Spring 4-20-2018

Analytical Hierarchy Process Evaluation of the Proposed Slim Modular Flexible Electric Bus Rapid Transit System

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By

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A Master's Thesis submitted to the Faculty of

Southern Polytechnic School of Engineering and Engineering Technology

Kennesaw State University

May 2018

ABSTRACT

As metropolitan Atlanta area is the one of the fastest growing regions in the nation, its demand for transportation infrastructure has grown. The region between Cobb County and Fulton County experiences the heaviest congestion in Metro-Atlanta. CobbLinc Route 10 is the only form of public transportation serving this area. To relieve the congestion and provide more effective public transportation system, Connect Cobb Corridor project has been proposed with the possible implementation of Bus Rapid Transit (BRT) system. Although BRT has gained popularity for its operational flexibility and efficiency, efforts have been put into developing a new concept vehicle that is better functioning and more cost-effective. Slim Modular Flexible Electric Bus Rapid Transit (SMFe-BRT) has characteristics that are expected to reduce the initial construction and operation and maintenance costs. Also, it is expected to have higher operational flexibility. The thesis evaluates these two public transit vehicle alternatives using analytical hierarchy process (AHP) method. Three categories of evaluation criteria—transit, emissions, and finances—are generated for AHP model. The traffic software Vissim is used to obtain evaluation results from Cobb Corridor for A.M., P.M., and off-peak conditions. Based on Vissim results and AHP, it is suggested that the implementation of SMFe-BRT is more beneficial than the traditional BRT.

AUTHOR ACKNOWLEDGEMENTS

I would first like to thank my thesis advisor Dr. Jidong Yang at Kennesaw State University. The door to Dr. Yang's office was always open whenever I ran into a trouble spot or had a question about my research or writing. He consistently allowed this paper to be my own work but steered me in the right the direction whenever he thought I needed it.

I would also like to thank the experts and organizations who provided much needed help for this research project:

- Cobb County Department of Transportation
- Georgia Department of Transportation
- Kimley-Horn and Associates, Inc.
- Andrea Foard, Cobb County DOT
- Jorge Pubillones, Cobb County DOT
- Michael Maxwell, Cobb County DOT
- Kyle Bright, PTV Group

LIST OF FIGURES

LIST OF TABLES

LIST OF EQUATIONS

TABLE OF CONTENTS

CHAPTER 1:

INTRODUCTION

1.1 Atlanta Region's Increasing Demand for Transportation Infrastructures

Atlanta, Georgia, and its metropolitan area are one of the fastest growing regions in the nation. According to Atlanta Regional Commission (ARC) 2014 Transportation Fact Book, Atlanta region has been adding 74,000 people each year since 1982. In 2011, Atlanta Metropolitan region is the ninth largest in the nation with population size of 4.3 million. Increasing population of the region and its demand for transportation infrastructure are causing severe congestion in Metro-Atlanta area. Total annual hours of delay have increased from 25,000 hours in 1982 to 150,000 hours in 2011. The population and the demand for transportation infrastructure changes have increased drastically. Despite the delay, the annual public transportation passenger miles traveled in Atlanta are only ranging between 500 miles to 1,000 miles from year of 1982 to 2011 [1].

The supply of public transportation does not satisfy the increasing demand. As a result, the major highways, Interstate 75, Interstate 85, and Interstate 285, suffer from severe congestions. As seen in Figure 1-1, mapped Levels-of-Service (LOS) by travel time index (TTI) indicates that most of the interstates located northern part of Atlanta were evaluated with LOS F. The region between Cobb County and Fulton County is one of the most congested areas in Metro-Atlanta. The area experiences the highest travel demand, especially from daily commuter traffic [2]. The only form of public transportation supplied is Cobb Linc Route 10, which travels from Marietta Transfer Center to Metropolitan Atlanta Rapid Transit Authority (MARTA) Arts Station located in Atlanta [3].

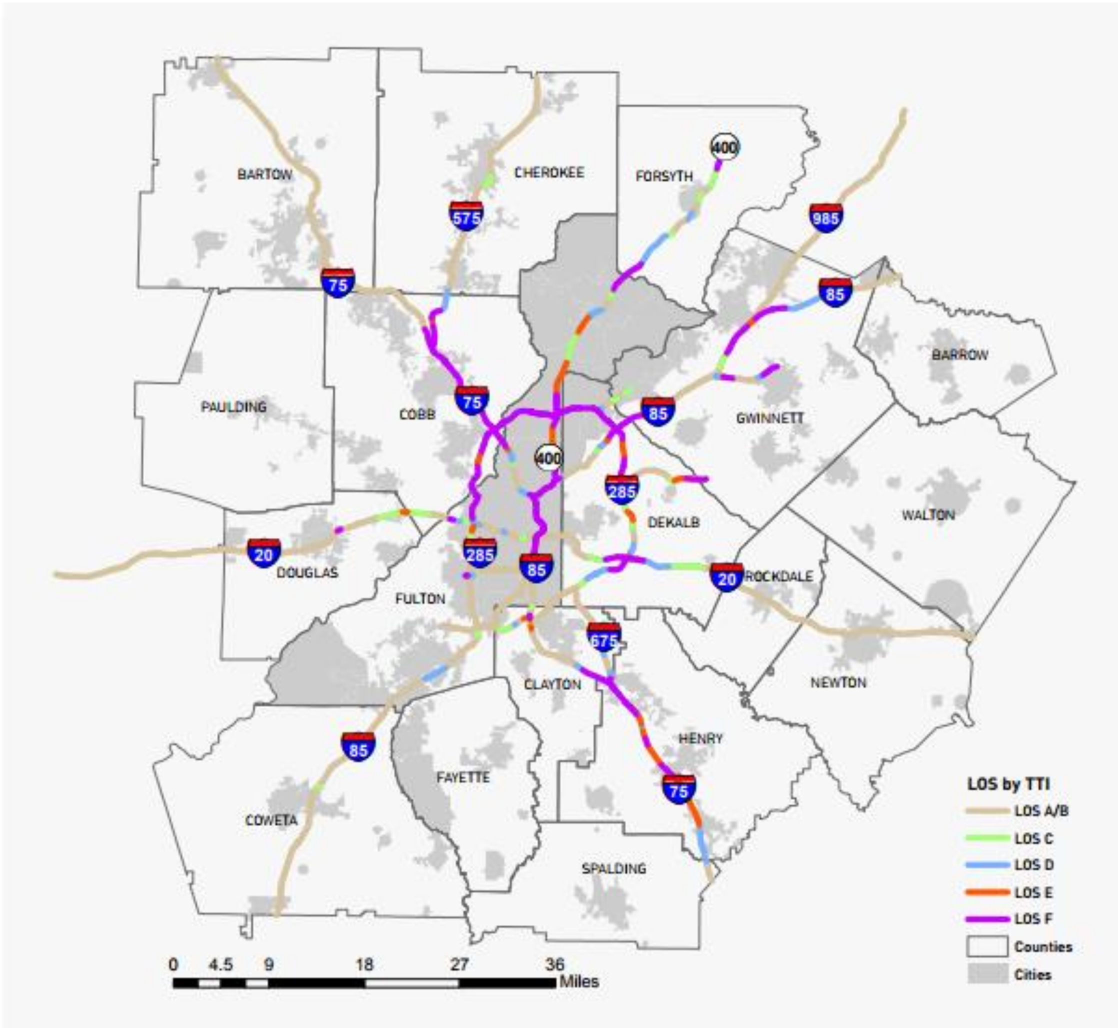

Figure 1-1Most Congested Highway Segments,2012 [1]

1.2 Project Objectives and Overview

As the demand rises for transportation infrastructure, the State of Georgia proposed Connect Cobb Corridor project in 2015 to improve the existing transit system. Connect Cobb Corridor project ranges from Kennesaw State University in Kennesaw, to MARTA Arts Center station in Atlanta. The project covers two counties suffer from severe traffic delay.

Connect Cobb Corridor project consists of following key features:

- Proposed Bus Rapid Transit (BRT) system
- Construction of dedicated bus lanes—center- and side-running dedicated guide lanes
- Usage of I-75 High Occupancy Vehicle (HOV) lanes
- The total distance of 25.3 miles of the proposed BRT line
- BRT with short headway of 8 minutes.
- 15 proposed BRT stations.

The location information of the above features can be found in Figure 1-2 in detail [2].

Introducing BRT in Metro-Atlanta region is one of the key features of the project. Since first implemented in Bogota, Colombia, BRT has gained popularities around the world in many cities. BRT system is adopted, because of its operation flexibility as well as lower operation costs [4]. Although BRTs have many benefits over the traditional municipal buses, efforts have been put into developing a new concept vehicle that is better functioning and more cost-effective.

Slim Modular Flexible Electric Bus Rapid Transit (SMFe-BRT) is an innovative concept vehicle. SMFe-BRT is:

- 25% narrower in width comparing to traditional BRT;
- Consisted with 1 lead module and driverless following modules;
- not physically coupled between each module, allowing easy attachments and detachments; and
- self-propelled using electric motors.

The key features of the new concept BRT expect to reduce construction and operation costs, and to be more environment-friendly. This thesis focuses on evaluating operational performance of SMFe-BRT, comparing to traditional BRT using Analytical Hierarchy Process (AHP). Traffic flow simulations were conducted using software Vissim.

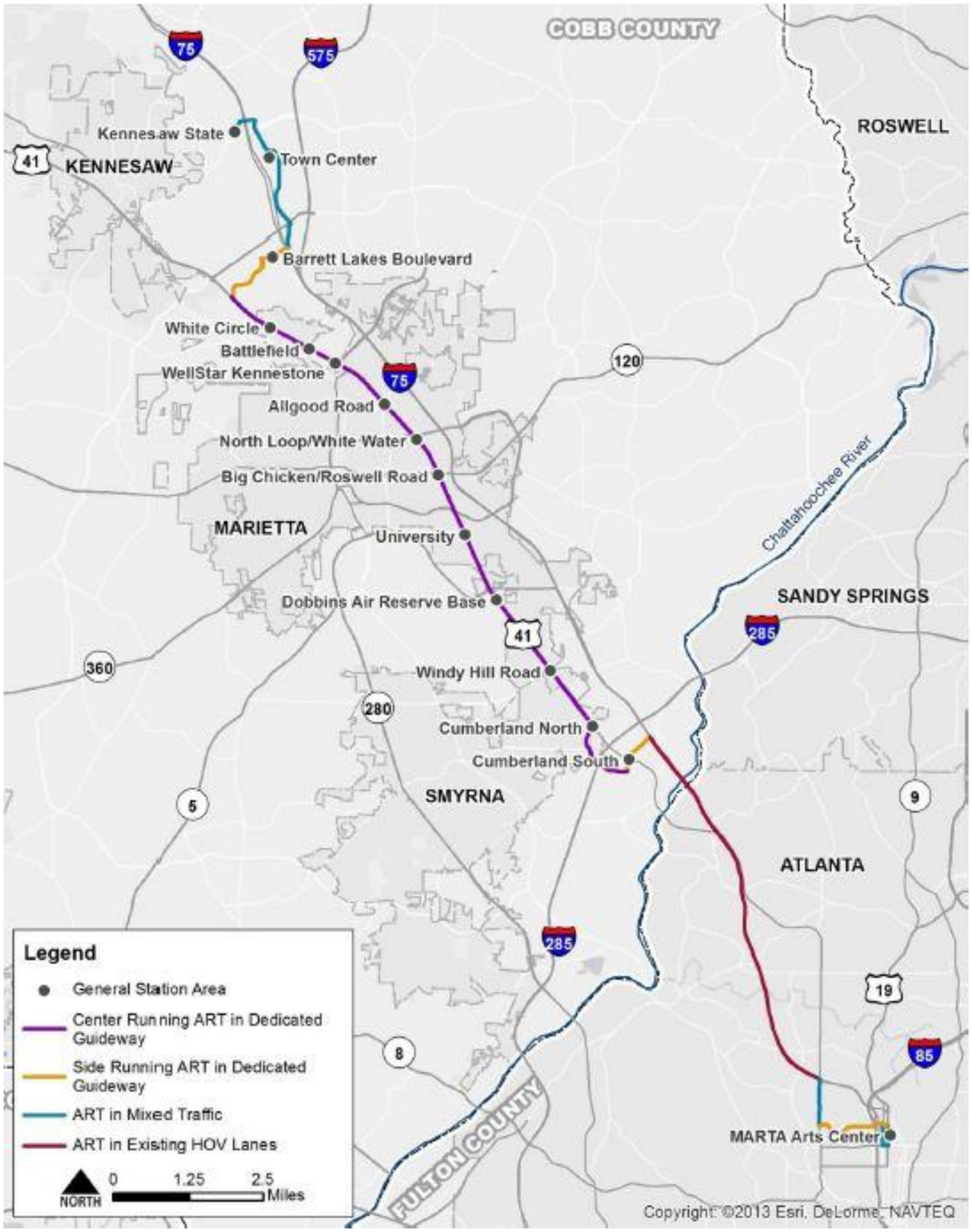

Figure 1-2 Proposed Connect Cobb Corridor Project

The primary objectives of this project are to:

1) Evaluate different alternative vehicles for the proposed Cobb Corridor project by using analytical hierarchy process method.
2) Incorporate traffic flow analysis software Vissim to obtain evaluation data results for AHP method.

1.3 Report Organization

The available literature needed in making future predictions, as well as developing AHP model is organized in Chapter 2. Chapter 3 includes the methodology and applications used for developing Vissim model, obtaining simulation results, and developing AHP method. Chapter 4 contains the application of the methodology introduced in Chapter 3, analyzes and summarizes the research data. Finally, Chapter 5 concludes the research findings.

CHAPTER 2:

REVIEW OF LITERATURE

2.1 Introduction

As one of the objectives of this thesis is the application of AHP method, future conditions of the corridor is forecasted. Generating future conditions involve many assumptions, therefore literature review needs to be conducted for needed subjects. To predict the future public transit ridership, literatures regarding the commuting tendency in Metro-Atlanta, and the study of BRT impact in other cities similar to Atlanta are studied. For environmental impact, emission studies by vehicle types are reviewed. Also, studies regarding applications of AHP method on transportation projects in various locations are also assessed.

2.2 Future Ridership Prediction

Commuting Data in Atlanta [5]

It is essential to investigate the existing average percentage of public transit demand, prior to make a prediction of future public transit ridership. The residents in Metropolitan Atlanta area rely heavily on their personal vehicles. The study shows 76.3 percent of the commute is by personal vehicles, although other modes of commute such as MARTA, bus and rail lines are also available. Statistics show that the percentage of commuters who choose their personal vehicles has been increasing, and of those who choose public transportation has been decreasing since 1990. Recent data in 2014 indicates percentage of public transit choice in Metro-Atlanta area is only 10.6%.

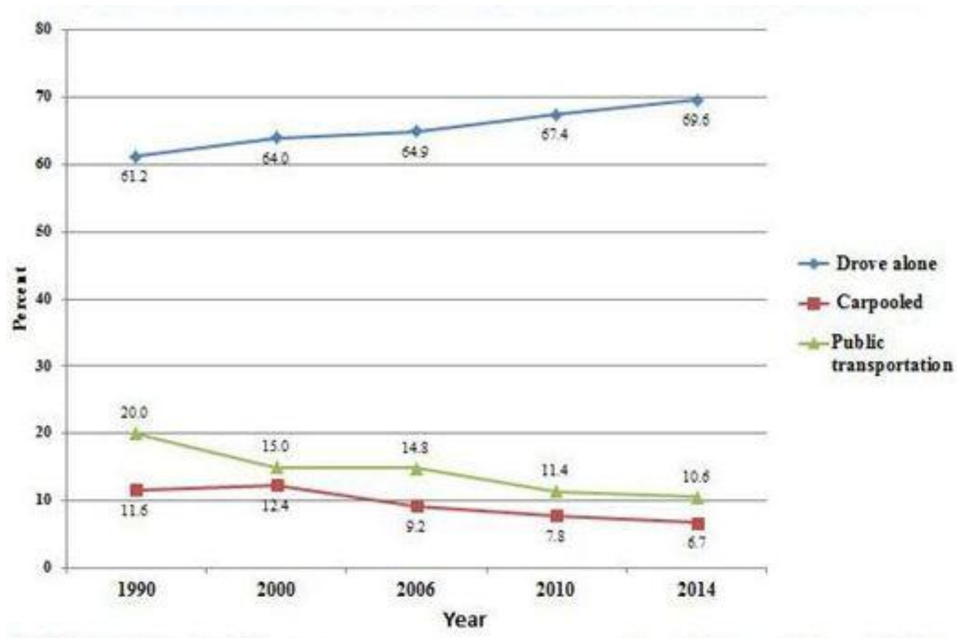

Figure 2-1 Commute Mode Share in Atlanta: 1990 to 2014

BRT Ridership Study [6]

Due to the advanced technology designs and features, BRT systems has gained popularity over the years. This popularity has promoted public's demand for the BRT systems. To measure the changes in BRT ridership, data was collected for 10 consecutive months in six BRT-operating cities. The results show that all six BRT-operating cities have experienced significant increases in ridership. In Las Vegas, "MAX" system introduced by Regional Transit Committee (RTC) is responsible for 35 to 40 percent growth in ridership. Alameda-Contra Costa (AC) Transit has resulted the highest 84 percent increases in ridership in the governing districts. Table 2-1 summarizes the ridership increase in various cities where BRT systems are adopted.

Table 2-1 The Effect of BRT Service on Transit Ridership

The Effect of BRT Service on Transit Ridership		
Transit Agency and Corridor	**Percent Increase in Ridership Levels**	**Percent Increase in Choice Riders**
AC Transit – 72R	66	32
Los Angeles MTA		
Wilshire/Whittier	42	67
Ventura	27	67
Boston MBTA – Silver Line	84	
Las Vegas RTC – MAX	>35-40	24
Phoenix RAPID	N/A	33

It can be inferred that the introduction of BRT system would induce increase of demand. As the highest percent increase in ridership level being 84%, the public transit ridership condition prior to the introduction of BRT is examined. Figure 2-2 pictures the mode choice distribution in California. The existing condition indicates that about 68% of individuals choose public transit, comparing to 19% using personal vehicles.

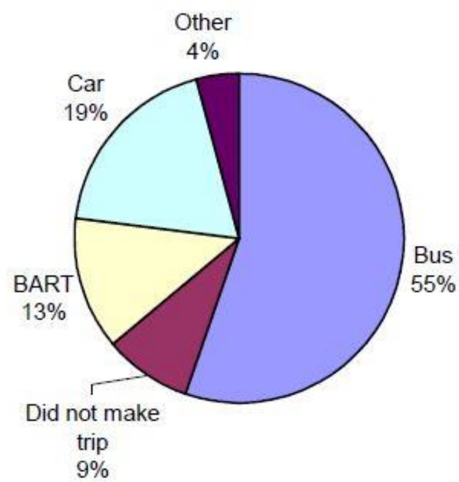

Figure 2-2 Mode Used before the Introduction of Rapid Bus

Ridership Responsiveness [7]

Traditionally the demand for public transportation has been more responsive to its service than the monetary values like bus fares. The service in public transportation includes values like headways and bus miles. The data gathered from cities such as Detroit, Chesapeake/Norfolk, Madison, Stevenage, Great Britain indicates the mean transit headway elasticity change is -0.47 with standard deviation of ±0.14 for all service hours. For high service level during peak hours, the mean value is -.27 with the standard deviation of ±0.14.

Analysis of Vehicle and Person Throughput [8]

As personal vehicles are the major mode of commute in Metro-Atlanta area, the existing high-occupancy vehicle (HOV) lanes on Interstate 85 (I-85) were experiencing congestion. To further improve the serviceability at I-85, HOV lanes were converted into high-occupancy toll (HOT) lanes. This report was generated after the conversion was taken place, to study changes in vehicle occupancy, vehicle and passenger throughput on I-85.

Since the implementation of HOT lanes, the average vehicle occupancy on HOT lanes have decreased from around 2 persons per vehicle to that of general purpose lanes. Observed occupancies for the lanes on I-85 shows on Table 2-1. Year 2012 is the latest observed year, and the average occupancy for all lanes are a little over 1 person per vehicle.

Table 2-2 Observed occupancy by Lane, Spring 2012, PM

Occupancy	HOT	GP1	GP2	GP3	GP4	GP5
1	85.3%	85.0%	86.0%	85.3%	83.7%	84.8%
2	12.2%	14.0%	12.9%	13.5%	14.6%	13.6%
3	0.8%	0.7%	0.6%	0.7%	1.2%	1.2%
4+	1.7%	0.4%	0.4%	0.6%	0.5%	0.5%
Sessions (n)	12	6	7	7	7	7
AVO	1.20	1.17	1.16	1.17	1.19	1.18

2.3 Emission Calculations

Public Transit Fuel Type [9]

Knowing the fuel type of a vehicle is the initial step for emission calculations. Most of heavy and public transit vehicles have used diesel fuel, and diesel is still the main source of fuel for heavy vehicles being manufactured. However, with the rising concerns on environment and air quality, alternative fuels have gained its popularity. Compressed and liquefied natural gas, duel fuel engines, grid connected, and hybrid electric are some alternative fuels that are available today.

Among the alternative fuels mentioned above, natural gas propulsion is the primary alternative for diesel public transit vehicles. In the U.S., approximately 7,000 public transit vehicles are operated by natural gas. Between two major types of natural gas propulsion system, compressed natural gas (CNG) is mainly selected over liquefied natural gas (LNG).

Automotive Emissions [10]

Depending on the purpose of a vehicle, the specific fuel type can be chosen upon designing. To control emissions and estimate emission from in-use vehicles, main pollutants from automobile emissions are defined. Harmful pollutants include: carbon monoxide (CO_2), nitrogen oxides (NO_x), unburned hydrocarbons, volatile organic compounds (VOCs), and particulate matter (PM). Other pollutants measured includes non-methane organic gases (HMOG). Since natural gas is mostly methane (CH_4), CNG vehicles are measured with much lower HMOG than gasoline or diesel vehicles. However, CNG vehicles produce higher emissions of methane.

Vehicle emission pollutants mentioned above are measured for CNG transit bus and listed as follows:

- **CO, PM 2.5, NO_x, THC** [11]

  CNG transit bus emission rates are measured for CO, PM2.5, and NO_x. It is found that vehicles emissions are emitted in different rates, depending on the manufactured year groups and the vehicle age groups. For the most recent manufactured years from 2007 to 2013, and age groups of 0-3 years, the pollutants are measured as follows: 2.18 g/mile for NO_x, 5.93 g/mile for CO, and 0.0016 g/mile for PM2.5 respectably. Total Hydrocarbon (THC) for the same manufactured year and age group is 4.33 g/mile.

- **Nitrous Oxide (N_2O), Methane (CH_4)** [12]

  N_2O and CH_4 emission rates are also measured for on-road CNG transit bus. The rates are listed as 1.97 g/mile for CH_4, and 0.175 g/mile for N_2O.

- **Carbon Dioxide (CO_2)** [13]

  CO_2 emission rates for CNG bus is measured as 2250 g/mile.

- **Volatile Organic Compounds (VOC)** [14]

  The ratio of VOC to THC is listed as 0.004. With THC rate of 4.33 g/mile provided above, VOC rate can be calculated using the given ratio. VOC rate is calculated as 0.017

g/mile.

2.4 Analytical Hierarchy Process in Practice

As AHP is a widely used MCDM method, there are examples application of AHP method for multi-criteria evaluations in transportation projects. This section of the paper focuses on introducing literatures adopted AHP method for evaluation of transportation projects. Also, the literature review explores the weight assignments of AHP method in transportation projects, seeking for implementation to this thesis.

The Case of Cracow, Poland [15]

AHP method is applied to evaluate Integrated System of Urban Transport (ISUPT) in Cracow. ISUPT is considered for mobility management purpose, and to encourage people's use of public transportation, use of bikes, and choice of walking. The purpose of this study is to present the methodology of MCDM method used, and to apply it to assess ISUPT alternatives. 8 variants are presented for ISUPT design in Cracow, and 10 evaluation criteria are created.

Criteria are chosen based on the survey of three interest groups: passengers, operator, and city authorities; and 10 criteria are as follows: 1) travel time, 2) journey standard, 3) rolling stock use index, 4) environmentally friendly, 5) level of integration of public urban transport system, 6) reliability of urban public transport system, 7) safety of journeys, 8) the profitability of the urban public transport systems, 9) availability of the urban public transport system, and 10) investment costs. The importance of criteria weighted by three interest groups are indicated in Figure 2-3.

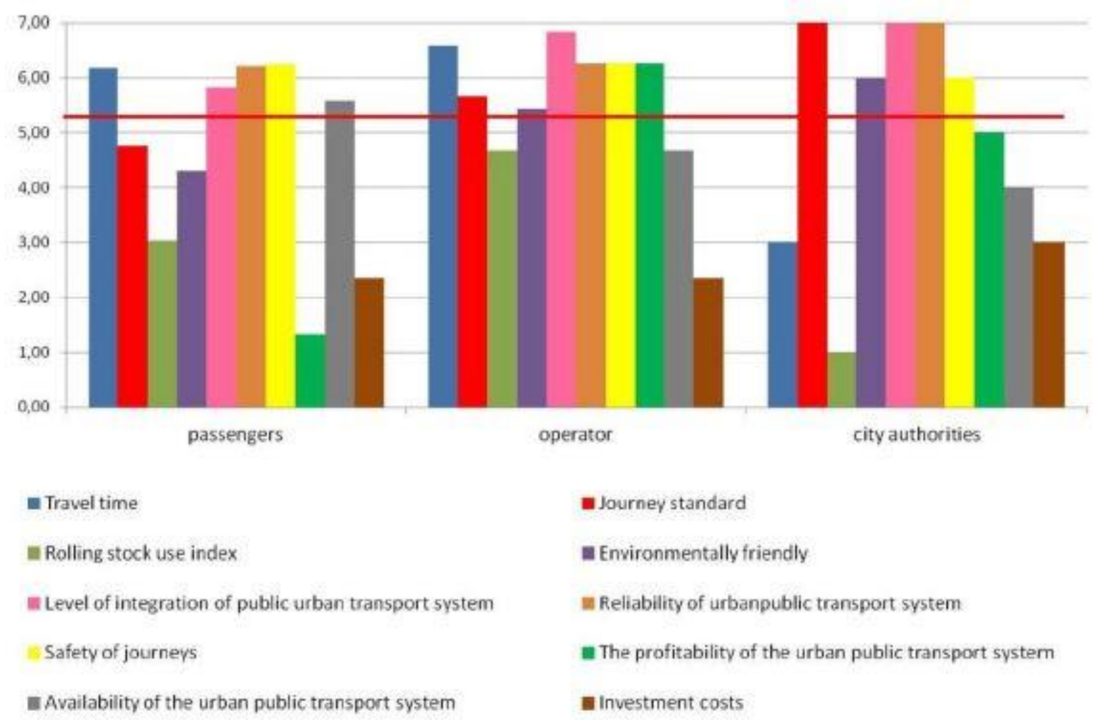

Figure 2-3 Definition of the Importance of the Criteria, Results of Surveys Conducted in Cracow

The Case of Korea [16]

As the highway system affects the users greatly, improvements of the infrastructure are emphasized. AHP tool was used to select the alternative modes of highway route improvements in Korea, using the measures of effectiveness (MOE). The AHP model was developed using the survey data, project interview, and personal interviews. The highway users, the government, and the community members were chosen as the interest groups for the AHP model development. Among three interest groups, the most important group was the highway users, with the weight assigned as 57%. The community members were the next in line with the weight of 29%, and the government was the least important with the weight of 13%. The significance of the community members in the literature was due to people's socio-economic statues, and the diverse demand.

Each interest groups were given with different importance of factors. The highway users were given with travel time, travel cost, safety, congestion, and convenience; weighting travel time the highest. Community members were given with regional equity, air pollution, noise impact, household displacement, and convenience. Regional equity was valued the most for community members. Lastly, safety, congestion, return on investment, project cost, energy consumption, regional equity, and air pollution were assigned with the government group. Safety was the most heavily weighted.

The authors compare the preference order result. AHP method was the main tool of evaluation in this literature, however economic analysis such as Net Present Worth, Benefit-Cost Ratio, and Internal Rate of Return result was expressed for comparison purpose. As shown, application of AHP method yields different priority result than other economic analysis.

Table 2-3 The Preference Order Using Both Economic and AHP Analysis

	A-1	A-2	A-3	B-1	B-2	B-3	B-4
Economic Analysis	1	2	3	1	2	3	4
AHP analysis	2	1	3	1	2	4	3

The Case of Lithuania [17]

The rail system in Lithuania is not very attractive to its passengers, because of the low speed, low level of comfort, and the low quality of railways and the dynamic characteristics of the locomotives. The study develops an AHP method to aid decision-making for adopting a more effective rail system in Lithuania.

The evaluation criteria for this study is organized based on the railway trip quality. It is divided into four main categories, which include the technical state of the track, railway planning and technology, price of the ticket, and the safety of the railroad. Once the evaluation criteria questionnaires are completed by three interest groups, passengers, train workers, and the administration staff, the criteria weight significance is calculated.

The Case of Singapore [18]

The research problem lies with rapid economic development in Singapore. Singapore's desire to build world-class transportation system encouraged the researchers to investigate different alternatives on alternative fuel use for the years of 2020-2030. The years of 2020-2030 are referred as Year X. The goal would be to displacing oil as a source of fuel. A multiple criteria decision method is used to identify 10 different fuel options, and then filter down to 4 main fuel alternatives for Year X. Analytical hierarchy process (AHP) method is used for selecting the best fuel system, and they are evaluated based on economic, technical and social considerations.

AHP method is extensively used for the evaluation of the alternatives. Sensitivity analysis is also performed, as it is an important concept when the quantitative decision model is used. It provides stability for the most optimum solution, especially when the parameters are sensitive to change. Forward and backward planning are also used with AHP method, to determine the likely future as well as the necessary policies.

The 10 preliminary alternative fuels are provided below. As mentioned earlier, alternatives are screened using the multiple criteria decision method, and narrowed down to 4. They are: status quo, oil and electric vehicles (EV), oil and natural gas vehicles (NGV), and methanol. Status quo refers to no change in transportation fuel. These 4 alternatives that are screened are evaluated using different criteria: consumer preference, safety, cost, supply, technology, and emission.

Also, the policy that aids the selected alternatives is also chosen from the list:

- Policy P1: to provide financial incentives to promote the use of electric vehicles;
- Policy P2: to adopt stricter emissions standards for motor vehicles;
- Policy P3: to provide the infrastructure to facilitate recharging of electric vehicles; or
- Policy P4: to lengthen the life of the certificate of entitlement for electric vehicles compared with oil vehicles.

It was found, after performing three steps of forward and backward processes, that the use of electric vehicles would be the best option, along with the combination of Policy P1 and P3.

2.5 Application of Analytical Hierarchy Process

Weight Assignments by Experts [19]

Multi-Criteria Decision Analysis (MCDA) is normally used for a decision supporting tool for selecting the optimal option for transportation projects. Although Cost-Benefit Analysis (CBA) is a popular decision-supporting tool, it is hard to use when the alternatives have values that are hard to be monetized. In this study, AHP method approach is used for this evaluation of BRT project. The alternatives are defined as: no build, BRT and light rail transit (LRT). Three main criteria: finance, transport, and land use are selected.

One of the crucial steps in performing AHP method reflects experts' opinions on weighing the criteria. The study shows the recent survey data that was answered by 19 experts from different countries—Brazil, Canada, Germany, the Netherlands, Portugal and USA. The survey data is shown on Table 2-4 According to the assigned weights, travel time, revenues, mode share and operation and maintenance (O&M) costs are the biggest influence factor for choosing an alternative, since they take up to 60% of the total weight.

Table 2-4 Priority Profile

Criteria	Sub-criteria	Final weights	Equivalent weights
Finance		**27,3%**	
	Capital cost	21,7%	5,9%
	O&M cost	33,0%	9,0%
	Revenues	45,3%	12,4%
Transport		**52,4%**	
	Travel time	42,7%	22,4%
	Mode share	23,5%	12,3%
	Transfers per trip	17,0%	8,9%
	Emissions	16,8%	8,8%
Land use		**20,2%**	
	Real estate	18,1%	3,7%
	Mixed-use	31,3%	6,3%
	Density	15,7%	3,2%
	Accessibility	34,9%	7,1%

2.6 Summary of Literature Review

Based on the literature review, assumptions and value that are used for the generation of Vissim model are created. The existing condition for public transit choice percentage in commuting is 10.6%, and with the new introduction of BRT system, 27% of increase is expected. This new BRT system is also anticipating the emission rates of different pollutants. Lastly, AHP model is generated according to the procedure and the criteria weights assigned based on the literatures.

CHAPTER 3:

METHODOLOGY

3.1 Vissim Model Simulation Parameters

The following list contains the unchanging value of Vissim network inputs throughout alternatives.

Desired Speed Decisions

Desired speed decision follows the local speed limits. The local speed limits are set for 45 mph on Cobb Parkway; 35 mph on intersecting roads with Cobb Parkway; and 65 mph on freeways. The desired speed decisions introduced are set for the personal vehicles.

Driving Behaviors

The driving behaviors on all simulations follow urban (motorized) driving behavior. It includes Wiedemann 74 car following model, which the desired distance between each car is calculated following formula [20]:

$$d = ax + bx, \tag{1}$$

where:

ax = standstill distance,

$bx = (bx_{additive} + bx_{multiplicative} \times z) \times \sqrt{v}$,

v = vehicle speed (m/s), and

z = value of range (0.1), which is normally distributed around 0.5 with a standard deviation of 0.15.

Vehicle Compositions

According to the existing data gathered, the percentage of trucks is estimated to be 3%. Also, the percentage of bus is 2%. The personal vehicle percentage is 95%.

Signal Controllers

Ring barrier signal controllers are the typical type of signal controller used in all Vissim models. A typical ring barrier diagram looks like Figure 3-1.

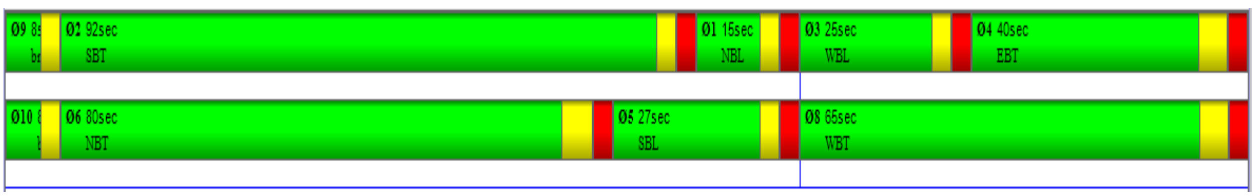

Figure 3-1 Typical Ring Barrier Diagram

Simulation Characteristics

Once the Vissim models are generated, the simulations are run for five times in total to gather network data. The purpose of multiple simulation runs is to get the variance in the results. Changing random seed number within Vissim for each simulation prevents each simulation to have the same outcome.

The total length of Vissim simulation is generated for 5400 simulation seconds (5400 real time seconds). 1800 simulation seconds are set to be seeding period. During the seeding period, a unique traffic composition is planted into Vissim network. The actual result recording period is 3600 simulation seconds. The simulation results are gathered at A.M. peak, P.M. peak, and off-peak each for following conditions:

(1) Future condition with BRT, 27% ridership increase;

(2) Future condition with SMFe-BRT, 27% ridership increase; and

(3) Future condition with SMFe-BRT, 32% ridership increase.

3.2 Vissim Model Development: Existing Conditions

Vehicle Volume Inputs

As vehicle input data is obtained from different agencies along the Cobb Parkway, the obtained data is organized using Excel Spreadsheet. A simplified intersection feature is shown in Figure 3-2. Each number box located by the arrow indicate the number of turning movements for the assigned routes, and the numbers in green boxes indicate the total number of vehicles for the merging bound. For example, green box number 1673 on the top right corner indicates the resulting number of vehicles taking northbound routes. Thus, it is an addition of turning movement counts of 182, 1418, and 73.

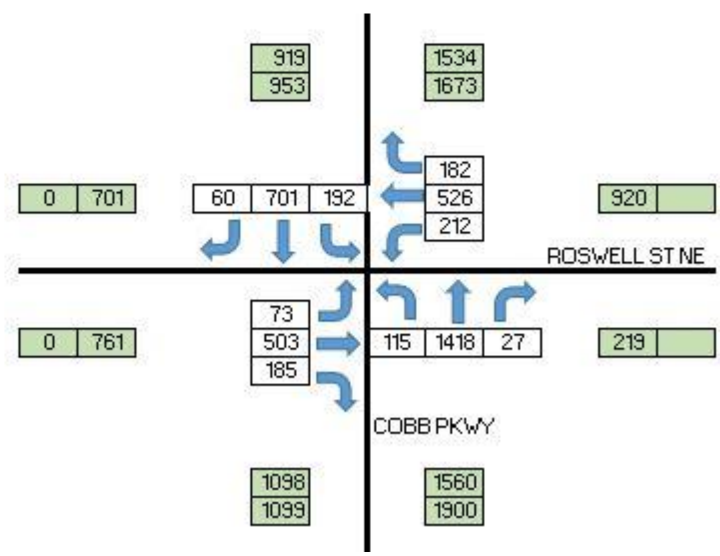

Figure 3-2 Turning Movement Diagram at Cobb Parkway + Roswell Street Intersection, PM Peak, 2019

The base year for this thesis is set to 2019. It is based on the area development condition. Since the future condition would capture year 2040 scenario, the base year was imposed after the completion of the Atlanta Braves Stadium and its surrounding structures. Vehicle volume adjustment is done using the average annual daily traffic (AADT) forecasting formula, as displayed in Equation 2 [21].

$$E_{t+n} = E_t \times (1 + g)^n \tag{2}$$

where,

E_{t+n} = AADT value of t year, forecasted n years in the future;

E_{t} = AADT observed in base year t; and

g = AADT annual growth rate.

The vehicle volume adjustments provide the consistency of the vehicle volumes, and prohibiting the discrepancies between intersections, when 2 different datasets were obtained in different years.

Existing Public Transit: CobbLinc

The existing CobbLinc ridership data was obtained during the marked data collection duration. The typical duration of the data collection period is about 3 months. Since Vissim input is hourly based, an appropriate conversion is done to pair the rate. As ridership data is divided into all day, A.M. peak, P.M. peak, and mid-day conditions; the total number of ridership for each A.M. peak, P.M. peak, and mid-day conditions from the data is divided into the number of weekdays during the data collection period. This yields average number of ridership of each peak condition.

3.3 Vissim Model Development: Future Peak Conditions

Dedicated Bus Lanes

An important feature of the future condition is that the future public transit vehicles will be exclusively using dedicated bus lanes. As shown in Figure 1-2, from the northernmost part to southernmost part of Cobb Parkway, center-running dedicated guideway will be added. From the center-running dedicated lanes, the express lanes will be transformed into the side-running dedicated guideways [3]. In Vissim, at center-running locations, the existing lanes will be shifted to the side, adding the proposed dedicated guideways in the middle.

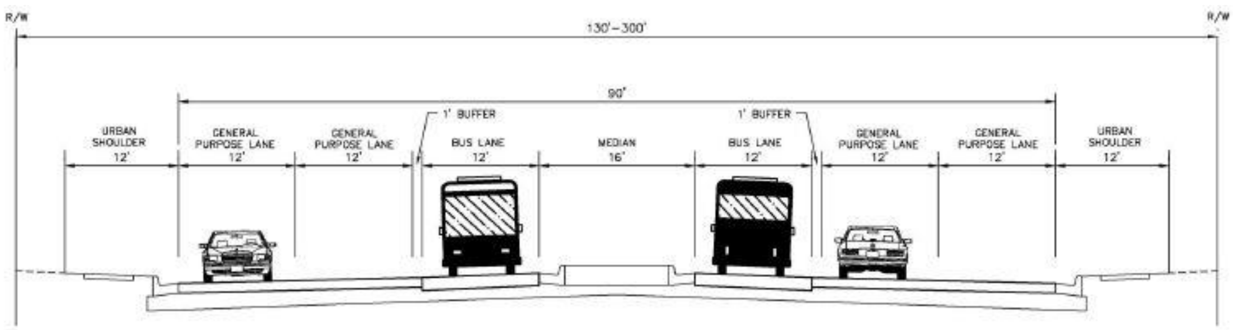

Figure 3-3 Proposed Typical Section on Cobb Parkway -- Center-Running Dedicated Guideway

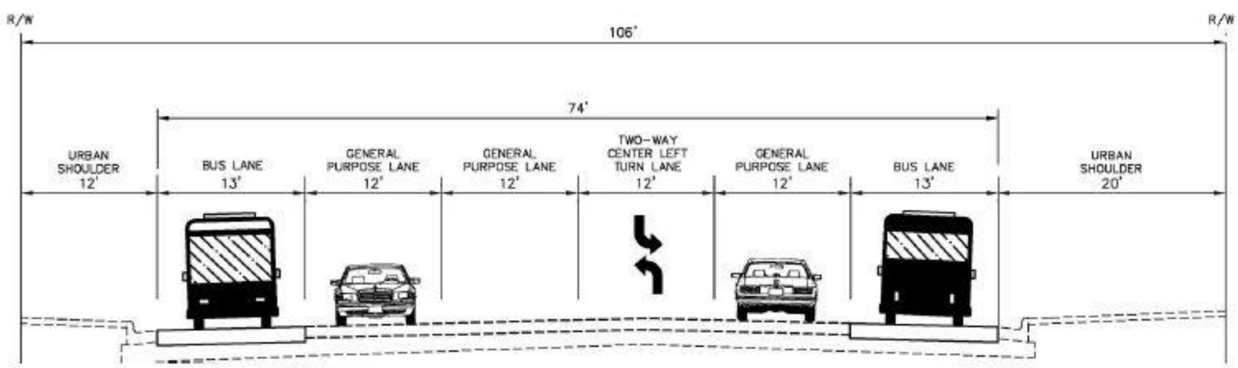

Figure 3-4 Proposed Typical Section on Akers Mill Road -- Side-Running Dedicated Guideway

Future Vehicle Volume Predictions

Future conditions in this thesis is in year 2040. To reflect the traffic changes over the time, vehicle volumes are calculated for 2040 condition. The main development of the area is the Atlanta Braves Stadium. The new complex is expecting to draw high number of visitors, so it is important to acknowledge the area development. Future vehicle volume predictions take the new amenities into a consideration.

Since the Cobb Corridor Project's main purpose is to promote public transport riding to the public, it is expected for a network to experience a growth in public transit ridership and a small decrease in network vehicle volume accordingly. Considering the assumption made in ridership and the decrease in vehicle volume, the future vehicle volume prediction calculation follows the steps below.

(1) From the existing volume data, calculate for 2040 condition using AADT forecasting formula introduced (Equation 2).

(2) Obtain additional project volume from Development Regional Impact report. Then, adjust it to 2040 condition using AADT formula.

(3) Add the volumes from (1) and (2).

(4) Apply volume reduction from new public transit (described in next section).

Future Ridership Forecast

On top of the existing 10.6% of public transit choice for commute [5], the introduction of new BRT vehicle and SMFe-BRT will yield the increased public transportation ridership. From the cities that have already adopted BRT, it has been observed that BRT is responsible for the drastic percentage increase of ridership. However, cities in California is very different from Metro-Atlanta area. The existing percentage of public transit choice in California, 68%, was far higher than that of Metro-Atlanta area. It is unrealistic to adopt the ridership percentage growth such as 84%. Therefore, the lowest percentage growth 27% observed is assumed in this thesis [6].

Since the traditional BRTs alone increases the ridership, the new concept vehicle SMFe-BRTs are expected to draw higher number of ridership than the traditional BRTs. The additional percent change in ridership assumption is made referencing to *Ridership Responsiveness* in Review of Literature chapter. Because the ridership response and the change in wait time is interdependent, an assumption was made that SMFe-BRT would reduce the passenger wait time by 5 minutes comparing to the traditional BRT, due to the operational flexibility of SMFe-BRT. The wait time for BRT is set to 30 minutes, setting the wait time for SMFe-BRT to 25 minutes. The 17% change in waiting time, using elasticity of waiting time on ridership at peak hours condition -0.27, yields 5% change in ridership [7]. SMFe-BRT is expecting to have 5% additional increase in ridership than the traditional BRT.

The future ridership forecast is calculated using the following formula:

$$Future\ Ridership = Vehicles\ Reduced\ \times Average\ Vehicle\ Occupancy \qquad (3)$$

As the vehicles reduced from the network due to the increase of public transit ridership, average vehicle occupancy is multiplied. The equation considers the number of passengers from removed cars. However, because the average vehicle occupancy in Metro-Atlanta area is very close to 1, it is assumed that future ridership is equal to vehicles removed [8]. Notice that equations 3.1 to 3.3) use step (3) from Future Vehicle Volume Predictions section as their variables.

$$Vehicles\ Reduced_{27\%} = 0.106\ V_{(3)} + (0.106)(1 + 0.27)V_{(3)} \quad (3.1)$$

$$Vehicles\ Reduced_{27\%} = (0.106)(2.27)V_{(3)} \quad (3.2)$$

$V_{(3)}$ indicates the step (3) results from Future Vehicle Volume Predictions. Equations 3.1 and 3.2 are used for the traditional and SMFe-BRT's base 27% increase in ridership. Likewise, with SMFe-BRT's 32% increase in ridership can be calculated using:

$$Vehicles\ Reduced_{32\%} = (0.016)(2.32)V_{(3)} \quad (3.3)$$

The results of Equations 3.2 and 3.3) can be used as reduction volume on step (4) of Future Vehicle Volume Predictions.

Future Signal Timing

Adjustments are made on future signal timing as additional bus dedicated guideways are added. Without proper signal timing distribution, the new public transit would experience a heavy delay. Transit priority technique is used for signalized intersections that has center dedicated BRT lanes. Using check-in and check-out detectors, the signal controller gives the green priority to the buses. When the check-in detector detects the bus, signal phase for the bus dedicated lane can be extended. For the locations where the signalized intersection is located just ahead of a proposed station, standard presence detectors are used instead. The typical method of revising the signal timing includes:

(1) Adding signal phases (9 and 10) for bus dedicated lane;
(2) Assigning 8-second split, and 3-second minimum green time, 5-second max 1, and 3-second red clearance to the new signal phases each;
(3) Reducing 8-second split each from the existing phases;

(4) Setting up the transit priority with additional check-in and check-out detectors.

An example of signal times table at Cobb Parkway and South Marietta Parkway intersection signal times table after modification is provided in Figure 3-5. The assigned bounds for each signal group are as follows: SG 1: Northbound left; SG2: Southbound through; SG3: Westbound left; SG4: Eastbound through; SG5: Southbound left; SG 6: Northbound through; SG 8: Westbound through; SG 9: Dedicated lane Southbound; SG 10: Dedicated lane Northbound. Additional signal groups 12 and 16 are assigned as overlap signals of SG 2 and SG 6. The primary purpose of the overlapped signals is to allow green time for dedicated lanes when the southbound and northbound phases, SG 2 and SG 6, are green. SG 302 and SG 306 are assigned to dedicated lanes for transit priority purpose. Check-in detectors 312 and 316 are assigned to SG 302 and 306 each, and so as checkout detectors 322 and 326. Figure 3-5 captures the moment when a public transit enters the intersection. As shown on signal times table, the phases are shortened once the vehicle checks in with detector 316, and the green phase is given to SG 10 (SG 306).

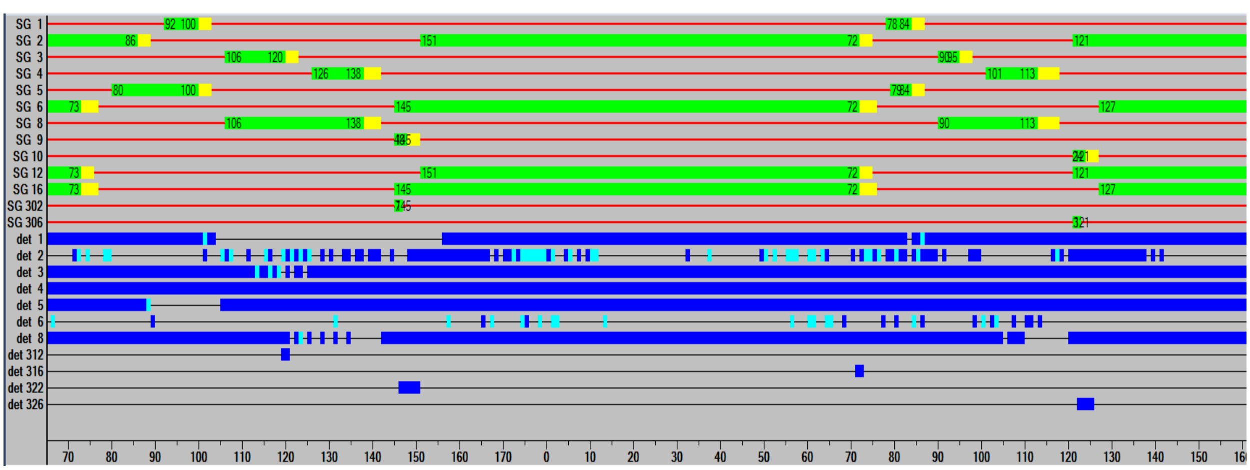

Figure 3-5 Ring Barrier Signal Times Table at Cobb Pkwy + S. Marietta Pkwy

Emission Calculations

It is essential to know the fuel type of the BRT in future conditions. Currently, MARTA's goal for sustainability introduced CNG buses [22]. Following the recent trend, it is assumed that the future BRTs will be run on CNG fuel.

The emission calculation based on CNG is computed using the Equation 4. The equation is formed based on the emission factors of each pollutants, multiplying the distance. The distance is converted from the speed the vehicle is traveling at the time step. This data is collected from Vissim every 10 seconds.

$$Emission_{pollutant}\ (g) = EF \times v \times \frac{1\ (hr)}{3600\ (sec)} \times 10\ (sec) \qquad (4)$$

where:

EF = Emission factor by pollutant (g/mile), and

v = Speed of the vehicle at the time step (mph).

Since SMFe-BRT vehicles are fully electric, there is no emission estimated.

3.4 Vissim Model Development: Future Off-Peak Conditions

Future Vehicle Volume Prediction

Future off-peak vehicle volume is predicted from the existing values. From GDOT traffic counts, off-peak hour is set to be 9 A.M. Comparing off-peak volumes and the A.M. peak volumes, it is found that off-peak volume is about 75% of the A.M. peak volume. Therefore, the off-peak volume is simply calculated by multiplying 0.75 to the A.M. peak volumes [23].

Future Signal Timing

To serve the network with reduced volume, new sets of signal timing is needed for off-peak condition. Using the predicted vehicle volume, the signal timing is optimized using Synchro software. Once the signal timing is optimized, transit priority is set following steps (1)-(4) from Future Signal Timing section.

3.5 Analytical Hierarchy Process

Priority Distribution

Table 2-4 is modified to this thesis paper's needs. The output of the location criteria—real estates, mixed-used, density, and accessibility—should be the same for BRT and SMFe-BRT conditions, as the development will undergo in same location for both alternatives. Under transport criteria, mode share is also the same for both scenarios.

Then, some sub-criteria are modified according to the simulation results. Travel time is equally divided into two sub-criteria of travel time and network average delay. Transfer per trip is assigned to be passenger wait time at transit stops. The emissions sub-criterion from the reference is isolated into a criterion, and pollutants measured from the simulation are assigned as its sub-criteria. The finance criterion is unaltered [19].

After the criteria and sub-criteria are modified, the final weights and equivalent weights are reassigned to fit 100% scale. The modified priority profile is shown in Table 3-1. As AHP model validation purposes, the consistency ratio for the table below is calculated. The modified AHP priority profile yields λ_{max} of 13, consistency index that is very close to zero, and consistency ratio of 0%.

Table 3-1 AHP Priority Profile

Criteria	Sub-Criteria	Final Weights	Equivalent Weights
Transport		**46%**	
	Travel time	36%	16.6%
	Delay	36%	16.6%
	Wait time	28%	13.2%
Emissions		**13%**	
	CO	14.3%	1.9%
	CO_2	14.3%	1.9%
	PM2.5	14.3%	1.9%
	NO_X	14.3%	1.9%
	CH_4	14.3%	1.9%
	N_2O	14.3%	1.9%
	VOC	14.3%	1.9%
Finance		**41%**	
	Capital cost	21.7%	8.8%
	O&M	33.0%	13.4%
	REVENUES	45.3%	18.3%

AHP method is used for pairwise comparison, and 6 different scenarios are compared:

1. BRT 27% vs. SMFe-BRT 27%
    a. A.M. Peak
    b. P.M. Peak
    c. Off-Peak
2. BRT 27% vs. SMFe-BRT 32%
    a. A.M. Peak
    b. P.M. Peak
    c. Off-Peak

The AHP model developed in this paper has the following hierarchical structure.

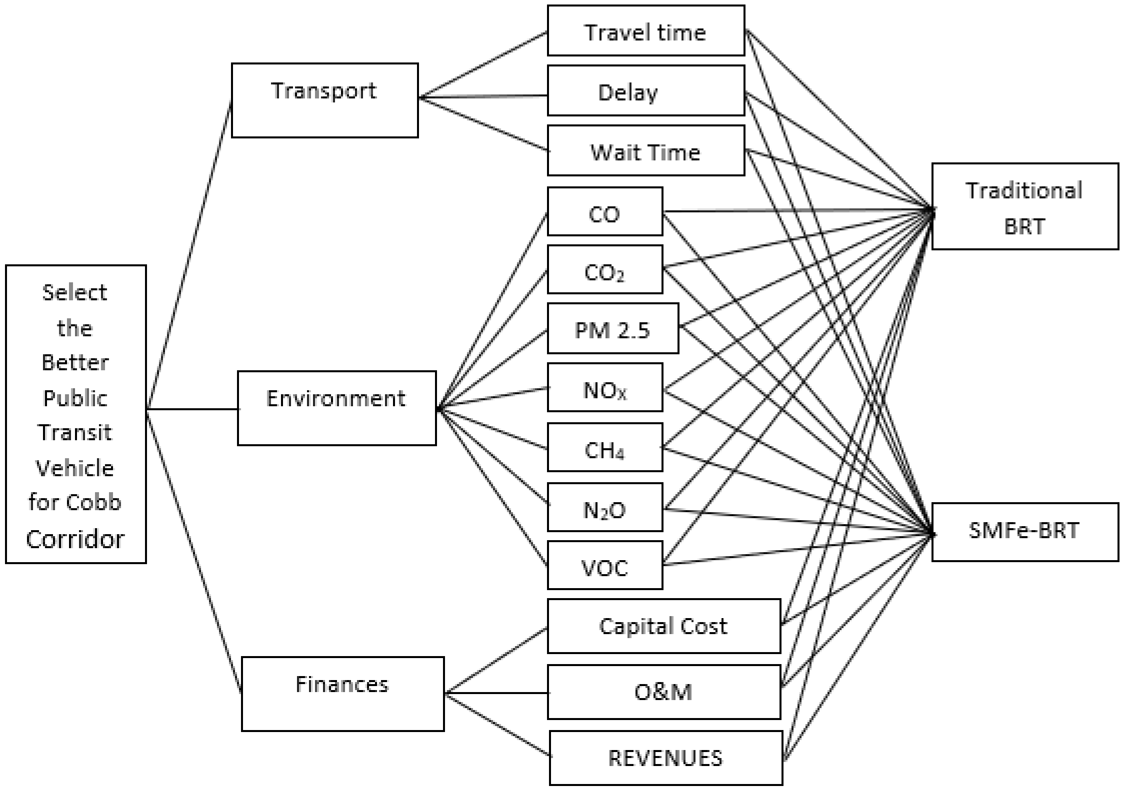

Figure 3-6 Hierarchical Structure of the Model

3.6 Finances

Capital Cost Estimate [24]

Connect Cobb Corridor Alternative Analysis lists the detailed costs per the design alternatives. While categories such as stations, support facilities, and sitework capital costs will remain the same for BRT and SMFe alternatives, guideway is expected to differ. SMFe-BRT anticipates having 25% slimmer width than the regular BRT, meaning the construction and material costs for the guideway and track elements would be lower than the traditional BRT alternative. The unit cost of grade-exclusive right of way is listed as $992 per linear feet in 2012. The unit cost is adjusted considering inflation, to 2019 existing condition. With inflation adjustments of 1.09, the unit cost of grade-exclusive right of way is $1081.28 [25]. The total costs for the traditional BRT is calculated with the estimated length of the proposed guideway, 11.9 miles. For SMFe-BRT, as stated in the characteristics, 25% of the material is reduced.

This project covers the corridor section where only at-grade dedicated lane is proposed. Therefore, other contents such as aerial structures and underground tunnels are not considered.

Operation and Maintenance Cost

According to Georgia Department of Transportation Fact Book, the total of $14,561,221 was spent on asphalt and concrete roadway pavement maintenance and repair in 2012 [26]. It breaks down to unit cost of $303.36 per lane mile, given the department does maintenance of 48,000 lanes in Georgia. The inflation is considered for O&M unit cost as well, adjusting the pavement maintenance unit cost to $330.66 [25].

BRT operation and maintenance (O&M) data is gathered from Seattle, where BRT had been adopted and operated. According to Madison Area Transportation Planning Board, vehicle operations and related costs is $75.61 per BRT annual revenue bus hours; vehicle maintenance related costs is $1.39 per BRT revenue bus miles; articulated bus premium is $0.35 per BRT revenue bus miles; ticket vending machine maintenance costs is $6,500 per machine unit; station and stop maintenance cost is $2,000 per directional bus stops [27].

Annual bus hours and bus miles are calculated using the simulation travel times and distance each for public transit lines. As the project only takes A.M., P.M., and off-peak conditions into consideration, the daily bus revenue takes only three conditions into account.

Although the annual bus miles are the same for all three conditions, bus hours are different depends on the network conditions.

Along Cobb Parkway, the proposed bus stations are located on the center of the road. For the O&M calculation purposes, it is assumed that the center-located bus stations are shared for both bounds. The number of ticket machines share the number of bus stations.

Revenues

Annual revenues for the proposed systems are calculated using the simulation public transit results. The total boarding passengers for A.M., P.M., off-peak conditions are obtained, and annual total number of the boarding passengers are calculated for the weekday conditions. MARTA ticket costs $2.50 for a one-way trip [28]. The annual revenues are determined multiplying the ticket costs to the total number of boarding passengers.

CHAPTER 4:

APPLICATIONS AND FINDINGS

Limitations

Vissim software is a microscopic multi-modal traffic flow software, meaning it is very important to generate the models as close to the existing condition as possible. The existing condition data was needed for the categories as: vehicle turning movement counts, signal timing, and public transit ridership. The Cobb Corridor project is 25.3 miles in total distance, falling under two different jurisdictions of Cobb County and Fulton County. Furthermore, in some cases, even within the same county, the existing data are separated within city and county jurisdictions. Many attempts were made to be in contact with different government and private agencies. However, some of the agencies were unable to be reached. Due to this reason, there were limitations in obtaining the existing data, and selected area of evaluation was reduced.

Concentrated Corridor

Initially 46 intersections were selected for Vissim model generation. The criteria for selecting these intersections are: 1) to be signalized, and 2) to have more than 2 lanes at the signalized intersection. The location of these evaluation area could be summarized into three sections, which are Cobb Parkway, Midtown Atlanta, and Kennesaw. Midtown Atlanta area already includes the dedicated bus lanes, and the new BRT system will be using the existing lanes. Also, Fulton County was unable to be in contact, so there are no existing resources available. Although data was obtained for Kennesaw section, there were still insufficient amount of resources. Since it was unable to duplicate the current state of the corridor in Kennesaw and

Midtown Atlanta area, the locations are eliminated. Finally, the Vissim model is left with final 24 signalized intersections and are listed below.

1. Cobb Parkway + Barrett Lakes Boulevard/Greers Chapel Road
2. Cobb Parkway + Progressive Way
3. Cobb Parkway + Bells Ferry Road
4. Cobb Parkway + Canton Road ramps (exit and entrance)
5. Cobb Parkway + Allgood Road Northeast
6. Cobb Parkway + North Marietta Parkway
7. Cobb Parkway + Roswell Street Northeast
8. Cobb Parkway + South Marietta Parkway
9. Cobb Parkway + South Cobb Drive ramps (exit and entrance)
10. Cobb Parkway + Terrell Mill Road Southeast
11. Cobb Parkway + Windy Hill Road Southeast
12. Cobb Parkway + Herodian Way
13. Cobb Parkway + Cumberland Boulevard
14. Cobb Parkway + Spring Road Southeast
15. Cobb Parkway + Circle 75 Parkway
16. Cobb Parkway + I-285 Ramps (exit and entrance)
17. Cobb Parkway + Akers Mill Road
18. Cumberland Boulevard + Spring Road Southeast
19. Cumberland Boulevard + Cumberland Parkway Southeast
20. Cumberland Boulevard + Akers Mill Road
21. Akers Mill Road + I-75 HOV Lane ramp

4.1 Transit Results

Table 4-1 contains Vissim simulation results for the traditional BRT with 27% ridership increase, SMFe-BRT with 27% and 32% ridership increases each. As the data suggests, the network results for BRT 27% and SMFe 27% are not very different, since the only variable is the vehicle type. Comparing BRT 27% and SMFe 32% is more distinctive, as 32% conditions have higher ridership, and lower vehicle volume in the network. PM conditions, however, does not follow the trend of having lower average delay. This data abnormality shows in average stops. There could be a several reasons in this irregularity of PM data: 1) Inconsistencies in signal controllers, vehicle or pedestrian inputs, or public transportation stop profile might have been caused when generating the simulation; 2) The detectors might have not been set up correctly to detect SMFe-BRT; or 3) Randomness of Vissim simulation and results. The first possible reason has the highest possibilities for the data abnormality.

Table 4-1 Transit Results from Vissim Simulations

CONDITION	BRT 27%			SMFe 27%			SMFe 32%		
	AM	PM	OFF-PEAK	AM	PM	OFF-PEAK	AM	PM	OFF-PEAK
DELAY AVERAGE (ALL) (s)	205.0	204.6	98.3	204.8	215.2	95.9	199.9	219.9	93.5
STOPS AVERAGE (ALL)	2.7	2.6	1.9	2.7	2.7	1.9	2.7	2.8	1.9
TRAVEL TIME IN GP SB (s)	1299.5	1314.4	1091.7	1163.8	1240.1	1099.1	1235.9	1294.3	1107.4
TRAVEL TIME IN GP NB (s)	1156.2	1175.7	1077.5	1161.7	1128.4	1071.5	1147.4	1304.6	1070.2
PT SERVICE TIME SB (s)	1729.1	1662.1	1789.7	1840.7	1842.1	1708.0	1822.5	1852.5	1756.1
PT SERVICE TIME NB (s)	1644.5	1745.0	2001.8	1764.5	1829.2	1887.4	1791.0	1848.6	1900.2

Vehicle travel time in general purpose lanes for BRT 27% and SMFe-BRT 27% condition shows similar results. Also, BRT 27% indicate that the travel time in general purpose lanes is much higher than SMFe-BRT 32% condition. These are expected results, as SMFe 32% scenario has less total number of vehicle inputs comparing to BRT condition.

Public transit service time in SMFe-BRT is significantly higher than tradition BRT. It is due to the higher capacity of SMFe-BRT comparing to the traditional BRT. When a bus stops at the station with passengers, the traditional BRT tends to leave the station earlier, since the capacity of the bus is easily reached. SMFe-bus stays longer at each station, boarding more passengers to reach its higher capacity. The dwelling time at each station affects the public transit service time. Service time during off-peak hours may not show this relation, since the demand for the public transit is not as high comparing to peak hours.

4.2 Emission Results

Fuel type is one of the main differences between the traditional BRT and the SMFe-BRT. The traditional BRT in this thesis is assumed to be powered by CNG, while SMFe-BRT is fully electric. PT speed from Vissim simulation is recorded every 10 seconds, and total amount of emissions by pollutants during the simulation time is recorded. The total emissions data for each type of pollutant has very small variance. In fact, for more detailed emissions results, many more variables need to be considered. *Fuel Consumption Model for Bus Rapid Transit* suggests that the acceleration, deceleration, cruise, idling factors of BRT should be considered for emission calculation [29]. However, since the objective of the thesis is a pairwise comparison of the alternatives, SMFe-BRT would score much higher ranks than the traditional BRT in emissions criteria. For the simplicity purposes, the speed is the only variable considered in this thesis.

Table 4-2 PT Emission Results by Pollutants

CONDITION	BRT 27%			SMFe 27%, 32%		
	AM	PM	OFF-PEAK	AM	PM	OFF-PEAK
TOTAL PT EMISSIONS CO2 (g)	36926.39	37724.26	36665.99	0	0	0
TOTAL PT EMISSIONS CO (g)	97.322	99.424	96.635	0	0	0
TOTAL PT EMISSIONS PM 2.5 (g)	0.026	0.027	0.026	0	0	0
TOTAL PT EMISSIONS NOx (g)	35.778	36.551	35.525	0	0	0
TOTAL PT EMISSIONS CH4 (g)	32.331	33.030	32.103	0	0	0
TOTAL PT EMISSIONS N2O (g)	2.872	2.934	2.852	0	0	0
TOTAL PT EMISSIONS VOC (g)	0.279	0.285	0.277	0	0	0

4.3 Finances Results

The capital cost is estimated to be much lower in SMFe-BRT alternatives. With SMFe-BRT characteristic of possessing narrower width, it is expected to save $38,248,090 on capital cost alone.

Table 4-3 Capital Cost Estimates for Traditional and SMFe-BRT

Table 4-3-a) CAPITAL COST ESTIMATE -- TRADITIONAL BRT

CAT NO	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
10	**GUIDEWAY & TRACK ELEMENTS**				
10.01	At-grade exclusive right of way	62832	LF	$ 1081.28	$ 67,938,984.96
10.05	Built-up fill	62832	LF	$ 1572.87	$ 98,826,567.84
				TOTAL	$ 166,765,552.80

Table 4-3-b) CAPITAL COST ESTIMATE – SMFe-BRT

CAT NO	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL COST
10	**GUIDEWAY & TRACK ELEMENTS**				
10.01	At-grade exclusive right of way	47124	LF	$ 1081.28	$ 50,954,238.72
10.05	Built-up fill	47124	LF	$ 1572.87	$ 74,119,925.88
				TOTAL	$ 125,074,164.60

O&M results are calculated based on the operation characteristics from Vissim simulation. Service time for each condition is calculated from Table 4-1, averaging north and south bound service times.

Table 4-4 Operation Data (From Simulation)

VEHICLE TYPE	TIME (MIN)			DISTAN-CE (MI)	SERVICE FREQUENCY (WEEKDAYS ONLY)			DAILY REV.		ANNUAL REV.	
	AM PEAK	PM PEAK	OFF PEAK	ONE WAY	AM PEAK	PM PEAK	OFF PEAK	BUS MILES	BUS HRS	BUS MILES	BUS HRS
TRAD. BRT	28.11	28.39	31.60	11.94	16	16	16	572.9	23	150112	6155
SMFE BRT 27%	30.04	30.59	29.96	11.94	16	16	16	572.9	24	150112	6330
SMFE BRT 32%	30.11	30.11	30.47	11.94	16	16	16	572.9	24	150112	6336

O&M cost estimates indicates the SMFe-BRT would experience about $20,000 higher fees. As mentioned in Transit Results, SMFe-BRT results with higher service time, because of the longer dwelling time at each station.

Table 4-5 O&M Cost Estimates for BRT and SMFe-BRT

Table 4-5-a) O&M COSTS BRT			TOTAL	$ 849,522.52
CONTENTS	QTY	UNIT	UNIT COST	TOTAL COSTS
ASPHALT & CONCRETE ROADWAY PAVEMENT -- MAINTAIN/REPIAR	11.94	MI	$ 330.66	$ 3,948.09
VEHICLE OPERATIONS-RELATED COSTS	6155	BRT. REV BUS HOURS	$ 75.61	$ 465,379.55
VEHICLE MAINTENANCE RELATED COSTS	150112	BRT. REV BUS MI'S	$ 1.39	$ 208,655.68
ARTICULATED BUS PREMIUM	150112	BRT. REV BUS MI'S	$ 0.35	$ 52,539.20
TVM MACHINES	14	TVM MACHINES	$ 6,500.00	$ 91,000.00
STATION/STOP MAINTENANCE	14	DIRECTIONAL BRT STOP	$ 2,000.00	$ 28,000.00

Table 4-5-b) O&M COSTS SMFe-BRT TOTAL $ 862,754.26

CONTENTS	QTY	UNIT	UNIT COST	TOTAL COSTS
ASPHALT & CONCRETE ROADWAY PAVEMENT -- MAINTAIN/REPIAR	11.94	MI	$ 330.66	$ 3,948.08
VEHICLE OPERATIONS-RELATED COSTS	6330	BRT. REV BUS HOURS	$ 75.61	$ 478,611.30
VEHICLE MAINTENANCE RELATED COSTS	150112	BRT. REV BUS MI'S	$ 1.39	$ 208,655.68
ARTICULATED BUS PREMIUM	150112	BRT. REV BUS MI'S	$ 0.35	$ 52,539.20
TVM MACHINES	14	TVM MACHINES	$ 6,500.00	$ 91,000.00
STATION/STOP MAINTENANCE	14	DIRECTIONAL BRT STOP	$ 2,000.00	$ 28,000.00

Annual revenues for the proposed vehicles are organized as following table. SMFe-BRT with 32% reduction is expecting the highest revenue of $4,475,877. As SMFe-BRT 27% and BRT are expected to have very similar number of passengers riding, the annual revenues for both conditions are very similar with 3% of difference.

Table 4-6 Annual Revenues

CONTENTS	BRT 27%	SMFe 27%	SMFe 32%
DAILY TOTAL BOARDING PASSENGERS	6408	6231	6833
ANNUAL TOTAL BOARDING PASSENGERS	1678896	1632522	1790351
ANNUAL REVENUES	$ 4,197,240.00	$ 4,081,305.00	$ 4,475,877.00

4.4 AHP Model

From the study results mentioned in Sections 4.1 to 4.3, series of AHP models are generated to select the better mode of public transportation. Priority profile in Table 3-1 is used for the evaluation. The weighted average rating for each evaluation condition is performed as suggested in Table 4-7. The ratings for each decision alternatives are developed for the evaluation purposes in traditional AHP practice. However, since this thesis's result values are given in quantitative values, the values for comparing alternatives are compared in ratios. Therefore, the sum of weighted average in each row is calculated to be 1.

Table 4-7 Weighted Average Rating for Each Comparing Scenarios

4-6-1.A BRT 27% vs SMFe 27% -- AM PEAK

CRITERIA	SUB-CRITERIA	WEIGHTS	BRT 27%	SMFe 27%
TRANSPORT	TRAVEL TIME	0.166	0.486	0.514
	DELAY	0.166	0.500	0.500
	WAIT TIME	0.132	0.470	0.530
EMISSIONS	CO2 (g)	0.019	0.000	1.000
	CO (g)	0.019	0.000	1.000
	PM 2.5 (g)	0.019	0.000	1.000
	NOx (g)	0.019	0.000	1.000
	CH4 (g)	0.019	0.000	1.000
	N2O (g)	0.019	0.000	1.000
	VOC (g)	0.019	0.000	1.000
FINANCE	CAPITAL COST	0.088	0.429	0.571
	O&M	0.134	0.504	0.496
	REVENUES	0.183	0.507	0.493
		SCORE	0.424	0.576

4-6-1.B BRT 27% vs SMFe 27% -- PM PEAK

CRITERIA	SUB-CRITERIA	WEIGHTS	BRT 27%	SMFe 27%
TRANSPORT	TRAVEL TIME	0.166	0.474	0.513
	DELAY	0.166	0.513	0.487
	WAIT TIME	0.132	0.490	0.510
EMISSIONS	CO2 (g)	0.019	0.000	1.000
	CO (g)	0.019	0.000	1.000
	PM 2.5 (g)	0.019	0.000	1.000
	NOx (g)	0.019	0.000	1.000
	CH4 (g)	0.019	0.000	1.000
	N2O (g)	0.019	0.000	1.000
	VOC (g)	0.019	0.000	1.000
FINANCE	CAPITAL COST	0.088	0.429	0.571
	O&M	0.134	0.504	0.496
	REVENUES	0.183	0.507	0.493
		SCORE	0.427	0.571

4-6-1.C BRT 27% vs SMFe 27% -- OFF PEAK

CRITERIA	SUB-CRITERIA	WEIGHTS	BRT 27%	SMFe 27%
TRANSPORT	TRAVEL TIME	0.166	0.500	0.500
	DELAY	0.166	0.494	0.506
	WAIT TIME	0.132	0.506	0.494
EMISSIONS	CO2 (g)	0.019	0.000	1.000
	CO (g)	0.019	0.000	1.000
	PM 2.5 (g)	0.019	0.000	1.000
	NOx (g)	0.019	0.000	1.000

4-6-2.A BRT 27% vs SMFe 32% -- AM PEAK

CRITERIA	SUB-CRITERIA	WEIGHTS	BRT 27%	SMFe 32%
TRANSPORT	TRAVEL TIME	0.166	0.493	0.507
	DELAY	0.166	0.500	0.500
	WAIT TIME	0.132	0.470	0.530
EMISSIONS	CO2 (g)	0.019	0.000	1.000
	CO (g)	0.019	0.000	1.000
	PM 2.5 (g)	0.019	0.000	1.000
	NOx (g)	0.019	0.000	1.000

	CH4 (g)	0.019	0.000	1.000
	N2O (g)	0.019	0.000	1.000
	VOC (g)	0.019	0.000	1.000
FINANCE	CAPITAL COST	0.088	0.429	0.571
	O&M	0.134	0.504	0.496
	REVENUES	0.183	0.507	0.493
		SCORE	0.430	0.570

	CH4 (g)	0.019	0.000	1.000
	N2O (g)	0.019	0.000	1.000
	VOC (g)	0.019	0.000	1.000
FINANCE	CAPITAL COST	0.088	0.429	0.571
	O&M	0.134	0.504	0.496
	REVENUES	0.183	0.484	0.516
		SCORE	0.421	0.579

4-6-2.B BRT 27% vs SMFe 32% -- PM PEAK

CRITERIA	SUB-CRITERIA	WEIGHTS	BRT 27%	SMFe 32%
TRANSPORT	TRAVEL TIME	0.166	0.474	0.513
	DELAY	0.166	0.513	0.487
	WAIT TIME	0.132	0.490	0.510
EMISSIONS	CO2 (g)	0.019	0.000	1.000
	CO (g)	0.019	0.000	1.000
	PM 2.5 (g)	0.019	0.000	1.000
	NOx (g)	0.019	0.000	1.000
	CH4 (g)	0.019	0.000	1.000
	N2O (g)	0.019	0.000	1.000
	VOC (g)	0.019	0.000	1.000
FINANCE	CAPITAL COST	0.088	0.429	0.571
	O&M	0.134	0.504	0.496
	REVENUES	0.183	0.484	0.516
		SCORE	0.423	0.575

4-6-2.C BRT 27% vs SMFe 32% -- OFF PEAK

CRITERIA	SUB-CRITERIA	WEIGHTS	BRT 27%	SMFe 32%
TRANSPORT	TRAVEL TIME	0.166	0.500	0.500
	DELAY	0.166	0.494	0.506
	WAIT TIME	0.132	0.506	0.494
EMISSIONS	CO2 (g)	0.019	0.000	1.000
	CO (g)	0.019	0.000	1.000
	PM 2.5 (g)	0.019	0.000	1.000
	NOx (g)	0.019	0.000	1.000
	CH4 (g)	0.019	0.000	1.000
	N2O (g)	0.019	0.000	1.000
	VOC (g)	0.019	0.000	1.000
FINANCE	CAPITAL COST	0.088	0.429	0.571
	O&M	0.134	0.504	0.496
	REVENUES	0.183	0.484	0.516
		SCORE	0.426	0.574

The result table shows traditional BRT seems more effective in some sub-criteria like travel time, delay, and O&M. However, SMFe-BRT has received weights in emissions criteria significantly more than the traditional BRT. Though the final score for BRT and SMFe-BRT are similar in each scenario, it is resulted that adoption of SMFe-BRT as a mode of public transportation in Cobb Corridor is more beneficial.

CHAPTER 5:

SUMMARY AND CONCLUSIONS

5.1 Summary

The purpose of this thesis is to evaluate alternatives of Connect Cobb Corridor Project, using AHP model, and to develop Vissim network models to gather necessary data. Chapter 5 includes conclusions on the simulation results, in terms of AHP criteria, and the final suggested decision based on AHP model developed.

5.2 Vissim Simulation Results

The scope of Connect Cobb Corridor Project covers from Kennesaw to Atlanta MARTA Arts Center Station. The total length of the proposed corridor is over 26 miles. However, in this thesis, only 11.9 miles of Cobb Parkway is selected. Vissim network models are generated for 9 different future scenarios, in 2040 future year. The generated scenarios include each A.M., P.M, and off-peak conditions of the traditional BRT, SMFe-BRT with 27% ridership increase, and SMFe-BRT with 32% ridership increase conditions.

Although SMFe-BRT was expected to show the significant efficiency comparing to the traditional BRT, the network-level results are very similar. It has been mentioned that the result data for P.M. condition shows inconsistencies comparing to the A.M. and off-peak conditions.

The total emissions by the major pollutants are calculated based on public transit speed. SMFe-BRT displays one of its advantages over CNG traditional BRT, by having zero emissions.

Table 5-1 Results by Alternatives

CRITERIA	SUB-CRITERIA	BRT 27% AM	BRT 27% PM	BRT 27% OFF-PEAK	SMFe 27% AM	SMFe 27% PM	SMFe 27% OFF-PEAK	SMFe 32% AM	SMFe 32% PM	SMFe 32% OFF-PEAK
TRANS-PORT (s)	TRAVEL TIME 1	1299.5	1314.4	1091.7	1163.8	1240.1	1099.1	1235.9	1294.3	1107.4
	TRAVEL TIME 2	1156.2	1175.7	1077.5	1161.7	1128.4	1071.5	1147.4	1304.6	1070.2
	TRAVEL TIME 3	1729.1	1662.1	1789.7	1840.7	1842.1	1708.0	1822.5	1852.5	1756.1
	TRAVEL TIME 4	1644.5	1745.0	2001.8	1764.5	1829.2	1887.4	1791.0	1848.6	1900.2
	DELAY	204.99	204.57	98.28	204.78	215.24	95.91	199.85	219.93	93.54
	PT WAIT TIME	121625	123344	110942	107815	118508	113776	128768	115655	118004
EMISS-IONS	CO2 (g)	36926	37724	36666	0	0	0	0	0	0
	CO (g)	97.32	99.42	96.64	0	0	0	0	0	0
	PM 2.5 (g)	0.026	0.027	0.026	0	0	0	0	0	0
	NOx (g)	35.78	36.55	35.53	0	0	0	0	0	0
	CH4 (g)	32.33	33.03	32.10	0	0	0	0	0	0
	N2O (g)	2.872	2.934	2.852	0	0	0	0	0	0
	VOC (g)	0.279	0.285	0.277	0	0	0	0	0	0
FINANCE	CAPITAL COST	$ 166,765,552.80			$ 125,074,164.60			$ 125,074,164.60		
	O&M	$ 849,522.52			$ 862,754.26			$ 862,754.26		
	REVENUE	$ 4,197,240.00			$ 4,081,305.00			$ 4,475,877.00		

5.3 AHP Results

AHP method is chosen for this thesis, because it enables pairwise comparison of its criteria. The criteria weights are determined based on the survey answered by experts from different countries and modified based on the thesis needs. With 9 different future scenarios, 6 final AHP comparisons are generated. The AHP results show the final scores of weighted average ratings. All comparisons indicate SMFe-BRT has received more score than traditional BRT. The weighted average scores of BRT and SMFe-BRT at each scenario are similar, since many of the results from Table 5-1 are alike.

Table 5-2 AHP Results Summary

NO.	BRT	SMFe-BRT
1.A	0.42	0.58
1.B	0.43	0.57
1.C	0.43	0.57
2.A	0.42	0.58
2.B	0.42	0.58
2.C	0.43	0.57

1.A BRT 27% vs SMFe 27% -- AM PEAK
1.B BRT 27% vs SMFe 27% -- PM PEAK
1.C BRT 27% vs SMFe 27% -- OFF PEAK
2.A BRT 27% vs SMFe 32% -- AM PEAK
2.B BRT 27% vs SMFe 32% -- PM PEAK
2.C BRT 27% vs SMFe 32% -- OFF PEAK

5.4 Conclusions

This thesis has evaluated two different proposed mode of public transportation for Connect Cobb Corridor project, using AHP method. A traffic software Vissim is used to generate the future conditions of the different scenarios at A.M., P.M, and off-peak conditions with implementation of traditional BRT and the new-concept vehicle SMFe-BRT. The results from AHP method comparing BRT and SMFe-BRT suggests the adoption of SMFe-BRT is more preferred over traditional BRT, based on the experts' opinion on evaluation criteria.

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APPENDIX

Appendix A: Vissim Input Data

Vehicle Input

AM EXISTING CONDITION

NO	NAME	LINK	VOLUME
1	SB	16: COBB PKWY	2172
2	EB	34: GREERS CHAPEL RD NW	118
3	EB	410: PROGRESSIVE WAY	47
4	WB	41: PROGRESSIVE WAY	5
5	NB	170: BELLS FERRY RDS	369
6	SB	166: BELLS FERRY RD	843
7	SB	607: CANTON ROAD RAMP	1060
8	SB	49: ALLGOOD RD	877
9	NB	202: ALLGOOD RD	593
10	EB	43: NORTH MARIETTA PKWY NE	774
11	WB	197: NORTH MARIETTA PKWY NE	1048
12	WB	222: ROSWELL ST NE	700
13	EB	47: ROSWELL ST NE	867
14	WB	255: SOUTH MARIETTA PKWY SE	1086
15	EB	52: SOUTH MARIETTA PKWY SE	1482
16	EB	54: BARCLAY CIR	87
17	EB	275: S COBB DR RAMP	100
18		277: SPINKS DR	102
19	EB	55: ATLANTIC AVE SE	203
20		311: TERRELL MILL ROAD SE	560
21	EB	61: WINDY HILL RD SE	2210
22	WB	316: WINDY HILL RD SE	737
23	WB	357: WINDY RIDGE PKWY SE	466
24	WB	69: CIRCLE 75 PARKWAY	422
25	WB	388: I-285 WB RAMP	1692
26	EB	72: I-285 EB RAMP	1433
27	WB	421: COBB PKWY	617
28	EB	660: SPRING RD SE	2463
29	NB	690: CUMBERLAND BLVD SE	1452
30	SB	449: CUMBERLAND PKWY SE	91
31	WB	426: CUMBERLAND BLVD SE	262
32	WB	74: AKERS MILL SQUARE	84
33	EB	461: GALLERIA DR	76
34	SB	466: COBB GALLERIA PKWY	40
35	NB	76: COBB GALLERIA PKWY	450
36	WB	402: AKERS MILL RD	621
37	NB	590: I-75 NB HOV	31
38		35: BARRETT LAKES BLVD	231

PM EXISTING CONDITION

NO	NAME	LINK	VOLUME
1		4: CHASTAIN RD NW	1370
2		28: BARRETT LAKES BLVD	571
3		80: Frey RD NW	829
6		605: PARKING LOT DRIVEWAY (EXIT)	0
7		3: OLD FREY ROAD	268
8		589: I-75 SB RAMP	468
9		103: I-75 NB EXIT RAMP	757
10		82: CHASTAIN RD NW	1288
11		89: BUSBEE DR	150
12		91: SKIP SPANN CONNECTOR	260
15	SB	16: COBB PKWY	891
16	EB	34: GREERS CHAPEL RD NW	75
17	EB	410: PROGRESSIVE WAY	149
18	WB	41: PROGRESSIVE WAY	25
19	NB	170: BELLS FERRY RDS	734
20	SB	166: BELLS FERRY RD	504
21	SB	607: CANTON ROAD RAMP	566
22	SB	49: ALLGOOD RD	689
23	NB	202: ALLGOOD RD	896
24	EB	43: NORTH MARIETTA PKWY NE	704
25	WB	197: NORTH MARIETTA PKWY NE	1102
26	WB	222: ROSWELL ST NE	920
27	EB	47: ROSWELL ST NE	761
28	WB	255: SOUTH MARIETTA PKWY SE	1379
29	EB	52: SOUTH MARIETTA PKWY SE	760
30	EB	54: BARCLAY CIR	230
31	EB	275: S COBB DR RAMP	100
32		277: SPINKS DR	102
33	EB	55: ATLANTIC AVE SE	606
34		311: TERRELL MILL ROAD SE	947
35	EB	61: WINDY HILL RD SE	1057
36	WB	316: WINDY HILL RD SE	1561
38	WB	357: WINDY RIDGE PKWY SE	988
39	WB	69: CIRCLE 75 PARKWAY	1181
40	WB	388: I-285 WB RAMP	1870
41	EB	72: I-285 EB RAMP	1289
42	WB	421: COBB PKWY	1680
43	EB	660: SPRING RD SE	1174
44	NB	690: CUMBERLAND BLVD SE	1051
45	SB	449: CUMBERLAND PKWY SE	451
46	WB	426: CUMBERLAND BLVD SE	1085
47	WB	74: AKERS MILL SQUARE	115
48	EB	461: GALLERIA DR	253
49	SB	466: COBB GALLERIA PKWY	277
50	NB	76: COBB GALLERIA PKWY	467
51	WB	402: AKERS MILL RD	898
52	NB	590: I-75 NB HOV	334
53		64: BARRETT LAKES BLVD	184

OFF-PEAK EXISTING CONDITION

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	1629
16	EB	34: GREERS CHAPEL RD NW	89
17	EB	410: PROGRESSIVE WAY	36
18	WB	41: PROGRESSIVE WAY	4
19	NB	170: BELLS FERRY RDS	277
20	SB	166: BELLS FERRY RD	631
21	SB	607: CANTON ROAD RAMP	794
22	SB	49: ALLGOOD RD	658
23	NB	202: ALLGOOD RD	443
24	EB	43: NORTH MARIETTA PKWY NE	582
25	WB	197: NORTH MARIETTA PKWY NE	786
26	WB	222: ROSWELL ST NE	525
27	EB	47: ROSWELL ST NE	651
28	WB	255: SOUTH MARIETTA PKWY SE	1093
29	EB	52: SOUTH MARIETTA PKWY SE	1112
30	EB	54: BARCLAY CIR	66
31	EB	275: S COBB DR RAMP	100
32		277: SPINKS DR	76
33	EB	55: ATLANTIC AVE SE	152
34		311: TERRELL MILL ROAD SE	420
35	EB	61: WINDY HILL RD SE	1657
36	WB	316: WINDY HILL RD SE	552
38	WB	357: WINDY RIDGE PKWY SE	361
39	WB	69: CIRCLE 75 PARKWAY	326
40	WB	388: I-285 WB RAMP	1307
41	EB	72: I-285 EB RAMP	1106
42	WB	421: COBB PKWY	476
43	EB	660: SPRING RD SE	1905
44	NB	690: CUMBERLAND BLVD SE	1121
45	SB	449: CUMBERLAND PKWY SE	71
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	64
48	EB	461: GALLERIA DR	59
49	SB	466: COBB GALLERIA PKWY	30
50	NB	76: COBB GALLERIA PKWY	349
51	WB	402: AKERS MILL RD	480
52	NB	590: I-75 NB HOV	24
53		35: BARRETT LAKES BLVD	174

AM BRT 27%

NO	NAME	LINK	VOLUME
1	SB	16: COBB PKWY	2074
2	EB	34: GREERS CHAPEL RD NW	112
3	EB	410: PROGRESSIVE WAY	45
4	WB	41: PROGRESSIVE WAY	5
5	NB	170: BELLS FERRY RDS	352
6	SB	166: BELLS FERRY RD	805
7	SB	607: CANTON ROAD RAMP	1011
8	SB	49: ALLGOOD RD	837
9	NB	202: ALLGOOD RD	567
10	EB	43: NORTH MARIETTA PKWY NE	739
11	WB	197: NORTH MARIETTA PKWY NE	1001
12	WB	222: ROSWELL ST NE	669
13	EB	47: ROSWELL ST NE	828
14	WB	255: SOUTH MARIETTA PKWY SE	1036
15	EB	52: SOUTH MARIETTA PKWY SE	1414
16	EB	54: BARCLAY CIR	82
17	EB	275: S COBB DR RAMP	192
18		277: SPINKS DR	98
19	EB	55: ATLANTIC AVE SE	194
20		311: TERRELL MILL ROAD SE	535
21	EB	61: WINDY HILL RD SE	2214
22	WB	316: WINDY HILL RD SE	704
23	WB	357: WINDY RIDGE PKWY SE	641
24	WB	69: CIRCLE 75 PARKWAY	664
25	WB	388: I-285 WB RAMP	1615
26	EB	72: I-285 EB RAMP	1658
27	WB	421: COBB PKWY	589
28	EB	660: SPRING RD SE	2351
29	NB	690: CUMBERLAND BLVD SE	1386
30	SB	449: CUMBERLAND PKWY SE	88
31	WB	426: CUMBERLAND BLVD SE	262
32	WB	74: AKERS MILL SQUARE	80
33	EB	461: GALLERIA DR	73
34	SB	466: COBB GALLERIA PKWY	38
35	NB	76: COBB GALLERIA PKWY	429
36	WB	402: AKERS MILL RD	592
37		182: BARRETT LAKES BLVD	221

PM BRT 27%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	2060
16	EB	34: GREERS CHAPEL RD NW	111
17	EB	410: PROGRESSIVE WAY	44
18	WB	41: PROGRESSIVE WAY	5
19	NB	170: BELLS FERRY RDS	350
20	SB	166: BELLS FERRY RD	799
21	SB	607: CANTON ROAD RAMP	1004
22	SB	49: ALLGOOD RD	830
23	NB	202: ALLGOOD RD	563
24	EB	43: NORTH MARIETTA PKWY NE	733
25	WB	197: NORTH MARIETTA PKWY NE	994
26	WB	222: ROSWELL ST NE	663
27	EB	47: ROSWELL ST NE	822
28	WB	255: SOUTH MARIETTA PKWY SE	1029
29	EB	52: SOUTH MARIETTA PKWY SE	1405
30	EB	54: BARCLAY CIR	82
31	EB	275: S COBB DR RAMP	192
32		277: SPINKS DR	96
33	EB	55: ATLANTIC AVE SE	192
34		311: TERRELL MILL ROAD SE	531
35	EB	61: WINDY HILL RD SE	2199
36	WB	316: WINDY HILL RD SE	699
38	WB	357: WINDY RIDGE PKWY SE	636
39	WB	69: CIRCLE 75 PARKWAY	660
40	WB	388: I-285 WB RAMP	1604
41	EB	72: I-285 EB RAMP	1646
42	WB	421: COBB PKWY	586
43	EB	660: SPRING RD SE	2335
44	NB	690: CUMBERLAND BLVD SE	1376
45	SB	449: CUMBERLAND PKWY SE	86
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	80
48	EB	461: GALLERIA DR	73
49	SB	466: COBB GALLERIA PKWY	38
50	NB	76: COBB GALLERIA PKWY	426
51	WB	402: AKERS MILL RD	588
52	NB	590: I-75 NB HOV	33
53		182: BARRETT LAKES BLVD	220

OFFPEAK BRT 27%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	1555
16	EB	34: GREERS CHAPEL RD NW	84
17	EB	410: PROGRESSIVE WAY	34
18	WB	41: PROGRESSIVE WAY	4
19	NB	170: BELLS FERRY RDS	264
20	SB	166: BELLS FERRY RD	604
21	SB	607: CANTON ROAD RAMP	758
22	SB	49: ALLGOOD RD	629
23	NB	202: ALLGOOD RD	425
24	EB	43: NORTH MARIETTA PKWY NE	555
25	WB	197: NORTH MARIETTA PKWY NE	751
26	WB	222: ROSWELL ST NE	503
27	EB	47: ROSWELL ST NE	621
28	WB	255: SOUTH MARIETTA PKWY SE	778
29	EB	52: SOUTH MARIETTA PKWY SE	1061
30	EB	54: BARCLAY CIR	62
31	EB	275: S COBB DR RAMP	192
32		277: SPINKS DR	74
33	EB	55: ATLANTIC AVE SE	146
34		311: TERRELL MILL ROAD SE	402
35	EB	61: WINDY HILL RD SE	1661
36	WB	316: WINDY HILL RD SE	529
38	WB	357: WINDY RIDGE PKWY SE	481
39	WB	69: CIRCLE 75 PARKWAY	498
40	WB	388: I-285 WB RAMP	1211
41	EB	72: I-285 EB RAMP	1244
42	WB	421: COBB PKWY	442
43	EB	660: SPRING RD SE	1764
44	NB	690: CUMBERLAND BLVD SE	1040
45	SB	449: CUMBERLAND PKWY SE	66
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	61
48	EB	461: GALLERIA DR	55
49	SB	466: COBB GALLERIA PKWY	28
50	NB	76: COBB GALLERIA PKWY	323
51	WB	402: AKERS MILL RD	445
53		182: BARRETT LAKES BLVD	167
54		590: I-75 NB HOV	25

AM SMFE 27%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	2074
16	EB	34: GREERS CHAPEL RD NW	112
17	EB	410: PROGRESSIVE WAY	45
18	WB	41: PROGRESSIVE WAY	5
19	NB	170: BELLS FERRY RDS	352
20	SB	166: BELLS FERRY RD	805
21	SB	607: CANTON ROAD RAMP	1011
22	SB	49: ALLGOOD RD	837
23	NB	202: ALLGOOD RD	567
24	EB	43: NORTH MARIETTA PKWY NE	739
25	WB	197: NORTH MARIETTA PKWY NE	1001
26	WB	222: ROSWELL ST NE	669
27	EB	47: ROSWELL ST NE	828
28	WB	255: SOUTH MARIETTA PKWY SE	1036
29	EB	52: SOUTH MARIETTA PKWY SE	1414
30	EB	54: BARCLAY CIR	82
31	EB	275: S COBB DR RAMP	192
32		277: SPINKS DR	98
33	EB	55: ATLANTIC AVE SE	194
34		311: TERRELL MILL ROAD SE	535
35	EB	61: WINDY HILL RD SE	2214
36	WB	316: WINDY HILL RD SE	704
38	WB	357: WINDY RIDGE PKWY SE	641
39	WB	69: CIRCLE 75 PARKWAY	664
40	WB	388: I-285 WB RAMP	1615
41	EB	72: I-285 EB RAMP	1658
42	WB	421: COBB PKWY	589
43	EB	660: SPRING RD SE	2351
44	NB	690: CUMBERLAND BLVD SE	1386
45	SB	449: CUMBERLAND PKWY SE	88
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	80
48	EB	461: GALLERIA DR	73
49	SB	466: COBB GALLERIA PKWY	38
50	NB	76: COBB GALLERIA PKWY	429
51	WB	402: AKERS MILL RD	592
53		182: BARRETT LAKES BLVD	221
54		79: I-75 NB HOV EXIT	33

PM SMFE 27%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	850
16	EB	34: GREERS CHAPEL RD NW	72
17	EB	410: PROGRESSIVE WAY	142
18	WB	41: PROGRESSIVE WAY	25
19	NB	170: BELLS FERRY RDS	701
20	SB	166: BELLS FERRY RD	481
21	SB	607: CANTON ROAD RAMP	540
22	SB	49: ALLGOOD RD	658
23	NB	202: ALLGOOD RD	856
24	EB	43: NORTH MARIETTA PKWY NE	672
25	WB	197: NORTH MARIETTA PKWY NE	1053
26	WB	222: ROSWELL ST NE	879
27	EB	47: ROSWELL ST NE	727
28	WB	255: SOUTH MARIETTA PKWY SE	1316
29	EB	52: SOUTH MARIETTA PKWY SE	725
30	EB	54: BARCLAY CIR	220
31	EB	275: S COBB DR RAMP	49
32		277: SPINKS DR	98
33	EB	55: ATLANTIC AVE SE	579
34		311: TERRELL MILL ROAD SE	904
35	EB	61: WINDY HILL RD SE	1185
36	WB	316: WINDY HILL RD SE	1490
38	WB	357: WINDY RIDGE PKWY SE	1059
39	WB	69: CIRCLE 75 PARKWAY	1705
40	WB	388: I-285 WB RAMP	2568
41	EB	72: I-285 EB RAMP	1718
42	WB	421: COBB PKWY	1684
43	EB	660: SPRING RD SE	1120
44	NB	690: CUMBERLAND BLVD SE	1003
45	SB	449: CUMBERLAND PKWY SE	430
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	110
48	EB	461: GALLERIA DR	242
49	SB	466: COBB GALLERIA PKWY	264
50	NB	76: COBB GALLERIA PKWY	745
51	WB	402: AKERS MILL RD	1087
52	NB	590: I-75 NB HOV	452
53		182: BARRETT LAKES BLVD	176

OFF-PEAK SMFE 27%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	1555
16	EB	34: GREERS CHAPEL RD NW	84
17	EB	410: PROGRESSIVE WAY	34
18	WB	41: PROGRESSIVE WAY	4
19	NB	170: BELLS FERRY RDS	264
20	SB	166: BELLS FERRY RD	604
21	SB	607: CANTON ROAD RAMP	758
22	SB	49: ALLGOOD RD	629
23	NB	202: ALLGOOD RD	425
24	EB	43: NORTH MARIETTA PKWY NE	555
25	WB	197: NORTH MARIETTA PKWY NE	751
26	WB	222: ROSWELL ST NE	503
27	EB	47: ROSWELL ST NE	621
28	WB	255: SOUTH MARIETTA PKWY SE	778
29	EB	52: SOUTH MARIETTA PKWY SE	1061
30	EB	54: BARCLAY CIR	62
31	EB	275: S COBB DR RAMP	192
32		277: SPINKS DR	74
33	EB	55: ATLANTIC AVE SE	146
34		311: TERRELL MILL ROAD SE	402
35	EB	61: WINDY HILL RD SE	1661
36	WB	316: WINDY HILL RD SE	529
38	WB	357: WINDY RIDGE PKWY SE	481
39	WB	69: CIRCLE 75 PARKWAY	498
40	WB	388: I-285 WB RAMP	1211
41	EB	72: I-285 EB RAMP	1244
42	WB	421: COBB PKWY	442
43	EB	660: SPRING RD SE	1764
44	NB	690: CUMBERLAND BLVD SE	1040
45	SB	449: CUMBERLAND PKWY SE	66
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	61
48	EB	461: GALLERIA DR	55
49	SB	466: COBB GALLERIA PKWY	28
50	NB	76: COBB GALLERIA PKWY	323
51	WB	402: AKERS MILL RD	445
53		182: BARRETT LAKES BLVD	167
54		590: I-75 NB HOV	25

AM SMFE 32%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	2060
16	EB	34: GREERS CHAPEL RD NW	111
17	EB	410: PROGRESSIVE WAY	44
18	WB	41: PROGRESSIVE WAY	5
19	NB	170: BELLS FERRY RDS	350
20	SB	166: BELLS FERRY RD	799
21	SB	607: CANTON ROAD RAMP	1004
22	SB	49: ALLGOOD RD	830
23	NB	202: ALLGOOD RD	563
24	EB	43: NORTH MARIETTA PKWY NE	733
25	WB	197: NORTH MARIETTA PKWY NE	994
26	WB	222: ROSWELL ST NE	663
27	EB	47: ROSWELL ST NE	822
28	WB	255: SOUTH MARIETTA PKWY SE	1029
29	EB	52: SOUTH MARIETTA PKWY SE	1405
30	EB	54: BARCLAY CIR	82
31	EB	275: S COBB DR RAMP	192
32		277: SPINKS DR	96
33	EB	55: ATLANTIC AVE SE	192
34		311: TERRELL MILL ROAD SE	531
35	EB	61: WINDY HILL RD SE	2199
36	WB	316: WINDY HILL RD SE	699
38	WB	357: WINDY RIDGE PKWY SE	636
39	WB	69: CIRCLE 75 PARKWAY	660
40	WB	388: I-285 WB RAMP	1604
41	EB	72: I-285 EB RAMP	1646
42	WB	421: COBB PKWY	586
43	EB	660: SPRING RD SE	2335
44	NB	690: CUMBERLAND BLVD SE	1376
45	SB	449: CUMBERLAND PKWY SE	86
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	80
48	EB	461: GALLERIA DR	73
49	SB	466: COBB GALLERIA PKWY	38
50	NB	76: COBB GALLERIA PKWY	426
51	WB	402: AKERS MILL RD	588
53		182: BARRETT LAKES BLVD	220
54		79: I-75 NB HOV EXIT	33

PM SMFE 32%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	845
16	EB	34: GREERS CHAPEL RD NW	72
17	EB	410: PROGRESSIVE WAY	142
18	WB	41: PROGRESSIVE WAY	25
19	NB	170: BELLS FERRY RDS	695
20	SB	166: BELLS FERRY RD	477
21	SB	607: CANTON ROAD RAMP	536
22	SB	49: ALLGOOD RD	653
23	NB	202: ALLGOOD RD	849
24	EB	43: NORTH MARIETTA PKWY NE	668
25	WB	197: NORTH MARIETTA PKWY NE	1045
26	WB	222: ROSWELL ST NE	872
27	EB	47: ROSWELL ST NE	722
28	WB	255: SOUTH MARIETTA PKWY SE	1307
29	EB	52: SOUTH MARIETTA PKWY SE	720
30	EB	54: BARCLAY CIR	218
31	EB	275: S COBB DR RAMP	49
32		277: SPINKS DR	96
33	EB	55: ATLANTIC AVE SE	576
34		311: TERRELL MILL ROAD SE	898
35	EB	61: WINDY HILL RD SE	1176
36	WB	316: WINDY HILL RD SE	1480
38	WB	357: WINDY RIDGE PKWY SE	1052
39	WB	69: CIRCLE 75 PARKWAY	1692
40	WB	388: I-285 WB RAMP	2549
41	EB	72: I-285 EB RAMP	1706
42	WB	421: COBB PKWY	1674
43	EB	660: SPRING RD SE	1113
44	NB	690: CUMBERLAND BLVD SE	997
45	SB	449: CUMBERLAND PKWY SE	427
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	109
48	EB	461: GALLERIA DR	240
49	SB	466: COBB GALLERIA PKWY	262
50	NB	76: COBB GALLERIA PKWY	740
51	WB	402: AKERS MILL RD	1079
53		182: BARRETT LAKES BLVD	173

OFFPEAK SMFE
32%

NO	NAME	LINK	VOLUME
15	SB	16: COBB PKWY	1545
16	EB	34: GREERS CHAPEL RD NW	83
17	EB	410: PROGRESSIVE WAY	34
18	WB	41: PROGRESSIVE WAY	4
19	NB	170: BELLS FERRY RDS	263
20	SB	166: BELLS FERRY RD	600
21	SB	607: CANTON ROAD RAMP	753
22	SB	49: ALLGOOD RD	623
23	NB	202: ALLGOOD RD	422
24	EB	43: NORTH MARIETTA PKWY NE	550
25	WB	197: NORTH MARIETTA PKWY NE	745
26	WB	222: ROSWELL ST NE	497
27	EB	47: ROSWELL ST NE	616
28	WB	255: SOUTH MARIETTA PKWY SE	773
29	EB	52: SOUTH MARIETTA PKWY SE	1054
30	EB	54: BARCLAY CIR	62
31	EB	275: S COBB DR RAMP	192
32		277: SPINKS DR	72
33	EB	55: ATLANTIC AVE SE	144
34		311: TERRELL MILL ROAD SE	398
35	EB	61: WINDY HILL RD SE	1649
36	WB	316: WINDY HILL RD SE	525
38	WB	357: WINDY RIDGE PKWY SE	478
39	WB	69: CIRCLE 75 PARKWAY	496
40	WB	388: I-285 WB RAMP	1204
41	EB	72: I-285 EB RAMP	1235
42	WB	421: COBB PKWY	440
43	EB	660: SPRING RD SE	1751
44	NB	690: CUMBERLAND BLVD SE	1033
45	SB	449: CUMBERLAND PKWY SE	65
46	WB	426: CUMBERLAND BLVD SE	262
47	WB	74: AKERS MILL SQUARE	61
48	EB	461: GALLERIA DR	55
49	SB	466: COBB GALLERIA PKWY	28
50	NB	76: COBB GALLERIA PKWY	320
51	WB	402: AKERS MILL RD	442
53		182: BARRETT LAKES BLVD	166
54		590: I-75 NB HOV	25

Pedestrian Inputs

8AM BRT 27%

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	508
2	Bells Ferry	5: Bells Ferry	64
3	Wellstar	10: Wellstar	214
4	Allgood	15: Allgood	196
5	White Water	20: Whitewater	77
6	Big Chicken	25: Roswell	157
7	University	30: University	59
8	Dobbins	36: Dobbins	16
9	WIndy Hill	41: Windy Hill	234
10	Cumberland South	46: Cumerland north	64
11	Cumberland Transfer	51: Cumberland transfer center	112
12	Cumberland South NB	55: Cumberland south SB	52
13	Cumberland North NB	57: Cumberland South NB	86
14	North Loop	67: North Loop	207

PM BRT 27%

NO	NAME	AREA	VOLUME
1	White circle	62	480
2	Bells Ferry	5	303
3	Wellstar	10	477
4	Allgood	15	221
5	White Water	20	357
6	Big Chicken	25	383
7	University	30	231
8	Dobbins	36	434
9	WIndy Hill	41	374
10	Cumberland South	46	424
11	Cumberland Transfer	51	209
12	Cumberland South NB	55	39
13	Cumberland North NB	57	86
14	North Loop	67	346

OFFPEAK BRT 27%

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	381
2	Bells Ferry	5: Bells Ferry	49
3	Wellstar	10: Wellstar	160
4	Allgood	15: Allgood	147
5	White Water	20: Whitewater	58
6	Big Chicken	25: Roswell	118
7	University	30: University	44
8	Dobbins	36: Dobbins	12
9	WIndy Hill	41: Windy Hill	176
10	Cumberland South	46: Cumerland north	49
11	Cumberland Transfer	51: Cumberland transfer center	84
12	Cumberland South NB	55: Cumberland south SB	39
13	Cumberland North NB	57: Cumberland South NB	86
14	North Loop	67: North Loop	156

AM SMFE 27%

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	508
2	Bells Ferry	5: Bells Ferry	64
3	Wellstar	10: Wellstar	214
4	Allgood	15: Allgood	196
5	White Water	20: Whitewater	77
6	Big Chicken	25: Roswell	157
7	University	30: University	59
8	Dobbins	36: Dobbins	16
9	WIndy Hill	41: Windy Hill	234
10	Cumberland South	46: Cumerland north	64
11	Cumberland Transfer	51: Cumberland transfer center	112
12	Cumberland South NB	55: Cumberland south SB	52
13	Cumberland North NB	57: Cumberland South NB	86
14	North Loop	67: North Loop	207

PM SMFE 27%

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	196
2	Bells Ferry	5: bells ferry	67
3	Wellstar	10: wellstar	76
4	Allgood	15: allgood	42
5	White Water	20: whitewater	56
6	Big Chicken	25: roswell	119
7	University	30: university	40
8	Dobbins	36: dobbins	49
9	WIndy Hill	41: windy hill	174
10	Cumberland South	46: cumberland north	113
11	Cumberland Transfer	51: cumberland transfer center	261
12	Cumberland South NB	55: cumberland south SB	132
13	Cumberland North NB	57: Cumerland south NB	185
14	North Loop	67: north loop	188

OFFPEAK SMFE 27

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	381
2	Bells Ferry	5: Bells Ferry	49
3	Wellstar	10: Wellstar	160
4	Allgood	15: Allgood	147
5	White Water	20: Whitewater	58
6	Big Chicken	25: Roswell	118
7	University	30: University	44
8	Dobbins	36: Dobbins	12
9	WIndy Hill	41: Windy Hill	176
10	Cumberland South	46: Cumerland north	49
11	Cumberland Transfer	51: Cumberland transfer center	84
12	Cumberland South NB	55: Cumberland south SB	39
13	Cumberland North NB	57: Cumberland South NB	86
14	North Loop	67: North Loop	156

AM SMFE 32

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	519
2	Bells Ferry	5: Bells Ferry	67
3	Wellstar	10: Wellstar	219
4	Allgood	15: Allgood	202
5	White Water	20: Whitewater	78
6	Big Chicken	25: Roswell	161
7	University	30: University	60
8	Dobbins	36: Dobbins	16
9	WIndy Hill	41: Windy Hill	240
10	Cumberland South	46: Cumerland north	66
11	Cumberland Transfer	51: Cumberland transfer center	114
12	Cumberland South NB	55: Cumberland south SB	54
13	Cumberland North NB	57: Cumberland South NB	88
14	North Loop	67: North Loop	212

PM SMFE 32

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	200
2	Bells Ferry	5: bells ferry	69
3	Wellstar	10: wellstar	78
4	Allgood	15: allgood	43
5	White Water	20: whitewater	58
6	Big Chicken	25: roswell	122
7	University	30: university	42
8	Dobbins	36: dobbins	50
9	WIndy Hill	41: windy hill	178
10	Cumberland South	46: cumberland north	57
11	Cumberland Transfer	51: cumberland transfer center	262
12	Cumberland South NB	55: cumberland south SB	45
13	Cumberland North NB	57: Cumerland south NB	189
14	North Loop	67: north loop	192

OFFPEAK SMFE 32

NO	NAME	AREA	VOLUME
1	White circle	62: White Circle	389
2	Bells Ferry	5: Bells Ferry	50
3	Wellstar	10: Wellstar	164
4	Allgood	15: Allgood	150
5	White Water	20: Whitewater	59
6	Big Chicken	25: Roswell	121
7	University	30: University	45
8	Dobbins	36: Dobbins	12
9	WIndy Hill	41: Windy Hill	180
10	Cumberland South	46: Cumerland north	49
11	Cumberland Transfer	51: Cumberland transfer center	86
12	Cumberland South NB	55: Cumberland south SB	40
13	Cumberland North NB	57: Cumberland South NB	88
14	North Loop	67: North Loop	160

Appendix B: Vissim Simulation Results

Public Transit Results

Condition 8AM FUTURE BRT 27%

SUMMARY TABLE

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	343.6	352	538.2	20865.096
Proposed White Circle NB	53.8	21.8	113.8	730.6	1093.08
COBB PKWY+BELLSFERRY RD (BattleField SB)	140	71.2	364.4	615.2	1119.508
COBB PKWY+BELLS FERRY RD (BattleField NB)	105.6	65.8	150.8	715	2202.562
Proposed WellStar Kennestone SB	113.2	101.6	306.2	695.6	4200.248
Proposed WellStar Kennestone NB	104.4	93	153.6	647.2	3542.464
Proposed Allgood RD SB	96.2	105.6	274.6	723.8	3007.652
Proposed Allgood Rd NB	181.8	191	171.2	612.6	4516.968
Proposed North Loop/White Water SB	108.2	124	263.2	797	2787.768
Proposed North Loop/White Water NB	36.2	90.6	137	439.8	4874.926
Proposed Whitewater SB	119.2	85.6	254.6	907	2248.28
Proposed Whitewater NB	71.8	65.6	109.4	365	1644.862
Proposed Big Chicken/Roswell SB	97.4	83.6	254	979	2018.178
Proposed Big Chicken/Roswell NB	149	53.8	154.6	328.4	4318.032
Proposed University SB	212	16.8	209.4	959.2	276.168
Proposed University NB	48.4	29.6	153.8	273.8	490.94
Proposed Dobbins Air Base SB	46.8	5.4	70.4	891.4	3535.68
Proposed Dobbins Air Base NB	44.8	55.4	184.2	254	1312.296

COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	141.2	177.2	100.8	1042.8	3669.436
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	13.6	137.6	192.4	209.8	13573.098
Proposed Cumberland South SB	48.2	24	54.2	955.2	5467.62
Proposed Cumberland South NB	6.6	50.2	76.8	76.2	9179.184
Proposed CUMBERLAND TRANSFER CENTER SB	32.8	59	67.4	1034.8	2401.746
Proposed CUMBERLAND TRANSFER CENTER NB	2	85.8	57.8	42	18987.44
Proposed Cumberland North SB	242.4	219.6	87.8	1003	2111.604
Proposed Cumberland North NB	0	1	1	1.6	2179.82

Condition 5PM Future BRT 27%

SUMMARY

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	131.2	145	174	20840.358
Proposed White Circle NB	60.2	22.4	85	1005.2	1246.526
COBB PKWY+BELLSFERRY RD (BattleField SB)	56.2	86.6	152	219	2424.714
COBB PKWY+BELLS FERRY RD (BattleField NB)	174.6	176.4	110	989	2799.862
Proposed WellStar Kennestone SB	50.6	39.8	127	275.8	5206.82
Proposed WellStar Kennestone NB	35.6	33	75	816.6	3053.106
Proposed Allgood RD SB	42.8	27	123.6	321.4	4570.388
Proposed Allgood Rd NB	100.4	60.6	95.8	781.6	1199.8
Proposed North Loop/White Water SB	37.6	112.4	161	402.2	5721.418
Proposed North Loop/White Water NB	103.4	132.8	123.6	685.4	3908.568

Proposed Whitewater SB	70.6	51.4	151.6	475.6	2475.496
Proposed Whitewater NB	105.8	84.2	100.2	563.6	883.204
Proposed Big Chicken/Roswell SB	67.2	94	193.8	569.8	3515.11
Proposed Big Chicken/Roswell NB	155.8	24.2	159.6	501	1573.986
Proposed University SB	132	7	154.6	514.6	470.744
Proposed University NB	60	4.2	212	500.6	150.208
Proposed Dobbins Air Base SB	49.6	40.6	89.6	511.2	1967.692
Proposed Dobbins Air Base NB	113.6	107.8	262	506.6	2327.59
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	48	75.4	80.6	555.2	1407.596
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	50.2	129.2	244.8	370.8	7086.94
Proposed Cumberland South SB	51.6	85.2	97.8	626.4	7610.1
Proposed Cumberland South NB	54.6	47	186.2	268.6	4561.174
Proposed CUMBERLAND TRANSFER CENTER SB	48.8	89.8	105.6	680.4	2019.384
Proposed CUMBERLAND TRANSFER CENTER NB	6.4	251.6	230.8	195.4	26487.282
Proposed Cumberland North SB	132	214.6	162.8	707.4	4790.786
Proposed Cumberland North NB	0	2	2	3	5045.32

Condition OFF-PEAK FUTURE BRT 27%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	276	285.8	317	20760.448
Proposed White Circle NB	55.4	18.4	96.6	644.2	1114.914
COBB PKWY+BELLSFERRY RD (BattleField SB)	110.4	51.8	280.2	366	1208.514
COBB PKWY+BELLS FERRY RD (BattleField NB)	92.6	57.4	135.8	647	2371.964
Proposed WellStar Kennestone SB	93.4	79.4	240.8	432.8	4908.2
Proposed WellStar Kennestone NB	124.6	134	147.4	613.6	3130.258
Proposed Allgood RD SB	74.4	81	209.2	463.6	3841.292
Proposed Allgood Rd NB	104.4	105.8	130.6	478.4	3639.394
Proposed North Loop/White Water SB	67	66.2	188.2	504.2	3068.516
Proposed North Loop/White Water NB	52.8	100	111.2	397.2	4397.164
Proposed Whitewater SB	65.6	35	168.8	555	2734.012
Proposed Whitewater NB	56.6	42	81.4	299	1362.75
Proposed Big Chicken/Roswell SB	101.6	108	188	630.8	2318.538
Proposed Big Chicken/Roswell NB	124	58	115	273.8	3137.272
Proposed University SB	161	24.6	154.6	621.4	142.888
Proposed University NB	32.4	11	115.6	228.8	312.438
Proposed Dobbins Air Base SB	37.2	4.2	55.8	608.2	3314.094
Proposed Dobbins Air Base NB	39	59.8	141	229.4	1070.91
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	108.8	127.4	83.8	687	3906.274
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	12	102.8	141.6	175	12432.348
Proposed Cumberland South SB	48	44.4	50.2	730.2	3923.254
Proposed Cumberland South NB	8	54.2	58	72	7950.298
Proposed CUMBERLAND TRANSFER CENTER SB	98.8	108.6	67.4	796	1918.076
Proposed CUMBERLAND TRANSFER CENTER NB	4	28.8	42.8	42	13808.452
Proposed Cumberland North SB	121.2	126.8	73.4	737.8	2124.384
Proposed Cumberland North NB	0	13.6	13.6	14.4	2045.78

Condition 8AM FUTURE SMFE 27%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	378.6	378.6	316.6	20534.36
Proposed White Circle NB	47.2	8.4	29.6	671.6	87.946
COBB PKWY+BELLSFERRY RD (BattleField SB)	115	63.4	363	372.4	466.89
COBB PKWY+BELLS FERRY RD (BattleField NB)	164.2	131.6	78.8	669	1421.494
Proposed WellStar Kennestone SB	111	79.2	302	457.8	4304.872
Proposed WellStar Kennestone NB	88	83	100.2	541.4	3140.892
Proposed Allgood RD SB	78.8	57.4	249.8	469	2616.596
Proposed Allgood Rd NB	91.2	116	107.6	506.2	4207.55
Proposed North Loop/White Water SB	116.2	147.8	280.4	611.6	3154.594
Proposed North Loop/White Water NB	49.8	96.2	84.8	407.2	4397.078
Proposed Whitewater SB	80.8	37.4	240.6	647.8	1254.246
Proposed Whitewater NB	83.4	59	42	313	2109.918
Proposed Big Chicken/Roswell SB	67.6	66.2	220.8	690	2121.146
Proposed Big Chicken/Roswell NB	126.8	72.4	87.8	268.6	4599.204
Proposed University SB	146.2	6.2	130.8	650.4	45.7
Proposed University NB	35.4	33	132.8	209.8	36.492
Proposed Dobbins Air Base SB	44.6	3.6	24.8	633.6	106.278
Proposed Dobbins Air Base NB	33.2	11.2	156.8	200.8	887.668
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	117.6	142	49.2	777.2	1509.074
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	11.8	129.6	174.2	192.8	13219.414
Proposed Cumberland South SB	36	21.2	33.4	694.2	384.89
Proposed Cumberland South NB	3.8	35.8	58.2	70.8	11532.424
Proposed CUMBERLAND TRANSFER CENTER SB	99.6	139.6	68.8	837.4	1585.914

Proposed CUMBERLAND TRANSFER CENTER NB	1.6	29	27.6	36.8	21127.208
Proposed Cumberland North SB	140	156.6	92.2	980.6	2078.732
Proposed Cumberland North NB	0	0.2	0.2	0.2	884.48

Condition 5PM Future SMFe 27%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	168.6	168.6	170.2	25710.1
Proposed White Circle NB	59.8	16.6	58.4	993.8	208.698
COBB PKWY+BELLSFERRY RD (BattleField SB)	52	45.6	171.6	214.8	2370.502
COBB PKWY+BELLS FERRY RD (BattleField NB)	174.2	218	91.6	984.2	2065.84
Proposed WellStar Kennestone SB	54.2	38.2	146	265.4	5795.202
Proposed WellStar Kennestone NB	31.8	30.2	50.6	761.6	1969.062
Proposed Allgood RD SB	37	36.6	123.2	271.4	3213.754
Proposed Allgood Rd NB	120.4	67.2	69.4	775.2	1090.296
Proposed North Loop/White Water SB	41.8	87.6	167	375	6927.792
Proposed North Loop/White Water NB	44.4	99.4	114	716.4	4198.656
Proposed Whitewater SB	72	75.2	174.2	453.8	2129.276
Proposed Whitewater NB	99.8	47.6	65.2	619.8	856.63
Proposed Big Chicken/Roswell SB	57.4	80.6	193.2	538.4	4473.136
Proposed Big Chicken/Roswell NB	218.2	103.2	143.4	576.6	2152.514
Proposed University SB	125.8	14.4	113.2	495.4	55.45
Proposed University NB	60.8	6.4	246	490.4	30.868
Proposed Dobbins Air Base SB	40.6	1.8	28.4	489	179.46

Proposed Dobbins Air Base NB	109.8	135.4	322	523	2658.902
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	76.4	71	19.8	514.2	676.894
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	50.6	134.4	288.4	391.4	8593.402
Proposed Cumberland South SB	24	69.8	63.4	556	2781.286
Proposed Cumberland South NB	53.6	48.4	216.6	271.4	4390.402
Proposed CUMBERLAND TRANSFER CENTER SB	118	137.4	84.8	693.8	2139.2
Proposed CUMBERLAND TRANSFER CENTER NB	6	237.8	235.2	241.6	26844.682
Proposed Cumberland North SB	87	206.8	202.6	897.8	4777.42
Proposed Cumberland North NB	0	3.4	3.4	4.2	2218.26

Condition	OFF-PEAK FUTURE SMFE 27%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	284.6	288	333.2	20733.792
Proposed White Circle NB	64	16.2	101.6	742.2	813.654
COBB PKWY+BELLSFERRY RD (BattleField SB)	97.8	46.6	279.6	373.2	1272.718
COBB PKWY+BELLS FERRY RD (BattleField NB)	169.8	139.2	135.8	735	2215.62
Proposed WellStar Kennestone SB	111	89	248.8	455.6	5145.386
Proposed WellStar Kennestone NB	105.8	91	141	613.2	3661.172
Proposed Allgood RD SB	79.6	72.6	230.8	490.4	3888.94
Proposed Allgood Rd NB	148.2	175.6	140.6	524	4218.674
Proposed North Loop/White Water SB	67	78.6	206.6	517.2	3090.246
Proposed North Loop/White Water NB	32.2	62.2	97.2	346.8	4605.3
Proposed Whitewater SB	64.2	30.6	172.4	565	2210.15

Proposed Whitewater NB	53.8	45.8	74.8	290.6	1639.454
Proposed Big Chicken/Roswell SB	111	141.4	196.8	670.2	2277.876
Proposed Big Chicken/Roswell NB	132.6	51	89.8	241	3746.558
Proposed University SB	148	23.8	116	632.4	341.804
Proposed University NB	31	10.2	99.8	187.4	341.73
Proposed Dobbins Air Base SB	47.2	9	49.6	591.6	2217.462
Proposed Dobbins Air Base NB	27.6	28.2	135.8	192.8	799.758
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	69	111	72.8	703.6	4131.036
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	10.4	117	139.4	164.8	13057.142
Proposed Cumberland South SB	94.6	64.6	46.2	763.8	1578.49
Proposed Cumberland South NB	5	33.2	54.2	59.4	11319.632
Proposed CUMBERLAND TRANSFER CENTER SB	27.2	45.2	52	743	2076.63
Proposed CUMBERLAND TRANSFER CENTER NB	3	24.6	36	33.8	14405.44
Proposed Cumberland North SB	138.2	140.4	62.8	711.4	1927.026
Proposed Cumberland North NB	0	13.2	13.2	14.2	2060.62

Condition 8AM FUTURE SMFE 32%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	377.8	385.4	415	20934.382
Proposed White Circle NB	61.8	22.8	121.4	899.6	1228.218
COBB PKWY+BELLSFERRY RD (BattleField SB)	156	73.2	376.6	489	1209.064

COBB PKWY+BELLS FERRY RD (BattleField NB)	235.8	207.2	166	885	2227.742
Proposed WellStar Kennestone SB	126.8	97.2	318	571.2	5308.808
Proposed WellStar Kennestone NB	115.4	100.4	160	697.4	3740.032
Proposed Allgood RD SB	95	87.6	267	608.2	3841.774
Proposed Allgood Rd NB	124	161.4	179.8	635.2	4360.766
Proposed North Loop/White Water SB	145	174.2	295.4	760.2	3412.554
Proposed North Loop/White Water NB	45	94.4	149	511.4	5093.944
Proposed Whitewater SB	94.6	56.8	254.4	819.8	2328.572
Proposed Whitewater NB	123.6	89.4	110	401.6	1757.39
Proposed Big Chicken/Roswell SB	90.8	87.6	247.4	868.6	2315.822
Proposed Big Chicken/Roswell NB	160	56.4	124	341.4	4573.346
Proposed University SB	195	13.2	149.8	825.4	316.686
Proposed University NB	48.4	25.4	165	294	437.888
Proposed Dobbins Air Base SB	54	4.4	70.4	824	3317.816
Proposed Dobbins Air Base NB	43.6	64.6	186.6	270	1079.588
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	165.2	191.6	97.8	957.8	4143.432
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	15.6	136	190.6	220.4	13398.926
Proposed Cumberland South SB	43.2	28.8	48.2	896.2	5686.366
Proposed Cumberland South NB	7.8	50	78.2	85.6	11313.528
Proposed CUMBERLAND TRANSFER CENTER SB	72.4	120	85.6	1068.4	2103.64
Proposed CUMBERLAND TRANSFER CENTER NB	1.8	101.2	60.4	42.4	20307.666
Proposed Cumberland North SB	197.4	148.8	85.2	962.4	2138.46
Proposed Cumberland North NB	0	1.6	1.6	2	2191.2

Condition 5PM Future SMFe 32%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	135.6	144	174	20891.56
Proposed White Circle NB	47.2	22.2	77.2	1006.2	1245.3
COBB PKWY+BELLSFERRY RD (BattleField SB)	52.6	73.4	144.8	222.2	2850.234
COBB PKWY+BELLS FERRY RD (BattleField NB)	200.2	203	90.4	956.8	1619.982
Proposed WellStar Kennestone SB	51.4	46	130	260.2	5405.402
Proposed WellStar Kennestone NB	47.4	42.4	52.6	746.6	3526.11
Proposed Allgood RD SB	39	19.6	97.8	295.8	2138.972
Proposed Allgood Rd NB	33.2	52	79.4	751	1397.744
Proposed North Loop/White Water SB	38	133	190.2	447.2	8152.418
Proposed North Loop/White Water NB	44.6	42.2	81.4	777	1917.248
Proposed Whitewater SB	78.8	45	180.8	508.6	1893.736
Proposed Whitewater NB	93.2	40	103.8	743	749.982
Proposed Big Chicken/Roswell SB	85	124.6	213.6	598.2	3151.368
Proposed Big Chicken/Roswell NB	260.6	106.8	161.8	691.4	1436.444
Proposed University SB	129.8	23.6	156.2	550.6	360.308
Proposed University NB	75.2	3.4	208.6	586.4	129.726
Proposed Dobbins Air Base SB	52.6	8.8	97	533.6	1606.436
Proposed Dobbins Air Base NB	110.4	115.8	293.8	633	1929.388
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	110.8	127.8	99.8	608.6	805.182
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	77.4	119.8	281.2	506	5799.034
Proposed Cumberland South SB	14.4	29.4	101.6	636	3286.536
Proposed Cumberland South NB	76.4	63	251.2	401	1404.968
Proposed CUMBERLAND TRANSFER CENTER SB	134	191	141.8	793.8	5669.442
Proposed CUMBERLAND TRANSFER CENTER NB	47.4	195.4	296.4	351	16188.09
Proposed Cumberland North SB	58.2	78.8	99.4	649.8	2277.604
Proposed Cumberland North NB	0	134	134	138.4	19822.24

Condition OFF-PEAK FUTURE SMFE 32%

PTSTOP \ NO	ALIGHTING PASSENGERS	BOARDING PASSENGERS	OCCUPANCY	WAITING PASSENGERS	WAIT TIME AVERAGE
Proposed White Circle SB	0	274.6	283	320.8	20700.302
Proposed White Circle NB	56.4	17.8	97.2	813.2	965.824
COBB PKWY+BELLSFERRY RD (BattleField SB)	108.4	67.8	276.6	381	1032.338
COBB PKWY+BELLS FERRY RD (BattleField NB)	112.2	59.6	131.6	810.8	1837.148
Proposed WellStar Kennestone SB	100.2	82	253.2	456.8	5831.906
Proposed WellStar Kennestone NB	138	106.2	162.4	747.2	3278.442
Proposed Allgood RD SB	83.2	83	245.6	508.6	3988.974
Proposed Allgood Rd NB	137.4	171.2	163.6	656.4	4112.29
Proposed North Loop/White Water SB	68.8	81.2	211	523	3408.036
Proposed North Loop/White Water NB	45.8	85.2	123	498.2	4490.43
Proposed Whitewater SB	62.6	30.8	178.2	571.8	1822.14
Proposed Whitewater NB	86	80.2	83.8	412.6	2134.266
Proposed Big Chicken/Roswell SB	110.4	136.6	202.6	682.2	2578.62
Proposed Big Chicken/Roswell NB	169.4	76.4	113.2	350	3990.396
Proposed University SB	160.8	54	136	668.8	1274.546
Proposed University NB	43	16	138	285.6	928.012
Proposed Dobbins Air Base SB	62.2	8.2	70.4	646.2	2087.538
Proposed Dobbins Air Base NB	40.6	23.8	173.8	287.4	698.436
COBB PKWY +WINDY HILL RD (10 IN) (Proposed NB)	27.8	57	78.8	701.8	2660.598
COBB PKWY + WINDY HILL (10 OUT) (Proposed SB)	24	140.8	190.6	255.4	11300.786

Proposed Cumberland South SB	101.6	73.2	49.8	758	1583.356
Proposed Cumberland South NB	19	39.6	97.4	135.6	4895.118
Proposed CUMBERLAND TRANSFER CENTER SB	44.2	64	64	822.4	7148.63
Proposed CUMBERLAND TRANSFER CENTER NB	14.6	74.6	92.2	106	4728.332
Proposed Cumberland North SB	142.8	122.4	69.2	694.4	1962.54
Proposed Cumberland North NB	0	58.6	58.6	66.4	18564.78

* SIMRUN: SimRun, Simulation run (Number of simulation run)
* TIMEINT: TimeInt, Time interval
* DELAYAVG(ALL): DelayAvg(All), Delay (average) (All) (Average delay per vehicle: Total delay / (Number of veh in the network + number of veh that have arrived)) [s]
* DELAYAVG(40): DelayAvg(40), Delay (average) (40) (Average delay per vehicle: Total delay / (Number of veh in the network + number of veh that have arrived)) [s]
* STOPSAVG(ALL): StopsAvg(All), Stops (average) (All) (Average number of stops per vehicle: Total number of stops / (Number of veh in the network + number of veh that have arrived))
* STOPSAVG(40): StopsAvg(40), Stops (average) (40) (Average number of stops per vehicle: Total number of stops / (Number of veh in the network + number of veh that have arrived))
* SPEEDAVG(ALL): SpeedAvg(All), Speed (average) (All) (Average speed: Total distance DistTot / Total travel time TravTmTot) [mph]
* SPEEDAVG(40): SpeedAvg(40), Speed (average) (40) (Average speed: Total distance DistTot / Total travel time TravTmTot) [mph]
* DELAYSTOPAVG(ALL): DelayStopAvg(All), Delay stopped (average) (All) (Average standstill time per vehicle. Total standstill time / (Number of veh in the network + number of veh that have arrived)) [s]
* DELAYSTOPAVG(40): DelayStopAvg(40), Delay stopped (average) (40) (Average standstill time per vehicle. Total standstill time / (Number of veh in the network + number of veh that have arrived)) [s]
* DISTTOT(ALL): DistTot(All), Distance (total) (All) (Total distance of all vehicles that are in the network or have already left it.) [mi]
* DISTTOT(40): DistTot(40), Distance (total) (40) (Total distance of all vehicles that are in the network or have already left it.) [mi]
* TRAVTMTOT(ALL): TravTmTot(All), Travel time (total) (All) (Total travel time of vehicles traveling within the network or that have already left the network.) [s]
* TRAVTMTOT(40): TravTmTot(40), Travel time (total) (40) (Total travel time of vehicles traveling within the network or that have already left the network.) [s]
* DELAYTOT(ALL): DelayTot(All), Delay (total) (All) (Total delay of all vehicles that are in the network or have already left it. The delay of a vehicle in a time step is the part of the time step that must also be used because the actual speed is less than the desired speed. For the calculation, the quotient is obtained by subtracting the actual distance traveled in this time step and desired speed from the duration of the time step. The following are taken into account: (1) Passenger service times, (2) Stop times at stop signs, (3) StopDelay. The following are not taken into account: (1) Stop times of buses/trains at PT stops) [s]
* DELAYTOT(40): DelayTot(40), Delay (total) (40) (Total delay of all vehicles that are in the network or have already left it. The delay of a vehicle in a time step is the part of the time step that must also be used because the actual speed is less than the desired speed. For the

calculation, the quotient is obtained by subtracting the actual distance traveled in this time step and desired speed from the duration of the time step. The following are taken into account: (1) Passenger service times, (2) Stop times at stop signs, (3) StopDelay. The following are not taken into account: (1) Stop times of buses/trains at PT stops) [s]
* STOPSTOT(ALL): StopsTot(All), Stops (total) (All) (Total number of stops of all vehicles that are in the network or have already arrived. The following are taken into account: (1) Scheduled stops at PT stops, (2) Stop in parking lots A stop is counted if the speed of the vehicle at the end of the previous time step was greater than 0 and is 0 at the end of the current time step.)
* STOPSTOT(40): StopsTot(40), Stops (total) (40) (Total number of stops of all vehicles that are in the network or have already arrived. The following are taken into account: (1) Scheduled stops at PT stops, (2) Stop in parking lots A stop is counted if the speed of the vehicle at the end of the previous time step was greater than 0 and is 0 at the end of the current time step.)
* DELAYSTOPTOT(ALL): DelayStopTot(All), Delay stopped (total) (All) (Total standstill time of all vehicles that are in the network or have already arrived. Standstill time = time in which the vehicle is stationary (speed = 0) The following are not taken into account: (1) Stop times of buses/trains at PT stops, (2) Parking times, regardless of parking lot type) [s]
* DELAYSTOPTOT(40): DelayStopTot(40), Delay stopped (total) (40) (Total standstill time of all vehicles that are in the network or have already arrived. Standstill time = time in which the vehicle is stationary (speed = 0) The following are not taken into account: (1) Stop times of buses/trains at PT stops, (2) Parking times, regardless of parking lot type) [s]
* VEHACT(ALL): VehAct(All), Vehicles (active) (All) (Total number of vehicles in the network at the end of the simulation. The vehicles that have arrived VehArr (Vehicles (arrived) and the vehicles not deployed are not accounted for.)
* VEHACT(40): VehAct(40), Vehicles (active) (40) (Total number of vehicles in the network at the end of the simulation. The vehicles that have arrived VehArr (Vehicles (arrived) and the vehicles not deployed are not accounted for.)
* VEHARR(ALL): VehArr(All), Vehicles (arrived) (All) (Vehicles arrived: Total number of vehicles which have already reached their destination and have left the network before the end of the simulation.)
* VEHARR(40): VehArr(40), Vehicles (arrived) (40) (Vehicles arrived: Total number of vehicles which have already reached their destination and have left the network before the end of the simulation.)
* DELAYLATENT: DelayLatent, Delay (latent) (Total delay of vehicles that cannot be used (immediately). Total waiting time of vehicles from input flows and parking lots that were not used at their actual start time in the network. This value may also include the waiting time of vehicles that enter the network before the end of the simulation.) [s]
* DEMANDLATENT: DemandLatent, Demand (latent) (Number of vehicles that could not be used from input flows and parking lots. Number of vehicles that were not allowed to enter the network from input flows and parking lots until the end of the simulation. These vehicles are not counted as vehicles in the VehAct network.)

Condition	DELAYAVG (ALL)	DELAYAVG (PT)	STOPSAVG (ALL)	STOPSAVG (PT)	SPEEDAVG (ALL)	SPEEDAVG (PT)	DELAYSTOPAVG (ALL)	DELAYSTOPAVG (PT)
Base 8AM	147.73		2		18.05		108.58	
Base 5PM	157.95		2.13		16.8		121.78	
Base Off-Peak	86.69		1.63		25.2		58.8	
Future SMFe 27% 8AM	200.41	454.26	2.69	5.48	16.01	23.47	144.25	129.48
Future SMFe 27% 5PM	215.24	482.28	2.71	6.31	14.1	23.34	164.72	137.4
Future SMFe 27% Off-Peak	95.91	453.99	1.88	6.47	24.14	23.75	62.43	292.61
Future SMFe 32% 8AM	202.2	448.41	2.68	5.54	15.95	23.48	145.72	124.21
Future SMFe 32% 5PM	219.93	489.84	2.79	6.25	13.99	23.06	166.77	149.77
Future SMFe 32% Off-Peak	93.54	453.61	1.85	6.9	24.39	23.91	61.21	285.03
Future BRT 27% 8AM	204.99	341.26	2.73	7.05	15.8	25.33	147.29	177.63
Future BRT 27% 5PM	204.57	333.26	2.63	7.08	14.69	25.49	154.94	168.03
Future BRT 27% Off-Peak	98.28	518.86	1.92	6.97	23.88	22.32	64.1	353.26

Condition	DISTTOT(ALL)	DISTTOT(PT)	TRAVTMTOT(ALL)	TRAVTMTOT(PT)	DELAYTOT(ALL)	DELAYTOT(PT)	STOPSTOT(ALL)	STOPSTOT(PT)
Base 8AM	42267.38		8430377		4800894		64882	
Base 5PM	44237.94		9484963		5606129		75709	
Base Off-Peak	31838.64		4550143		1881108		35369	
Future SMFe 27% 8AM	36533.13	179.88	8215341	27602.2	5157964	9993.62	69269	121
Future SMFe 27% 5PM	35979.17	181.79	9189478	28041.86	6104423	10610.08	76857	139
Future SMFe 27% Off-Peak	30721.7	180.34	4581040	27363.12	2002063	9987.71	39271	142
Future SMFe 32% 8AM	36554.11	180.24	8252860	27636.16	5192885	9865.09	68745	122
Future SMFe 32% 5PM	35949.14	180.96	9254103	28265.1	6175939	10776.55	78263	137
Future SMFe 32% Off-Peak	30612.74	185.13	4519649	27881.66	1950052	9979.33	38560	152
Future BRT 27% 8AM	36832.21	180.01	8394723	25581.96	5312809	7507.75	70625	155
Future BRT 27% 5PM	36803.94	183.84	9027804	25970.04	5872663	7331.74	75569	156
Future BRT 27% Off-Peak	30822.18	179	4647752	28898.38	2059656	11415.02	40168	153

Condition	DELAYSTOPTOT(ALL)	DELAYSTOPAVG(PT)	VEHACT(ALL)	VEHACT(PT)	VEHARR(ALL)	VEHARR(PT)	DELAYLATENT	DEMANDLATENT
Base 8AM	3528313		2400		30105		6176514	2970.6
Base 5PM	4322136		2721		32772		2568218	1204.4
Base Off-Peak	1275885		1236		20461		1281.12	0.2
Future SMFe 27% 8AM	3712516	129.48	2325	7	23411	15	6206172	3100.8
Future SMFe 27% 5PM	4671429	3022.75	2788	7	25577	15	6962981	3314.6
Future SMFe 27% Off-Peak	1303169	6437.33	1230	6	19643	16	251166	160.8
Future SMFe 32% 8AM	3742434	2732.54	2399	7	23284	15	6001473	3002.2
Future SMFe 32% 5PM	4683189	3294.88	2703	7	25377	15	6581726	3061.4
Future SMFe 32% Off-Peak	1276039	6270.64	1237	6	19613	16	222534.9	94.6
Future BRT 27% 8AM	3817268	3907.82	2439	6	23479	16	6398565	3054.6
Future BRT 27% 5PM	4447824	3696.55	2605	6	26099	16	6186891	2962
Future BRT 27% Off-Peak	1343315	7771.82	1297	7	19661	15	253652.4	156.6

Vehicle Travel Time Results

1: Vehicle travel time on general purpose lanes southbound

2: Vehicle travel time on general purpose lanes northbound

3: Public transit vehicle travel time southbound

4: Public transit vehicle travel time northbound

CONDITION	VEH TYPE	TIME	RED	Number of Vehicles Recorded				Vehicle Travel Time				Distance Traveled			
				1	2	3	4	1	2	3	4	1	2	3	4
Base		8AM		3	12	-	-	1303.01	1181.37	-	-	55430.41	55632.19	-	-
Base		5PM		37	3	-	-	1233.79	1188.08	-	-	55430.19	55467.3	-	-
Base		Off-Peak		2	12	-	-	1056.89	1101.09	-	-	55430.22	55614.76	-	-
Future	SMFe	8AM	27%	3	16	8	8	1163.77	1161.7	1840.74	1764.46	55770.09	55596.25	63024.84	62828.48
Future	SMFe	5PM	27%	28	2	8	8	1240.14	1128.44	1842.07	1829.23	55441.86	55468.66	63024.84	62828.48
Future	SMFe	Off-Peak	27%	3	12	8	8	1099.08	1071.53	1707.95	1887.36	55441.83	55510.31	63024.84	62828.48
Future	SMFe	8AM	32%	2	19	8	8	1235.86	1147.38	1822.51	1790.99	55678.82	55468.84	63024.84	62828.48
Future	SMFe	5PM	32%	27	1	8	7	1294.3	1304.57	1852.45	1848.64	55441.87	55468.9	63024.84	62828.48
Future	SMFe	Off-Peak	32%	2	10	8	8	1107.43	1070.15	1756.12	1900.15	55441.61	55468.98	63024.84	62828.48
Future	BRT	8AM	27%	3	16	8	8	1299.52	1156.23	1729.09	1644.5	55441.94	55468.9	63024.84	62828.48
Future	BRT	5PM	27%	33	1	8	8	1314.41	1175.73	1662.05	1745.01	55468.22	55468.66	63024.84	62828.48
Future	BRT	Off-Peak	27%	1	11	7	8	1091.66	1077.51	1789.65	2001.8	55441.8	55469.11	63024.84	62828.48

Appendix C: AHP Model Validation

Criteria	No	Sub-Criteria	Final Weights	Equivalent Weights
1	1.a	travel time	0.358	0.166
TRANSPORT	1.b	pt delay	0.358	0.166
	1.c	wait time	0.285	0.132
2	2.a	co2	0.143	0.019
EMISSIONS	2.b	co2	0.143	0.019
	2.c	pm2.5	0.143	0.019
	2.d	nox	0.143	0.019
	2.e	ch4	0.143	0.019
	2.f	n2o	0.143	0.019
	2.g	voc	0.143	0.019
3	3.a	capital cost	0.217	0.088
FINANCE	3.b	O&M	0.330	0.134
	3.c	EAUC	0.453	0.183

Pairwise Comparison Matrix

Criteria	1.a	1.b	1.c	2.a	2.b	2.c	2.d	2.e	2.f	2.g	3.a	3.b	3.c
1.a	1	1.00	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91
1.b	1.00	1	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91
1.c	0.80	0.80	1	7.09	7.09	7.09	7.09	7.09	7.09	7.09	1.50	0.99	0.72
2.a	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
2.b	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
2.c	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
2.d	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
2.e	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
2.f	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
2.g	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10
3.a	0.53	0.53	0.66	4.71	4.71	4.71	4.71	4.71	4.71	4.71	1	0.66	0.48
3.b	0.80	0.80	1.01	7.17	7.17	7.17	7.17	7.17	7.17	7.17	1.52	1	0.73
3.c	1.10	1.10	1.39	9.84	9.84	9.84	9.84	9.84	9.84	9.84	2.09	1.37	1.00

1. normalize

Criteria	1.a	1.b	1.c	2.a	2.b	2.c	2.d	2.e	2.f	2.g	3.a	3.b	3.c	sum	Estimate (w)
1.a	1	1.00	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91	70	0.17
1.b	1.00	1	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91	70	0.17
1.c	0.80	0.80	1	7.09	7.09	7.09	7.09	7.09	7.09	7.09	1.50	0.99	0.72	55	0.13
2.a	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
2.b	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
2.c	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
2.d	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
2.e	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
2.f	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
2.g	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	8	0.02
3.a	0.53	0.53	0.66	4.71	4.71	4.71	4.71	4.71	4.71	4.71	1	0.66	0.48	37	0.09

3.b	0.80	0.80	1.01	7.17	7.17	7.17	7.17	7.17	7.17	7.17	1.52	1	0.73	56	0.13
3.c	1.10	1.10	1.39	9.84	9.84	9.84	9.84	9.84	9.84	9.84	2.09	1.37	1.00	77	0.18
	6	6	8	54	54	54	54	54	54	54	11	7	5	419	

2. normalize/average

Criteria	1.a	1.b	1.c	2.a	2.b	2.c	2.d	2.e	2.f	2.g	3.a	3.b	3.c	estimate (w)
1.a	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661
1.b	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661	0.1661
1.c	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322	0.1322
2.a	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
2.b	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
2.c	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
2.d	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
2.e	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
2.f	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
2.g	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187	0.0187
3.a	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879	0.0879
3.b	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337	0.1337
3.c	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835	0.1835

3. normalize geometric mean

Criteria	1.a	1.b	1.c	2.a	2.b	2.c	2.d	2.e	2.f	2.g	3.a	3.b	3.c	geomean	estimate (w)

1.a	1	1.00	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91	3.500304	0.166
1.b	1.00	1	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91	3.500304	0.166
1.c	0.80	0.80	1	7.09	7.09	7.09	7.09	7.09	7.09	7.09	1.50	0.99	0.72	2.787128	0.132
2.a	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
2.b	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
2.c	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
2.d	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
2.e	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
2.f	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
2.g	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.393118	0.019
3.a	0.53	0.53	0.66	4.71	4.71	4.71	4.71	4.71	4.71	4.71	1	0.66	0.48	1.852509	0.088
3.b	0.80	0.80	1.01	7.17	7.17	7.17	7.17	7.17	7.17	7.17	1.52	1	0.73	2.817179	0.134
3.c	1.10	1.10	1.39	9.84	9.84	9.84	9.84	9.84	9.84	9.84	2.09	1.37	1.00	3.867219	0.183
														21.07647	

A^2

Criteria	1.a	1.b	1.c	2.a	2.b	2.c	2.d	2.e	2.f	2.g	3.a	3.b	3.c	sum		check with w
1.a	13	13.00	16.33	115.75	115.75	115.75	115.75	115.75	115.75	115.75	24.56	16.15	11.77	905	0.166	0.00
1.b	13.00	13	16.33	115.75	115.75	115.75	115.75	115.75	115.75	115.75	24.56	16.15	11.77	905	0.166	0.00
1.c	10.35	10.35	13	92.17	92.17	92.17	92.17	92.17	92.17	92.17	19.56	12.86	9.37	721	0.132	0.00
2.a	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
2.b	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
2.c	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
2.d	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
2.e	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
2.f	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
2.g	1.46	1.46	1.83	13	13	13	13	13	13	13	2.76	1.81	1.32	102	0.019	0.00
3.a	6.88	6.88	8.64	61.26	61.26	61.26	61.26	61.26	61.26	61.26	13	8.55	6.23	479	0.088	0.00

3.b	10.46	10.46	13.14	93.16	93.16	93.16	93.16	93.16	93.16	93.16	19.77	13	9.47	728	0.134	0.00
3.c	14.36	14.36	18.04	127.88	127.88	127.88	127.88	127.88	127.88	127.88	27.14	17.85	13.00	1000	0.183	0.00
														5450		

CONSISTENCY CHECK

Criteria	1.a	1.b	1.c	2.a	2.b	2.c	2.d	2.e	2.f	2.g	3.a	3.b	3.c	Estimate w
1.a	1	1.00	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91	0.166
1.b	1.00	1	1.26	8.90	8.90	8.90	8.90	8.90	8.90	8.90	1.89	1.24	0.91	0.166
1.c	0.80	0.80	1	7.09	7.09	7.09	7.09	7.09	7.09	7.09	1.50	0.99	0.72	0.132
2.a	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
2.b	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
2.c	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
2.d	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
2.e	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
2.f	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
2.g	0.11	0.11	0.14	1	1	1	1	1	1	1	0.21	0.14	0.10	0.019
3.a	0.53	0.53	0.66	4.71	4.71	4.71	4.71	4.71	4.71	4.71	1	0.66	0.48	0.088
3.b	0.80	0.80	1.01	7.17	7.17	7.17	7.17	7.17	7.17	7.17	1.52	1	0.73	0.134
3.c	1.10	1.10	1.39	9.84	9.84	9.84	9.84	9.84	9.84	9.84	2.09	1.37	1.00	0.183
	6	6	8	54	54	54	54	54	54	54	11	7	5	

λ	1	1	1	1	1	1	1	1	1	1	1	1	1
λmax =	13.00												
CI	-1.48E-16												
CR	-9.869E-17	0%	OK										

Pairwise Comparison Matrix

CRITERIA	1	2	3
1	1	3.56	1.15
2	0.28	1	0.32
3	0.87	3.10	1

1. NORMALIZE

CRITERIA	1	2	3		Estimate (w)
1	1	3.56	1.15	5.70	0.4644
2	0.28	1	0.32	1.60	0.1306
3	0.87	3.10	1	4.97	0.4050
	2.15	7.66	2.47	12.28	

2. NORMALIZE/AVERAGE

CRITERIA	1	2	3	Estimate(w)
1	0.46	0.46	0.46	0.46
2	0.13	0.13	0.13	0.39
3	0.41	0.41	0.41	1.22

3. NORMALIZE GEOMETRIC MEAN

CRITERIA	1	2	3		Estimate (w)
1	1	3.56	1.15	1.60	0.4644
2	0.28	1	0.32	0.45	0.1306
3	0.87	3.10	1	1.39	0.4050
				3.44	

A^2

CRITERIA	1	2	3			CHECK
1	3	10.67	3.44	17.11	0.4644	0.0000
2	0.84	3	0.97	4.81	0.1306	0.0000
3	2.62	9.31	3	14.92	0.4050	0.0000
				36.84		

λmax =	3
CI	0
CR	0

TRANSPORTATION

CRITERIA	1.a	1.b	1.c
1.a	1	1.00	1.26
1.b	1	1	1.26
1.c	0.796	0.796	1

1. NORMALIZE

CRITERIA	1	2	3		Estimate (w)
1	1	1.00	1.26	3.26	0.3576
2	1.00	1	1.26	3.26	0.3576
3	0.80	0.80	1	2.59	0.2848
	2.80	2.80	3.51	9.10	

2. NORMALIZE/AVERAGE

CRITERIA	1	2	3	Estimate(w)
1	0.36	0.36	0.36	0.36
2	0.36	0.36	0.36	1.07
3	0.28	0.28	0.28	0.85

3. NORMALIZE GEOMETRIC MEAN

CRITERIA	1	2	3		Estimate (w)
1	1	1.00	1.26	1.08	0.3576
2	1.00	1	1.26	1.08	0.3576
3	0.80	0.80	1	0.86	0.2848
				3.02	

A^2

CRITERIA	1	2	3			CHECK
1	3	3.00	3.77	9.77	0.2651	-0.0925
2	3.00	3	3.77	9.77	0.2651	-0.0925
3	2.39	2.39	3	7.78	0.2111	-0.0737
				27.31		

λmax =	3
CI	0
CR	0

FINANCES

CRITERIA	3.A	3.B	3.C
3.A	1	0.66	0.48
3.B	1.520737	1	0.73
3.C	2.088	1.373	1

1. NORMALIZE

CRITERIA	1	2	3		Estimate (w)
1	1	0.66	0.48	2.14	0.2170
2	1.52	1	0.73	3.25	0.3300
3	2.09	1.37	1	4.46	0.4530
	4.61	3.03	2.21	9.85	

2. NORMALIZE/AVERAGE

CRITERIA	1	2	3	Estimate(w)
1	0.22	0.22	0.22	0.22
2	0.33	0.33	0.33	0.99
3	0.45	0.45	0.45	1.36

3. NORMALIZE GEOMETRIC MEAN

CRITERIA	1	2	3		Estimate (w)
1	1	0.66	0.48	0.68	0.1978
2	1.52	1	0.73	1.03	0.3008
3	2.09	1.37	1	1.42	0.4129
				3.14	

A^2

CRITERIA	1	2	3			CHECK
1	3	1.97	1.44	6.41	0.2170	0.0000
2	4.56	3	2.19	9.75	0.3300	0.0000
3	6.26	4.12	3	13.38	0.4530	0.0000
				29.54		

λmax =	3
CI	0
CR	0