expenses are further classified as salaries/wages, fringe benefits, services, materials/supplies, utilities, casualty and liability, taxes/fees, and miscellaneous. As was noted for the other regional transit operators, some line item costs have been assigned to multiple supply variables. For the CHT model, there was only one split line item:

- ***Vehicle Operations: Non-Operator Salaries and Wages*** are 70 percent driven by revenue bus-hours and 30 percent driven by the number of garages. Fringe benefits are allocated proportionally to the same driving variables.

In addition to the supply variables listed in Table 6-1, from which line item unit costs are derived, the model also incorporates resource variables specifically to provide labor productivity and fuel consumption ratios.

- NTD-reported employee work hours are included as a resource variable for estimating salaries and wages by functional area for the project alternatives. For Vehicle Operations, NTD does not subdivide total work hours reported by operator and non-operator so the 2012 model maintains the same ratio of operator and non-operator work hours that was provided by CHT staff for the 2011 version of the cost model. Fringe benefit cost estimates pivot off labor work hours.
- The CHT bus O&M cost model uses gallons of fuel as the resource variable for estimating those fuel costs for the future.

For all other line items, the model calculates productivity using supply variable input.

Table 6-2 summarizes the dollar impact that each of the bus model's key supply variables has on the calibration (FY 2011 base year) system. The unit costs in this table reflect the dollar amount the model will adjust for each added or deleted unit of a supply variable – the incremental change from the calibration bus system. In other words, for each CHT revenue bus-mile added, the model will increase its total estimate by $2.37; for each revenue bus-hour deleted, the model will subtract $47.38 from its estimate, and so forth.

Table 6-2: Chapel Hill Transit Bus Cost Model Supply Variable Impacts for the 2012 Calibration Bus System (in 2012 dollars)

Key Supply Variable	Share of Total O&M Cost		Unit Cost
	Dollar Amount	Percentage	
Annual Revenue Bus-Hours	$7,474,914	51.4%	$47.38
Annual Revenue Bus-Miles	$4,268,684	29.3%	$2.37
Garages	$1,246,279	8.6%	$1,246,279
Peak Buses	$1,559,742	10.7%	$21,366
Total	**$14,549,619**	**100.0%**	

Table 6-3 presents the Chapel Hill Transit bus O&M cost model worksheet for the 2012 calibration (base year), created with the supply variables shown in Table 6-1. Model results are inflated to represent 2015 dollars using the same CPI-U factor as in the Triangle Transit bus O&M cost model.

Table 6-3: Chapel Hill Transit Bus Line Item Detail

Durham-Orange County Corridor
Triangle Regional Transit Program
O&M Cost Models
CHAPEL HILL TRANSIT BUS LINE ITEM DETAIL

												Calibration		
												Inflation Factor:		1.049
				Bus Supply Variable Unit Cost Rate ($2012)				Productivity Ratio					Results in:	2015$
Expense Line Item	2012 Bus Expenses	Existing Unit Cost Adjusted	New Unit Cost Added	Revenue Bus-Hours	Revenue Bus-Miles	Garages	Peak Buses	Resource Variable	Resource Value	Resource/ Supply	Base Year Resource Unit Cost	Inflation Factor	Resource Unit Cost	Estimated Annual Cost
VEHICLE OPERATIONS														
OPERATORS' SALARIES & WAGES	*$4,196,294*			$26.60				Work Hours	273,394	1.73	$15.35	1.049	$16.10	$4,402,404
OTHER SALARIES & WAGES - Rev-Hours Driven (70%)	*$238,768*			$1.51				Work Hours	9,569	0.06	$24.95	1.049	$26.18	$250,495
OTHER SALARIES & WAGES - Oper Garage Driven (30%)	*$102,329*					$102,329		Work Hours	4,101	4,101	$24.95	1.049	$26.18	$107,355
FRINGE BENEFITS - Rev-Hours Driven	*$3,039,852*			$19.27				Work Hours	282,963	1.79	$10.74	1.049	$11.27	$3,189,161
FRINGE BENEFITS - Oper Garage Driven	*$70,138*					$70,138		Work Hours	4,101	4,101	$17.10	1.049	$17.94	$73,583
FUEL & LUBRICANTS	*$1,696,001*				$0.94			Gallons	499,763	0.28	$3.39	1.049	$3.56	$1,779,304
TIRES & TUBES	*$14,356*				$0.01			Revenue Miles	1,799,539	1.00	$0.01	1.049	$0.01	$15,061
OTHER MATERIALS & SUPPLIES	*$68,572*					$68,572		Garages	1	1.00	$68,572	1.049	$71,940	$71,940
MISCELLANEOUS EXPENSES	*$52,080*					$52,080		Garages	1	1.00	$52,080	1.049	$54,638	$54,638
VEHICLE MAINTENANCE														
SALARIES & WAGES	*$951,167*				$0.53			Work Hours	54,118	0.03	$17.58	1.049	$18.44	$997,886
FRINGE BENEFITS	*$570,020*				$0.32			Work Hours	54,118	0.03	$10.53	1.049	$11.05	$598,018
FUEL & LUBRICANTS	*$45,831*						$627.82	Peak Buses	73	1.00	$628	1.049	$659	$48,082
TIRES & TUBES	*$0*						$0.00	Peak Buses	73	1.00	$0.00	1.049	$0.00	$0
OTHER MATERIALS & SUPPLIES	*$745,440*				$0.41			Revenue Miles	1,799,539	1.00	$0.41	1.049	$0.43	$782,054
MISCELLANEOUS EXPENSES	*$15,343*					$15,343		Garages	1	1.00	$15,343	1.049	$16,097	$16,097
NON-VEHICLE MAINTENANCE														
SALARIES & WAGES	*$59,134*					$59,134		Work Hours	3,310	3,310	$17.87	1.049	$18.74	$62,038
FRINGE BENEFITS	*$46,405*					$46,405		Work Hours	3,310	3,310	$14.02	1.049	$14.71	$48,684
PROF & TECH SERVICES	*$591,975*					$591,975		Garages	1	1.00	$591,975	1.049	$621,051	$621,051
MATERIALS & SUPPLIES	*$13,417*					$13,417		Garages	1	1.00	$13,417	1.049	$14,076	$14,076
MISCELLANEOUS EXPENSES	*$7,350*					$7,350		Garages	1	1.00	$7,350	1.049	$7,711	$7,711
GENERAL ADMINISTRATION														
SALARIES & WAGES	*$439,892*						$6,026	Work Hours	20,970	287.26	$20.98	1.049	$22.01	$461,498
FRINGE BENEFITS	*$198,083*						$2,713	Work Hours	20,970	287.26	$9.45	1.049	$9.91	$207,812
PROFESSIONAL & TECHNICAL SERVICES	*$819,817*						$11,230	Peak Buses	73	1.00	$11,230	1.049	$11,782	$860,084
MATERIALS & SUPPLIES	*$15,991*					$15,991		Garages	1	1.00	$15,991	1.049	$16,776	$16,776
UTILITIES	*$203,545*					$203,545		Garages	1	1.00	$203,545	1.049	$213,543	$213,543
CASUALTY & LIABILITY	*$291,700*				$0.16			Revenue Miles	1,799,539	1.00	$0.16	1.049	$0.17	$306,027
MISCELLANEOUS EXPENSES	*$56,119*						$769	Peak Buses	73	1.00	$769	1.049	$807	$58,875
TOTALS	***$14,549,619***			**$47.38**	**$2.37**	**$1,246,279**	**$21,366**							**$15,264,254**
2012 Resource Variable Values				**157,768**	**1,799,539**	**1**	**73**						Revenue Hours	157,768
													Revenue Miles	1,799,539
													Garages	1
													Transit Centers	0
													Peak Buses	73

Notes:
1. NTD Fringe Benefit Rate for Vehicle Ops = 68.5%
2. NTD Fringe Benefit Rate for Vehicle Maint = 59.9%
3. NTD Fringe Benefit Rate for Non-Vehicle Maint = 78.5%
4. NTD Fringe Benefit Rate for General Admin = 45.0%

7. Light Rail Transit Operations and Maintenance Cost Model

Because LRT would be a new mode of transit in Durham and Orange Counties, the LRT cost model for the project's Light Rail Alternatives is based on operating characteristics and costs for a group of existing systems. The first step in developing this model was to identify a set of peer systems that would be averaged to form the basis for the D-O LRT Project. Following selection of the peers, the LRT O&M modeling process resembles that described above for the local bus systems: selecting key supply variables to use as cost drivers; extracting peer system values from the NTD; combining LRT line item expenses with supply variables to obtain unit costs; and identifying any special cost adjustments appropriate for the project's Light Rail Alternatives.

7.1 Peer Selection

This project's initial LRT peer selection process was carried out in 2012 using the 2010 NTD, which was the most current information publicly available at that time. Selection criteria were established to identify transit systems with service characteristics similar to what is proposed for the Light Rail Alternatives. The peers were identified from the "universe" of the 36 U.S. LRT systems in the NTD. The primary selection criteria included operating environment, system age, system size, and geographic location.

7.1.1 Operating Environment

It was deemed very important that the peer candidates operate conventional LRT systems with, for example, traction power for propulsion and typical LRT station spacing as opposed to the closer stops that generally occur in streetcar lines. Also, to more closely resemble the operating environment assumed for the Light Rail Alternatives, peer LRT systems should be directly operated by public transportation agencies rather than purchased transportation services operated by a contractor. Therefore, peer selection for this project would eliminate streetcar operations and purchased transportation systems.

7.1.2 System Age

Peers for the D-O LRT Project should be considered modern LRT systems to increase the likelihood that they represent consumption, productivity, and unit costs related to vehicle and track technologies that a new system would be purchasing. Therefore, older LRT systems would be deemed "not modern" and eliminated as candidates for O&M cost modeling purposes.

7.1.3 System Size

Using the number of peak vehicles as an indicator of overall system size, it was decided that the initial screening would focus on LRT systems within the fairly narrow range of 10 to 45 peak cars. If five to seven peers could pass this screen, these would best represent the Light Rail Alternatives in terms of system size.

7.1.4 Geographic Location

California and other West Coast systems were excluded as potential LRT peers for the Light Rail Alternatives because experience on other projects suggests that costs for these systems often do not

align with costs for other U.S. systems (e.g., higher wages and fringe benefit rates because of a higher cost of living, different utility rates, different insurance premium structures, and claims experience).

Table 7-1 displays the city locations of existing LRT systems and their performance on the criteria for peer system selection, based on information in the 2010 NTD. Cells marked with an "X" reflect systems eliminated as potential peers for this project. The five highlighted systems were accepted as an appropriate peer group for O&M costing purposes as required for the D-O LRT Project.

Table 7-1: Light Rail Peer System Selection

City	Peak Cars	Not LR Mode*	Purchased Transp.	Not Modern	System Size	Geographic Location
Baltimore	38					
Boston	156			X	X	
Buffalo	23			X		
Charlotte	14					
Cleveland	17			X		
Dallas	76				X	
Denver	104				X	
Detroit	10	X				
Galveston	0				X	
Hampton	0				X	
Houston	17					
Kenosha	3				X	
Little Rock	3	X			X	
Los Angeles	118				X	X
Memphis	12	X				
Minneapolis	27					
New Orleans	21	X	X	X		
Newark	16			X		
Newark	57		X		X	
Oceanside	6		X		X	X
Philadelphia	124				X	
Phoenix	32		X			
Pittsburgh	51				X	
Portland	110				X	X
Sacramento	56				X	X
Salt Lake City	43					
San Diego	93				X	X
San Francisco	139			X	X	X
San Jose	47				X	X
Seattle (King County)	2				X	X
Seattle (King County)	0		X		X	X
Seattle (Sound Transit)	2				X	X
Seattle (Sound Transit)	26		X			X
St. Louis	50				X	
Tampa	4	X			X	
Tucson	32				X	

Data Source: 2010 NTD
If Peak Cars = 0, there were no service statistics reported in the 2010 NTD.
*Not classified as Light Rail in the NTD, these systems are Automated Guideway (Detroit) or Streetcar operations.

7.2 Key Supply Variables

The following key supply variables are used as cost drivers for the D-O LRT Project's LRT O&M cost model:

- ***Annual Revenue Train-Hours:*** The hours that trains, of any number of passenger cars, travel while in revenue service over the entire fiscal year. Revenue train-hours include layover and schedule recovery but exclude time for deadhead, operator training, and maintenance testing.
- ***Annual Revenue Car-Miles:*** Consistent with the NTD, this variable is defined as the miles that passenger vehicles travel while in revenue service over an entire fiscal year. Revenue car-miles include layover and schedule recovery but exclude miles for deadhead, operator training, and maintenance testing.
- ***Yards:*** The sites usually comprised of maintenance facilities, shops, and non-revenue track, where LRT vehicles are inspected, maintained, repaired, and stored. It is not unusual for both heavy and light maintenance activities to occur in the same facility.
- ***Directional Route Miles:*** The mileage in each direction over which trains travel in revenue service. Directional route miles exclude staging or storage tracks at the beginning or end of a rail line. From a maintenance perspective, the guideway includes all buildings and structures dedicated to the operation of LRT including track, tunnels, bridges, and the electrification system.
- ***Passenger Stations:*** Stations are passenger boarding and deboarding facilities with a platform which may include stairs, escalators, canopies, wind shelters, lighting, ticket vending machines, and signage.
- ***Peak Cars:*** The maximum number of passenger service vehicles actually operated simultaneously on an average weekday. The model might use peak cars as a variable when it needs to estimate a line item cost based on overall system size.

7.3 Peer LRT System Data

Between the initial selection of peer LRT systems based on data representing 2010 and the recalibration of the project's bus cost models with 2012 statistics, the corresponding data for peer LRT systems changed as well. For project consistency, it was decided to keep the original group of LRT peers but update their modeled NTD statistics to the 2012 Report Year.

The following three bar graphs illustrate the range in overall cost and labor productivities for the peer systems that were selected for use in the D-O LRT Project. For reference, each peer's 2010 and 2012 NTD data are included in the graphs, although from this point on in the project's O&M cost modeling process, only the 2012 values are used.

Figure 7-1: Total Cost per Revenue Train-Hour

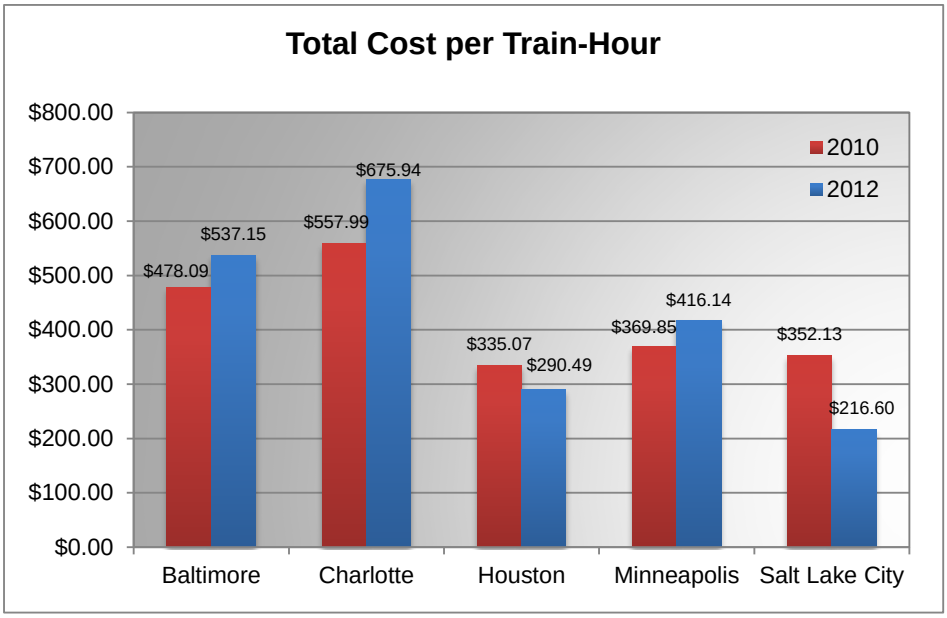


Figure 7-2: Total Cost per Revenue Car-Mile

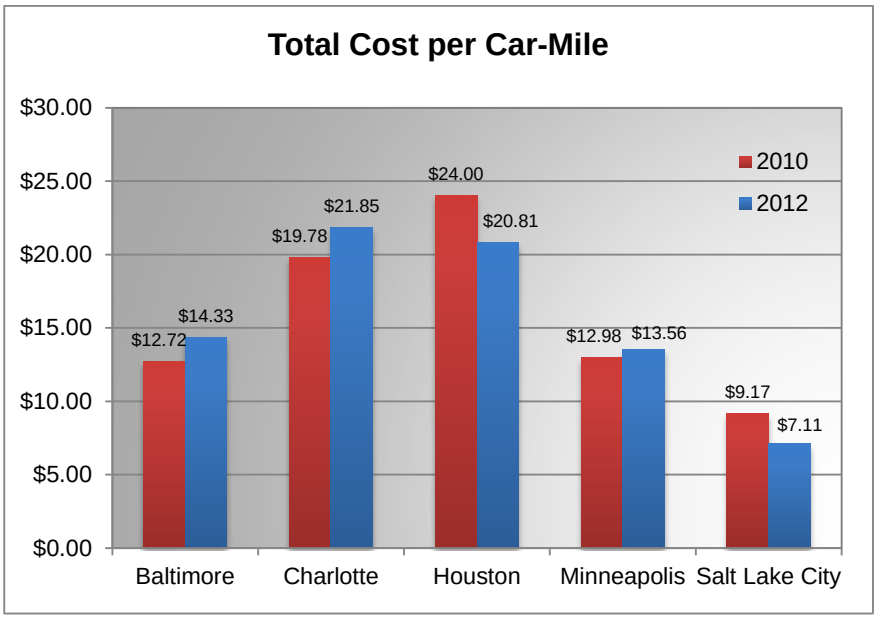
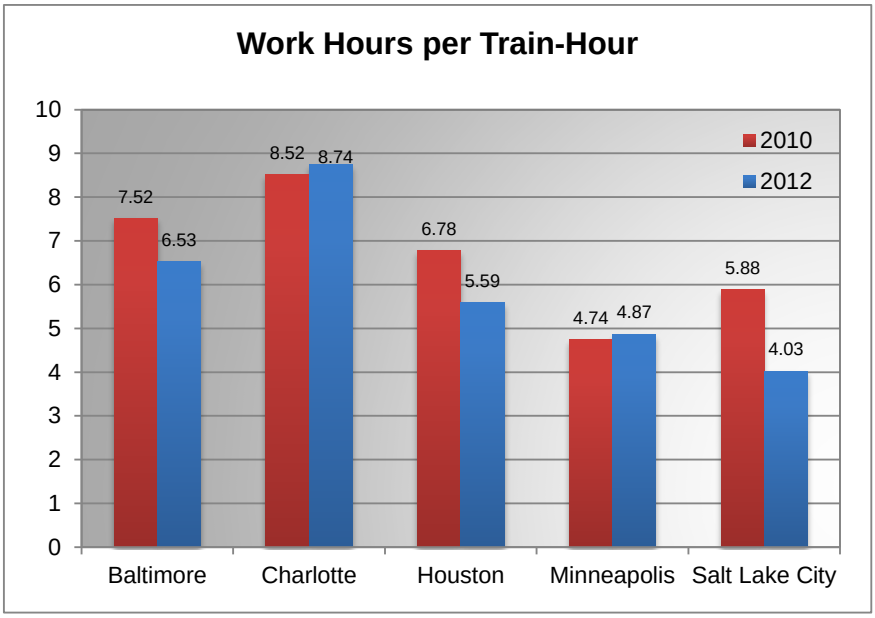


Figure 7-3: Work Hours per Revenue Train-Hour



Recalibration of the LRT O&M cost model began with values for the key supply variables, which were updated using the 2012 NTD for all of the LRT systems originally selected as D-O LRT peers. This system and service information is displayed in Table 7-2. The peer averages for the key supply variables function as the calibration LRT system on which the O&M cost model is based.

Table 7-2: Peer Light Rail Systems: Key Supply Variables

Service & System Inputs	Baltimore	Charlotte	Houston	Minneapolis	Salt Lake	Average
Annual Revenue Train-Hours	82,627	28,039	64,900	67,011	194,728	87,461
Annual Revenue Car-Miles	3,096,120	867,541	905,795	2,056,473	5,936,152	2,572,416
Peak Cars	38	14	16	24	71	33
Fixed Guideway Dir. Route Miles	57.6	18.6	14.8	24.7	70.7	37.28
Total Passenger Stations	33	15	16	19	50	22
Maintenance Facilities	2.0	1.0	1.0	1.0	2.0	1.4

NOTES:
1. Primary Calibration System Source: National Transit Database for the 2012 report year.
2. The NTD database shows 19 stations which include 15 LRT stations and four trolley stations. Charlotte Trolley service was discontinued in June of 2010 and as of 2012 there were 15 LRT stations in operation.

In addition to service and system characteristics, the O&M cost model incorporates employee work hour data for the peer LRT systems, which is shown below in Table 7-3.

Table 7-3: Peer LRT Systems: Annual Employee Work Hours

Work Hours by Functional Area	Baltimore	Charlotte	Houston	Minneapolis	Salt Lake	Average
Vehicle Operations						
FT Employee Work Hours	194,635	88,446	174,852	148,406	289,073	
PT Employee Work Hours	12,844	0	0	2,335	0	
Total Employee Work Hours	207,479	88,446	174,852	150,741	289,073	182,118
Vehicle Maintenance						
FT Employee Work Hours	119,476	60,059	78,391	73,714	202,644	
PT Employee Work Hours	0	0	0	202	0	
Total Employee Work Hours	119,476	60,059	78,391	73,916	202,644	106,897
Non-Vehicle Maintenance						
FT Employee Work Hours	148,906	37,804	99,586	79,045	200,355	
PT Employee Work Hours	0	0	0	0	4,242	
Total Employee Work Hours	148,906	37,804	99,586	79,045	204,597	113,988
General Administration						
FT Employee Work Hours	50,913	58,639	10,032	21,942	83,738	
PT Employee Work Hours	12,495	0	0	917	4,022	
Total Employee Work Hours	63,408	58,639	10,032	22,859	87,760	48,540

Source: National Transit Database for the 2012 Report Year
FT and PT abbreviations are for Full-Time and Part-Time employees, respectively.

7.4 Line Item Detail

After identifying peer systems and key supply variables, the next steps in model development were establishing the list of expense items, assigning a supply variable to each item, and calculating unit costs and productivity ratios.

The Appendices to this report provide the specific unit costs by supply variable for each line item cost, and labor productivity rates by supply variable for each labor category. These are displayed for each of the five peers and also averaged to create the calibration system values that the cost model uses. Features of the unit costs and labor productivity rates include the following:

- Peer system line items and costs are derived from the 2012 NTD. For consistency among the peers, all reported fuel/lube and tire/tube costs are combined under Vehicle Maintenance and casualty/liability, taxes and utilities (except for Vehicle Operations) expenses are classified as General Administration.
- The calibration (averaged) unit cost calculations give equal weight to each system (i.e., unit costs for larger systems are not more heavily weighted than unit costs for smaller systems). This is consistent with direction provided by FTA for other New Starts projects.

As was done in the bus cost models, select line items were assigned to two or more supply variables. This was done to more accurately reflect the likely contributing factors that affect increases or reductions for those specific items. Split line items in the LRT cost model are as follows:

- ***Vehicle Operations***: ***Non-Operator Salaries and Wages*** are 50 percent driven by revenue train-hours and 50 percent by the number of peak cars. The associated Fringe benefits are allocated proportionally to the same driving variables.

- ***Vehicle Operations***: ***Professional and Technical Services*** are 50 percent driven by revenue train-hours and 50 percent by stations. This line item cost typically includes contracted security and fare inspection services, which are influenced by the level of train service (i.e., train frequencies and span of service) and the number of stations.
- ***Vehicle Operations***: ***Utilities*** for traction power are 50 percent driven by revenue car-miles and 50 percent by peak cars. Typically, traction power costs are influenced by the maximum number of trains operating at one time in the peak periods, and the overall level of train service throughout the day.
- ***Vehicle Maintenance: Other Materials and Supplies*** are 50 percent driven by car-miles and 50 percent by peak cars, representing the typical focus on balancing provision of scheduled maintenance and running repair.
- ***Non-Vehicle Maintenance***: ***Salaries and Wages*** in the cost model are 40 percent driven by directional route miles, 40 percent by stations, and 20 percent by yards. The associated Fringe Benefits are allocated proportionally to the same driving variables. Past reviews of more detailed cost data from other rail systems has suggested that specific labor and non-labor expenses falling under non-vehicle maintenance can vary depending on the type of stations (e.g., aerial, subway stations), alignment characteristics (e.g., the type of train control system, right-of-way characteristics, aerial structures) and the size of the yard.
- ***Non-Vehicle Maintenance***: ***Professional and Technical Services*** are 40 percent driven by directional route miles, 40 percent by stations, and 20 percent by yards. These are the same splits noted above for salaries and wages.
- ***Non-Vehicle Maintenance***: ***Materials and Supplies*** are 40 percent driven by directional route miles, 40 percent by stations, and 20 percent by yards. These are the same splits noted above for salaries and wages.
- ***General Administration: Utilities*** are 50 percent driven by stations and 50 percent by yards, which simulates the facilities use of electricity, water, telephone, etc. (as separate from traction power for vehicle operations).
- ***General Administration***: ***Casualty and Liability*** expenses are 50 percent driven by stations and 50 percent by car-miles.

The NTD does not distinguish between operator and non-operator work hours under Vehicle Operations. However, work hour data available from Metro Transit (Minneapolis/St. Paul) indicates that two-thirds of their work hours reported under Vehicle Operations were associated with operator wages. The model assumes this split.

Finally, salaries and wages in the LRT cost model also were adjusted to reflect wage differences between Raleigh-Durham and the peer cities. The Bureau of Labor Statistics conducts periodic wage compensation studies. The 2013 survey was used to identify the mean wage rate for all occupations for the peer systems and Raleigh-Durham. The wage data presented in Table 7-4 indicates that Raleigh-Durham wage rates are 3.3 percent higher than the peer system average.

Table 7-4: Light Rail Cost Model Peer Earnings Adjustment for Raleigh-Durham

City	2012 Mean Hourly Wage
Baltimore	$24.95
Charlotte	$22.51
Houston	$23.96
Minneapolis	$24.54
Salt Lake City	$22.14
Peer Average	$23.62
Raleigh-Durham	$24.41
% Difference	3.32%
Adjustment Factor	103.3%

In addition to adjusting for the regional difference in wages, the model substitutes Triangle Transit's fringe benefit rates for the peer average.

Table 7-5 lists the resulting unit costs (in NTD 2012 Report Year dollars), which enable estimating the incremental change from the peer calibration system for any Light Rail Alternative tested. In other words, for each LRT revenue car-mile added, the model will increase its estimate by $2.98; for each revenue train-hour deleted, the model will subtract $87.43 from its estimate, and so forth.

Table 7-5: Light Rail Cost Model Supply Variable Unit Costs for the Calibration LRT System (in 2012 dollars)

Key Supply Variable	Unit Cost
Annual Revenue Train-Hours	$87.43
Annual Revenue Car-Miles	$2.98
Yards	$1,103,974
Directional Route Miles	$68,546
Passenger Stations	$144,147
Peak Cars	$296,889

Table 7-6 shows the LRT O&M cost model worksheet, created with the peer system average base year supply variable input (from Table 7-2) and the peer system average unit cost and labor productivity factors that are identified in this report's Appendices. Note that no existing peer unit costs were adjusted and no new unit costs were added to the LRT cost model.

The cost model applies a 1.049 inflation factor to estimate costs in 2015 dollars. This factor was derived from the Bureau of Labor Statistics, Consumer Price Index (CPI-U) for U.S. city average. The average of the two most recent annual periods (2012 to 2013, and 2013 to 2014) was used as a proxy for an additional 12 months of inflation so that project O&M cost estimates will represent 2015 dollars., Note that this rate is slightly different than the rate used to inflate costs for Triangle Transit, DATA and CHT bus O&M costs, for the inflation rate used for those systems is based on the CPI-U for the South U.S. region.

Table 7-6: Light Rail Line Item Detail

Durham-Orange County Corridor
Triangle Regional Transit Program
O&M Cost Models
LIGHT RAIL LINE ITEM DETAIL

C1-NHC LPA

												Inflation Factor:	1.049
	Light Rail Supply Variable Unit Cost Rate (2012$)						Productivity Ratio			Base Year		Results in:	2015$
Expense Line Item	Revenue Train-Hours	Revenue Car-Miles	Yards	Revenue Route-Mi	Stations	Peak Cars	Resource Variable	Resource Value	Resource/ Supply	Resource Unit Cost	Inflation Factor	Resource Unit Cost	Estimated Annual Cost
VEHICLE OPERATIONS													
VO Operator Salaries & Wages	$41.17						Train-Hours	Work Hours	1.586	$25.96	1.049	$27.24	$3,777,686
VO Other Salaries & Wages (Train-Hr)	$12.19						Train-Hours	Work Hours	0.416	$29.28	1.049	$30.72	$1,118,890
VO Other Salaries & Wages (Peak Cars)						$32,559	Peak Cars	Work Hours	1138	$28.60	1.049	$30.01	$819,795
VO Fringe Benefits (Train-Hr)	$17.81						Train-Hours	Work Hours	2.002	$8.89	1.049	$9.33	$1,634,053
VO Fringe Benefits (Peak Car)						$10,865	Peak Cars	Work Hours	1,138	$9.54	1.049	$10.01	$273,577
VO Prof/Tech Services (Train-Hr)	$16						Train-Hours	87,461	1.000	$15.53	1.049	$16.30	$1,425,286
VO Prof/Tech Services (Stations)					$29,227		Stations	22	1.000	$29,227	1.049	$30,663	$680,717
VO Other Matl & Supplies	$0.67						Train-Hours	87,461	1.000	$0.67	1.049	$0.70	$61,076
VO Utilities (Car-Mi)		$0.37					Car-Miles	2,572,416	1.000	$0.37	1.049	$0.39	$801,305
VO Utilities (Peak Cars)						$27,773	Peak Cars	33	1.000	$27,773	1.049	$29,137	$699,292
VO Miscellaneous	$0.06						Train-Hours	87,461	1.000	$0.06	1.049	$0.07	$5,763
VEHICLE MAINTENANCE													
VM Salaries & Wages		$1.35					Car-Miles	Work Hours	0.053	$25.57	1.049	$26.83	$2,918,129
VM Fringe Benefits		$0.448					Car-Miles	Work Hours	0.053	$8.47	1.049	$8.88	$966,205
VM Prof/Tech Services		$0.31					Car-Miles	2,572,416	1.000	$0.31	1.049	$0.32	$663,912
VM Fuel & Lubricants						$3,211	Peak Cars	33	1.000	$3,211	1.049	$3,369	$80,848
VM Tires & Tubes						$147	Peak Cars	33	1.000	$147	1.049	$154	$3,703
VM Other Matl & Supplies (Car-Miles)		$0.34					Car-Miles	2,572,416	1.000	$0.34	1.049	$0.35	$729,611
VM Other Matl & Supplies (Peak Cars)						$24,987	Peak Cars	33	1.000	$24,987	1.049	$26,215	$629,151
VM Miscellaneous						$4,119	Peak Cars	33	1.000	$4,119	1.049	$4,321.08	$103,706
NON-VEHICLE MAINTENANCE													
NVM Salaries & Wages (Route-Mi)				$36,531			Route-Mi	Work Hours	1,395	$26.18	1.049	$27.47	$1,428,751
NVM Salaries & Wages (Stations)					$45,251		Stations	Work Hours	1,721	$26.30	1.049	$27.59	$1,053,915
NVM Salaries & Wages (Yards)			$406,114				Yards	Work Hours	15,727	$25.82	1.049	$27.09	$596,486
Fringe Benefits (Route-Mi Driven)				$12,095			Route-Mi	Work Hours	1,395	$8.67	1.049	$9.09	$473,065
NVM Fringe Benefits (Stations Driven)					$14,983		Stations	Work Hours	1,721	$8.71	1.049	$9.14	$348,956
NVM Fringe Benefits (Yard Driven)			$134,466				Yards	Work Hours	15,727	$8.55	1.049	$8.97	$197,499
NVM Prof/Tech Services (Route-Mi)				$12,152			Route-Mi	37	1.000	$12,152	1.049	$12,749	$475,289
NVM Prof/Tech Services (Stations)					$16,978		Stations	22	1.000	$16,978	1.049	$17,812	$395,429
NVM Prof/Tech Services (Yards)			$150,340				Yards	1	1.000	$150,340	1.049	$157,724	$220,813
NVM Matl & Supplies (Route-Mi)				$7,441			Route-Mi	37	1.000	$7,441	1.049	$7,807	$291,039
NVM Matl & Supplies (Stations)					$8,928		Stations	22	1.000	$8,928	1.049	$9,367	$207,942
NVM Matl & Supplies (Yards)			$82,257				Yards	1	1.000	$82,257	1.049	$86,297	$120,816
NVM Miscellaneous				$327			Route-Mi	37	1.000	$327	1.049	$343	$12,777
GENERAL ADMINISTRATION													
GA Salaries & Wages						$88,290	Peak Cars	Work Hours	1,735	$50.90	1.049	$53.40	$2,223,037
GA Fringe Benefits						$29,233	Peak Cars	Work Hours	1,735	$16.85	1.049	$17.68	$736,057
GA Prof/Tech Services						$56,328	Peak Cars	33	1.000	$56,328	1.049	$59,095	$1,418,282
GA Matl & Supplies						$4,307	Peak Cars	33	1.000	$4,307	1.049	$4,518	$108,443
GA Utilities (Stations)					$18,174		Stations	22	1.000	$18,174	1.049	$19,067	$423,287
GA Utilities (Yards)			$330,797				Yards	1	1.000	$330,797	1.049	$347,045	$485,862
GA Casualty & Liability (Stations)					$10,605		Stations	22	1.000	$10,605	1.049	$11,126	$246,999
GA Casualty & Liability (Car-Mi)		$0.16					Car-Miles	2,572,416	1.000	$0.16	1.049	$0.17	$355,365
GA Taxes & Fees						$45.09	Peak Cars	33	1.000	$45	1.049	$47.30	$1,135.20
GA Miscellaneous						$15,025	Peak Cars	33	1.000	$15,025	1.049	$15,762	$378,299
TOTALS	**$87.43**	**$2.98**	**$1,103,974**	**$68,546**	**$144,147**	**$296,889**							**$29,592,247**
2012 Resource Variable Values	**87,461**	**2,572,416**	**1.4**	**37.3**	**22**	**33**						Rev Train-Hrs	87,461
Triangle Transit agency fringe benefit rates used:												Rev Car-Miles	2,056,473
Vehicle Operations =	33.37%											Peak Cars	24
Vehicle Maintenance =	33.11%											Track Miles	37.3
Non-Vehicle Maintenance =	33.11%											Stations	22
General Administration =	33.11%											Yards	1.4

8. Next Steps

The cost models described in this *Operations and Maintenance Cost Methodology Report* will be used to produce an annual O&M cost estimate for each of the Durham-Orange Corridor project alternatives. The required input statistics for the alternatives will be obtained from the project's *Transit Operating Plans*. The cost estimates will be documented in a separate *O&M Cost Results Report*, with expenses identified for each transit agency.

Appendices

APPENDIX A – Peer LRT Systems FY 2012 O&M Expenses and Unit Costs by Supply Variable

Peer LRT Systems
FY 2012 O&M Expenses and Unit Costs by Supply Variable

Line Item Cost	Supply Variable	% Split	Baltimore Cost	Baltimore Split Cost	Baltimore Unit Cost	Charlotte Cost	Charlotte Split Cost	Charlotte Unit Cost
Vehicle Operations								
VO Operator Salaries & Wages	Train-Hours	100%	$3,925,287	$3,925,287	$47.51	$1,327,801	$1,327,801	$47.36
VO Other Salaries & Wages (Train-Hr)	Train-Hours	50%	$2,249,772	$1,124,886	$13.61	$1,007,138	$503,569	$17.96
VO Other Salaries & Wages (Peak Cars)	Peak Cars	50%		$1,124,886	$29,602		$503,569	$35,969
VO Fringe Benefits	% of Wages	n/a	$4,969,182	$4,969,182	80%	$720,866	$720,866	31%
VO Prof/Tech Services (Train-Hr)	Train-Hours	50%	$4,369	$2,185	$0.03	$4,325,356	$2,162,678	$77.13
VO Prof/Tech Services (Stations)	Stations	50%		$2,185	$66.20		$2,162,678	$144,179
VO Other Matl & Supplies	Train-Hours	100%	$211,095	$211,095	$2.55	$2,870	$2,870	$0.10
VO Utilities (Car-Mi)	Car-Miles	50%	$2,742,660	$1,371,330	$0.44	$559,325	$279,663	$0.32
VO Utilities (Peak Cars)	Peak Cars	50%		$1,371,330	$36,088		$279,663	$19,976
VO Miscellaneous	Train-Hours	100%	$22,576	$22,576	$0.27	$1,144	$1,144	$0.04
Vehicle Maintenance								
VM Salaries & Wages	Car-Miles	100%	$3,531,394	$3,531,394	$1.14	$1,391,754	$1,391,754	$1.60
VM Fringe Benefits	% of Wages	n/a	$2,225,854	$2,225,854	63%	$404,443	$404,443	29%
VM Prof/Tech Services	Car-Miles	100%	$304,082	$304,082	$0.10	$248,482	$248,482	$0.29
VM Fuel & Lubricants	Peak Cars	100%	$81,955	$81,955	$2,157	$72,103	$72,103	$5,150
VM Tires & Tubes	Peak Cars	100%	$0	$0	$0.00	$1,628	$1,628	$116.29
VM Other Matl & Supplies (Car-Miles)	Car-Miles	50%	$4,740,253	$2,370,127	$0.77	$251,270	$125,635	$0.14
VM Other Matl & Supplies (Peak Cars)	Peak Cars	50%		$2,370,127	$62,372		$125,635	$8,974
VM Miscellaneous	Peak Cars	100%	$770,209	$770,209	$20,268.66	$2,129	$2,129	$152.07
Non-Vehicle Maintenance								
NVM Salaries & Wages (Route-Mi)	Route-Mi	40%	$4,216,180	$1,686,472	$29,279	$949,709	$379,884	$20,424
NVM Salaries & Wages (Stations)	Stations	40%		$1,686,472	$51,105		$379,884	$25,326
NVM Salaries & Wages (Yards)	Yards	20%		$843,236	$421,618		$189,942	$189,942
NVM Fringe Benefits	% of Wages	n/a	$2,753,137	$2,753,137	65%	$285,749	$285,749	30%
NVM Prof/Tech Services (Route-Mi)	Route-Mi	40%	$3,761,263	$1,504,505	$26,120	$111,600	$44,640	$2,400
NVM Prof/Tech Services (Stations)	Stations	40%		$1,504,505	$45,591		$44,640	$2,976
NVM Prof/Tech Services (Yards)	Yards	20%		$752,253	$376,126		$22,320	$22,320
NVM Matl & Supplies (Route-Mi)	Route-Mi	40%	$526,774	$210,710	$3,658	$46,721	$18,688	$1,005
NVM Matl & Supplies (Stations)	Stations	40%		$210,710	$6,385		$18,688	$1,246
NVM Matl & Supplies (Yards)	Yards	20%		$105,355	$52,677		$9,344	$9,344
NVM Miscellaneous	Route-Mi	100%	$4,757	$4,757	$82.59	$672	$672	$36.13
General Administration								
GA Salaries & Wages	Peak Cars	100%	$2,714,228	$2,714,228	$71,427	$1,477,816	$1,477,816	$105,558
GA Fringe Benefits	% of Wages	n/a	$1,885,385	$1,885,385	69%	$1,406,814	$1,406,814	95%
GA Prof/Tech Services	Peak Cars	100%	$44,926	$44,926	$1,182	$2,361,543	$2,361,543	$168,682
GA Matl & Supplies	Peak Cars	100%	$432,414	$432,414	$11,379.32	$16,383	$16,383	$1,170.21
GA Utilities (Stations)	Stations	50%	$1,232,209	$616,105	$18,670	$621,715	$310,858	$20,724
GA Utilities (Yards)	Yards	50%		$616,105	$308,052		$310,858	$310,858
GA Casualty & Liability (Stations)	Stations	50%	$434,975	$217,488	$6,591	$1,297,743	$648,872	$43,258
GA Casualty & Liability (Car-Mi)	Car-Miles	50%		$217,488	$0.07		$648,872	$0.75
GA Taxes & Fees	Peak Cars	100%	$0	$0	$0.00	$3,156	$3,156	$225.43
GA Miscellaneous	Peak Cars	100%	$597,860	$597,860	$15,733	$56,667	$56,667	$4,048
Total Costs			**$44,382,796**	**$44,382,796**		**$18,952,597**	**$18,952,597**	
Cost per Train-Hour			**$537.15**			**$675.94**		
Cost per Car-Mile			**$14.33**			**$21.85**		

Peer LRT Systems
FY 2012 O&M Expenses and Unit Costs by Supply Variable

Line Item Cost	Supply Variable	% Split	Houston Cost	Houston Split Cost	Houston Unit Cost	Minneapolis Cost	Minneapolis Split Cost	Minneapolis Unit Cost
Vehicle Operations								
VO Operator Salaries & Wages	Train-Hours	100%	$2,300,169	$2,300,169	$35.44	$2,514,877	$2,514,877	$37.53
VO Other Salaries & Wages (Train-Hr)	Train-Hours	50%	$1,592,159	$796,080	$12.27	$1,699,845	$849,923	$12.68
VO Other Salaries & Wages (Peak Cars)	Peak Cars	50%		$796,080	$49,755		$849,923	$35,413
VO Fringe Benefits	% of Wages	n/a	$2,207,437	$2,207,437	57%	$2,624,021	$2,624,021	62%
VO Prof/Tech Services (Train-Hr)	Train-Hours	50%	$23,635	$11,818	$0.18	$43,587	$21,794	$0.33
VO Prof/Tech Services (Stations)	Stations	50%		$11,818	$738.59		$21,794	$1,147.03
VO Other Matl & Supplies	Train-Hours	100%	$11,470	$11,470	$0.18	$33,122	$33,122	$0.49
VO Utilities (Car-Mi)	Car-Miles	50%	$614,989	$307,495	$0.34	$1,358,499	$679,250	$0.33
VO Utilities (Peak Cars)	Peak Cars	50%		$307,495	$19,218		$679,250	$28,302
VO Miscellaneous	Train-Hours	100%	$0	$0	$0.00	$0	$0	$0.00
Vehicle Maintenance								
VM Salaries & Wages	Car-Miles	100%	$2,007,936	$2,007,936	$2.22	$2,065,626	$2,065,626	$1.00
VM Fringe Benefits	% of Wages	n/a	$1,134,552	$1,134,552	57%	$1,286,027	$1,286,027	62%
VM Prof/Tech Services	Car-Miles	100%	$935,458	$935,458	$1.03	$7,775	$7,775	$0.00
VM Fuel & Lubricants	Peak Cars	100%	$13,378	$13,378	$836	$80,500	$80,500	$3,354
VM Tires & Tubes	Peak Cars	100%	$6,693	$6,693	$418.31	$4,712	$4,712	$196.33
VM Other Matl & Supplies (Car-Miles)	Car-Miles	50%	$815,086	$407,543	$0.45	$943,150	$471,575	$0.23
VM Other Matl & Supplies (Peak Cars)	Peak Cars	50%		$407,543	$25,471		$471,575	$19,649
VM Miscellaneous	Peak Cars	100%	$0	$0	$0.00	$0	$0	$0.00
Non-Vehicle Maintenance								
NVM Salaries & Wages (Route-Mi)	Route-Mi	40%	$2,480,158	$992,063	$67,031	$2,361,060	$944,424	$38,236
NVM Salaries & Wages (Stations)	Stations	40%		$992,063	$62,004		$944,424	$49,707
NVM Salaries & Wages (Yards)	Yards	20%		$496,032	$496,032		$472,212	$472,212
NVM Fringe Benefits	% of Wages	n/a	$1,381,574	$1,381,574	56%	$1,469,960	$1,469,960	62%
NVM Prof/Tech Services (Route-Mi)	Route-Mi	40%	$636,532	$254,613	$17,204	$462,118	$184,847	$7,484
NVM Prof/Tech Services (Stations)	Stations	40%		$254,613	$15,913		$184,847	$9,729
NVM Prof/Tech Services (Yards)	Yards	20%		$127,306	$127,306		$92,424	$92,424
NVM Matl & Supplies (Route-Mi)	Route-Mi	40%	$573,459	$229,384	$15,499	$773,417	$309,367	$12,525
NVM Matl & Supplies (Stations)	Stations	40%		$229,384	$14,336		$309,367	$16,282
NVM Matl & Supplies (Yards)	Yards	20%		$114,692	$114,692		$154,683	$154,683
NVM Miscellaneous	Route-Mi	100%	$328	$328	$22.16	$0	$0	$0.00
General Administration								
GA Salaries & Wages	Peak Cars	100%	$596,298	$596,298	$37,269	$4,247,544	$4,247,544	$176,981
GA Fringe Benefits	% of Wages	n/a	$485,230	$485,230	81%	$2,545,036	$2,545,036	60%
GA Prof/Tech Services	Peak Cars	100%	$684,536	$684,536	$42,784	$1,203,846	$1,203,846	$50,160
GA Matl & Supplies	Peak Cars	100%	$9,135	$9,135	$570.94	$138,357	$138,357	$5,764.88
GA Utilities (Stations)	Stations	50%	$382,546	$191,273	$11,955	$913,803	$456,902	$24,047
GA Utilities (Yards)	Yards	50%		$191,273	$191,273		$456,902	$456,902
GA Casualty & Liability (Stations)	Stations	50%	-$79,017	-$39,509	-$2,469	$66,751	$33,376	$1,757
GA Casualty & Liability (Car-Mi)	Car-Miles	50%		-$39,509	($0.04)		$33,376	$0.02
GA Taxes & Fees	Peak Cars	100%	$0	$0	$0.00	$0	$0	$0.00
GA Miscellaneous	Peak Cars	100%	$38,784	$38,784	$2,424	$1,042,599	$1,042,599	$43,442
Total Costs			**$18,852,525**	**$18,852,525**		**$27,886,232**	**$27,886,232**	
Cost per Train-Hour			**$290.49**			**$416.14**		
Cost per Car-Mile			**$20.81**			**$13.56**		

Peer LRT Systems
FY 2012 O&M Expenses and Unit Costs by Supply Variable

Line Item Cost	Supply Variable	% Split	Salt Lake City Cost	Salt Lake City Split Cost	Salt Lake City Unit Cost	Unweighted Average Cost	Unweighted Average Unit Cost
Vehicle Operations							
VO Operator Salaries & Wages	Train-Hours	100%	$6,114,275	$6,114,275	$31.40	$3,236,482	$41.17
VO Other Salaries & Wages (Train-Hr)	Train-Hours	50%	$968,218	$484,109	$2.49	$1,503,426	$12.19
VO Other Salaries & Wages (Peak Cars)	Peak Cars	50%		$484,109	$6,818		$32,559
VO Fringe Benefits	% of Wages	n/a	$3,919,412	$3,919,412	55%	$2,888,184	57%
VO Prof/Tech Services (Train-Hr)	Train-Hours	50%	$644	$322	$0.00	$879,518	$15.53
VO Prof/Tech Services (Stations)	Stations	50%		$322	$6.44		$29,227
VO Other Matl & Supplies	Train-Hours	100%	$0	$0	$0.00	$51,711	$0.67
VO Utilities (Car-Mi)	Car-Miles	50%	$5,009,920	$2,504,960	$0.42	$2,057,079	$0.37
VO Utilities (Peak Cars)	Peak Cars	50%		$2,504,960	$35,281		$27,773
VO Miscellaneous	Train-Hours	100%	$0	$0	$0.00	$4,744	$0.06
Vehicle Maintenance							
VM Salaries & Wages	Car-Miles	100%	$3,438,394	$3,438,394	$0.58	$2,487,021	$1.35
VM Fringe Benefits	% of Wages	n/a	$3,134,418	$3,134,418	91%	$1,637,059	60%
VM Prof/Tech Services	Car-Miles	100%	$697,287	$697,287	$0.12	$438,617	$0.31
VM Fuel & Lubricants	Peak Cars	100%	$323,589	$323,589	$4,558	$114,305	$3,211
VM Tires & Tubes	Peak Cars	100%	$309	$309	$4.35	$2,668	$147
VM Other Matl & Supplies (Car-Miles)	Car-Miles	50%	$1,202,824	$601,412	$0.10	$1,590,517	$0.34
VM Other Matl & Supplies (Peak Cars)	Peak Cars	50%		$601,412	$8,471		$24,987
VM Miscellaneous	Peak Cars	100%	$12,293	$12,293	$173.14	$156,926	$4,118.77
Non-Vehicle Maintenance							
NVM Salaries & Wages (Route-Mi)	Route-Mi	40%	$3,854,537	$1,541,815	$21,808	$2,772,329	$36,531
NVM Salaries & Wages (Stations)	Stations	40%		$1,541,815	$30,836		$45,251
NVM Salaries & Wages (Yards)	Yards	20%		$770,907	$385,454		$406,114
NVM Fringe Benefits	% of Wages	n/a	$2,672,242	$2,672,242	69%	$1,712,532	57%
NVM Prof/Tech Services (Route-Mi)	Route-Mi	40%	$1,335,216	$534,086	$7,554	$1,261,346	$12,152
NVM Prof/Tech Services (Stations)	Stations	40%		$534,086	$10,682		$16,978
NVM Prof/Tech Services (Yards)	Yards	20%		$267,043	$133,522		$150,340
NVM Matl & Supplies (Route-Mi)	Route-Mi	40%	$798,894	$319,558	$4,520	$543,853	$7,441
NVM Matl & Supplies (Stations)	Stations	40%		$319,558	$6,391		$8,928
NVM Matl & Supplies (Yards)	Yards	20%		$159,779	$79,889		$82,257
NVM Miscellaneous	Route-Mi	100%	$105,521	$105,521	$1,492.52	$22,256	$327
General Administration							
GA Salaries & Wages	Peak Cars	100%	$2,557,100	$2,557,100	$36,015	$2,318,597	$88,290
GA Fringe Benefits	% of Wages	n/a	$1,898,057	$1,898,057	74%	$1,644,104	76%
GA Prof/Tech Services	Peak Cars	100%	$1,337,230	$1,337,230	$18,834	$1,126,416	$56,328
GA Matl & Supplies	Peak Cars	100%	$188,091	$188,091	$2,649.17	$156,876	$4,307
GA Utilities (Stations)	Stations	50%	$1,547,598	$773,799	$15,476	$939,574	$18,174
GA Utilities (Yards)	Yards	50%		$773,799	$386,900		$330,797
GA Casualty & Liability (Stations)	Stations	50%	$388,995	$194,498	$3,890	$421,889	$10,605
GA Casualty & Liability (Car-Mi)	Car-Miles	50%		$194,498	$0.03		$0.16
GA Taxes & Fees	Peak Cars	100%	$0	$0	$0.00	$631	$45.09
GA Miscellaneous	Peak Cars	100%	$672,804	$672,804	$9,476	$481,743	$15,025
Total Costs			**$42,177,868**	**$42,177,868**		**$30,450,404**	
Cost per Train-Hour			**$216.60**			**$348.16**	
Cost per Car-Mile			**$7.11**			**$11.84**	

NOTES:
1. Fuel/Lube and Tire/Tube expenses are combined under Vehicle Maintenance.
2. Casualty & Liability expenses are combined under General Administration.
3. Taxes are combined under General Administration.
4. Utilities (except for Vehicle Operations) are combined under General Administration.
5. Minneapolis: $5.7 million G&A Expense Transfer redistributed proportionally to G&A salaries and wages, fringe benefits and services.
6. Red numbers in parentheses (if any) indicate credit values.
7. Wages for peer system average factored to represent difference in wages between the peer systems and Raleigh/Durham, based on Bureau of Labor Statistics National Wage Comparison Survey for Metropolitan Areas, May 2013

APPENDIX B – Peer LRT Systems FY 2012 Work Hour Productivity Rates by Supply Variable

Peer LRT Systems
FY 2012 Work Hours and Productivity Factors by Supply Variable

Line Item Cost	Supply Variable	% Split	Baltimore Hours	Baltimore Split Hours	Baltimore Unit Hours	Charlotte Hours	Charlotte Split Hours	Charlotte Unit Hours
VO Operator Salaries & Wages	Train-Hours	100%	136,035	136,035	1.65	57,990	57,990	2.07
VO Other Salaries & Wages (Train-Hr)	Train-Hours	50%	71,444	35,722	0.43	30,456	15,228	0.54
VO Other Salaries & Wages (Peak Cars)	Peak Cars	50%		35,722	940		15,228	1,088
VM Salaries & Wages	Car-Miles	100%	119,476	119,476	0.04	60,059	60,059	0.07
NVM Salaries & Wages (Route-Mi)	Route-Mi	40%	148,906	59,562	1,034	37,804	15,122	813
NVM Salaries & Wages (Stations)	Stations	40%		59,562	1,805		15,122	1,008
NVM Salaries & Wages (Yards)	Yards	20%		29,781	14,891		7,561	7,561
GA Salaries & Wages	Peak Cars	100%	63,408	63,408	1,669	58,639	58,639	4,189
Total Work Hours			**539,269**	**539,269**		**244,948**	**244,948**	
Work Hours per Train-Hour			**6.53**			**8.74**		

Line Item Cost	Supply Variable	% Split	Houston Hours	Houston Split Hours	Houston Unit Hours	Minneapolis Hours	Minneapolis Split Hours	Minneapolis Unit Hours
VO Operator Salaries & Wages	Train-Hours	100%	114,643	114,643	1.77	98,834	98,834	1.47
VO Other Salaries & Wages (Train-Hr)	Train-Hours	50%	60,209	30,105	0.46	51,907	25,953	0.39
VO Other Salaries & Wages (Peak Cars)	Peak Cars	50%		30,105	1,882		25,953	1,081
VM Salaries & Wages	Car-Miles	100%	78,391	78,391	0.09	73,916	73,916	0.04
NVM Salaries & Wages (Route-Mi)	Route-Mi	40%	99,586	39,834	2,692	79,045	31,618	1,280
NVM Salaries & Wages (Stations)	Stations	40%		39,834	2,490		31,618	1,664
NVM Salaries & Wages (Yards)	Yards	20%		19,917	19,917		15,809	15,809
GA Salaries & Wages	Peak Cars	100%	10,032	10,032	627	22,859	22,859	952
Total Work Hours			**362,861**	**362,861**		**326,561**	**326,561**	
Work Hours per Train-Hour			**5.59**			**4.87**		

Line Item Cost	Supply Variable	% Split	Salt Lake City Hours	Salt Lake City Split Hours	Salt Lake City Unit Hours	Average Hours	Average Unit Hours*
VO Operator Salaries & Wages	Train-Hours	100%	189,533	189,533	0.97	119,407	1.59
VO Other Salaries & Wages (Train-Hr)	Train-Hours	50%	99,540	49,770	0.26	62,711	0.42
VO Other Salaries & Wages (Peak Cars)	Peak Cars	50%		49,770	701		1,138
VM Salaries & Wages	Car-Miles	100%	202,644	202,644	0.03	106,897	0.05
NVM Salaries & Wages (Route-Mi)	Route-Mi	40%	204,597	81,839	1,158	113,988	1,395
NVM Salaries & Wages (Stations)	Stations	40%		81,839	1,637		1,721
NVM Salaries & Wages (Yards)	Yards	20%		40,919	20,460		15,727
GA Salaries & Wages	Peak Cars	100%	87,760	87,760	1,236	48,540	1,735
Total Work Hours			**784,074**	**784,074**		**451,543**	
Work Hours per Train-Hour			**4.03**			**5.16**	

NOTES:
Minneapolis ratio of Vehicle Operations (VO) rail operator/non-rail operator hours used for other peer systems.

Rail Operators	77,732	66%
Non-Rail Operators	40,824	34%
Total Work Hours	118,556	100%

*Average Unit Hours are unweighted.