CAMBRIDGE SYSTEMATICS

Raleigh Union Station Phase II: RUS Bus

BUILD Application

Appendix: Benefit-Cost Analysis Methodology

prepared by

Cambridge Systematics, Inc.

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report

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BUILD Application

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Executive Summary

This technical report summarizes the approach used for conducting a Benefit-Cost Analysis (BCA) for the Raleigh Union Station Phase II: RUS Bus. Table ES.1 shows the project matrix, which describes baseline conditions, proposed improvements, types of impacts to all users/population affected by them, a summary of monetized and non-monetized benefits, and benefit alignment with project goals.

- **The cost effectiveness results show that with discount rate of 7%, the project is expected to generate $49.36 million in benefits.**
- **The project's total cost with the same 7% discount rate is $38.42 million.**
- **The benefit cost ratio (BCR) at 7% discount rate is 1.28.**

The project is expected to generate $282.39 million in benefits in 2017 dollars. The project capital cost in 2017 dollars are estimated to be $50.72 million plus a 30 year total of annual operating and maintenance costs of $7.5 million. This yields a benefit to cost ratio of 4.85 in 2017 dollars.

These results are driven by the sizable impact of the value of travel time savings, vehicle operating cost savings, non-motorized traffic safety savings, and reduced cost of overall transportation expenditures. The next section of this report describes the project background and existing and future travel conditions in the region followed by the proposed BCA methodology and results. The last section of this appendix summarizes the BCA results.

Table ES.1 RUS Bus Project Matrix

Conditions	Changes to Baseline	Type of Impact	Population Affected	Economic Benefit	Project Goals Met	Summary of Results
Monetized Benefits						***$49,357,013***
Implementation of the Wake Transit Plan will **triple by 2025 the number of buses converging in Downtown Raleigh** from points throughout the Triangle region. This growth includes four bus rapid transit (BRT) corridors that intersect in Downtown, regional express routes connecting to park-and-ride lots in exurban and rural communities, frequent routes along high-travel corridors, and an expanded local bus network. This growth will **overwhelm the current capacity of the existing GoRaleigh station at Moore Square and the current access for buses at Raleigh Union Station (RUS)**, as well as lead to **increased congestion and safety issues on key travel corridors** in Downtown, and **negatively impact transit on-time performance**.	RUS Bus enables a **balanced and safe connection** among the BRT, express, and local routes converging in Downtown Raleigh to the **intercity and interregional services at RUS**, **growing and diversifying areas of Downtown**, and existing and planned **regional pedestrian and bicycle corridors**. RUS Bus helps to better distribute routes, **providing for a more flexible and resilient network**. RUS Bus also helps **capitalize on opportunities created by RUS, helping to deliver a world class multimodal hub** that will fully accommodate planned transit network expansion and projected regional population and employment growth. As part of a **mixed use development** on land owned by Go Triangle, RUS Bus will also **generate lease revenue to offset operations costs and increase the number of captive riders** within the area.	Passenger trip travel time, operating cost, transit travel savings, and non-carbon and carbon emissions	Local, state and national population	Monetized value of travel time savings	**1,2,3,4**	**$8,144,893**
				Monetized value of change in fuel based vehicle operating costs	**1,2,3,4**	**$1,158,754**
				Monetized value of non-fuel based vehicle operating costs	**1,2,3,4**	**$2,313,918**
				Monetized value of cost savings associated with mode diversion to transit and transit network efficiency	**1,2,3,4**	**$31,652,364**
			Regional population	Monetized value of reduced non-carbon emissions	**1,2,3,4**	**$86,271**
				Monetized value of reduced carbon emissions from purchase of five battery electric buses	**3,4**	**$186,741**
		Mode diversion from passenger vehicles to transit	Local, state and national population	Monetized value of reduced collisions (motorized only)	**3,4**	**$1,369,601**
		Bicycle and pedestrian safety	Local, state and national population	Monetized value of reduced non-motorized user involved collision	**3,4**	**$3,780,354**
		State of good repair costs	Government	Monetized value of the marginal impact of decreased VMT on pavement (SOGR)	**2,3**	**$12,375**
		Asset Residual Value	Government	Monetized value of asset residual value in years beyond analysis period	**1**	**$651,743**

Conditions	Changes to Baseline	Type of Impact	Population Affected	Economic Benefit	Project Goals Met	Summary of Results
Other Benefits (not monetized)						
Existing vacant, underutilized parcels at project site.	Full site buildout, integrating facility within neighborhood, including retail and mixed-use overbuild with residential and hotel uses.	Lease revenue to Go Triangle	Government	Value of the total annual lease revenue committed to RUS Bus operations	6	Pending development agreements, total lease revenue could offset share of annual facility O&M costs
The Warehouse District is already experiencing growth associated with RUS, however the street network is not ready to accommodate the planned influx of transit vehicles and expected increase in non-motorized activity, potentially limiting future development activity.	Projected employment at RUS Bus facility plus employment associated with supporting retail and overbuild mix (hotel and residential) will strengthen development market in Warehouse District.	Additional jobs from project construction, operations, and neighborhood project impacts	Local and Regional population	Cumulative economic impact of construction spending, RUS Bus operations and overbuild, and additional economic growth within Warehouse District	6	Potential short and long terms jobs generated, and property tax revenue generation
Single bus terminal (GoRaleigh at Moore Square) is disconnected from RUS (0.6 mile walk) and only immediately adjacent (< 0.25 mile) to eastern half of Downtown market.	Two interconnected terminals downtown can better facilitate transit services in emergency situations or during special events	More resilient and adaptable system during emergencies	Government and local and regional population	Interconnected and resilient network enabling more efficient emergency and special event operations	3,4,5	Transportation system that is more resilient to events, resulting in less economic losses
	RUS Bus will be designed and constructed to meet LEED standards.	Facility and bus operating cost savings and waste reduction	Government and local and regional population	Operating cost savings and emission associated with an energy efficient RUS Bus facility	3,5	Operating cost savings associated with energy efficient infrastructure and waste management
Warehouse District and adjacent neighborhoods are currently disconnected and require multiple transfers to access regional transit service.	RUS Bus Will enhance accessibility to transit for Raleigh downtown residents and employees and improve accessibility to regional destinations.	Enhanced passenger accessibility to transit	Local, state and national population	Enhanced and seamless access for transit users between intercity, interregional, regional, and local transit services, including access for both rural and urban populations	1,4,6	Enhanced access to transit within Raleigh downtown and to regional destinations

Conditions	Changes to Baseline	Type of Impact	Population Affected	Economic Benefit	Project Goals Met	Summary of Results
Monetized Costs						***$38,422,863***
			Government	Capital construction costs		**$36,217,861**
			Government	Annual operating and maintenance costs		**$2,205,002**
Overall Benefit / Cost Ratio (7% discount rate, 30 year analysis period – 2024-2053)						**1.28***

* Note: Inclusion or removal of the social cost of carbon within the BCA does on impact the overall BCA ratio, internal rate of return, or payback period for RUS Bus given its relatively low benefit value compared to total overall benefits and costs.

1.0 Project Background

Currently, GoRaleigh, the City of Raleigh bus transit system, and GoTriangle operate bus service to the GoRaleigh station in downtown Raleigh at Moore Square. This 21-bay facility has over 6,000 daily boardings and serves as a major transportation hub on the east side of downtown. GoRaleigh serves the downtown area with eighteen standard fixed bus routes, two express bus routes, and a free downtown circulator.

In November 2016 Wake County voters chose to invest in a half-cent sales tax to pay for an ambitious transit plan to meet the needs of our growing population. Over the next 10 years, the county, City, and GoTriangle will begin to implement the Wake Transit Plan which will triple countywide bus service, increase the frequency of bus service, and add BRT and commuter rail systems. To implement the Wake County Transit Plan, an additional 8 – 12 standard bus bays would be required, along with on-street facilities, and BRT infrastructure in a constrained part of downtown. The existing GoRaleigh station does not have the capacity to adequately accommodate this growth.

To date, through a partnership between GoTriangle, the City of Raleigh, NCDOT, and the United States Department of Transportation/Federal Railroad Administration, Phase IA (rail infrastructure) and Phase IB (station facility) of Raleigh Union Station have been completed. Phases IA and IB were made possible through appropriations from TIGER 12 and TIGER 13, respectively, and the facility became fully operational on July 10, 2018. Further detail on Raleigh Union Station can be found at www.GoRaleighUnionStation.org.

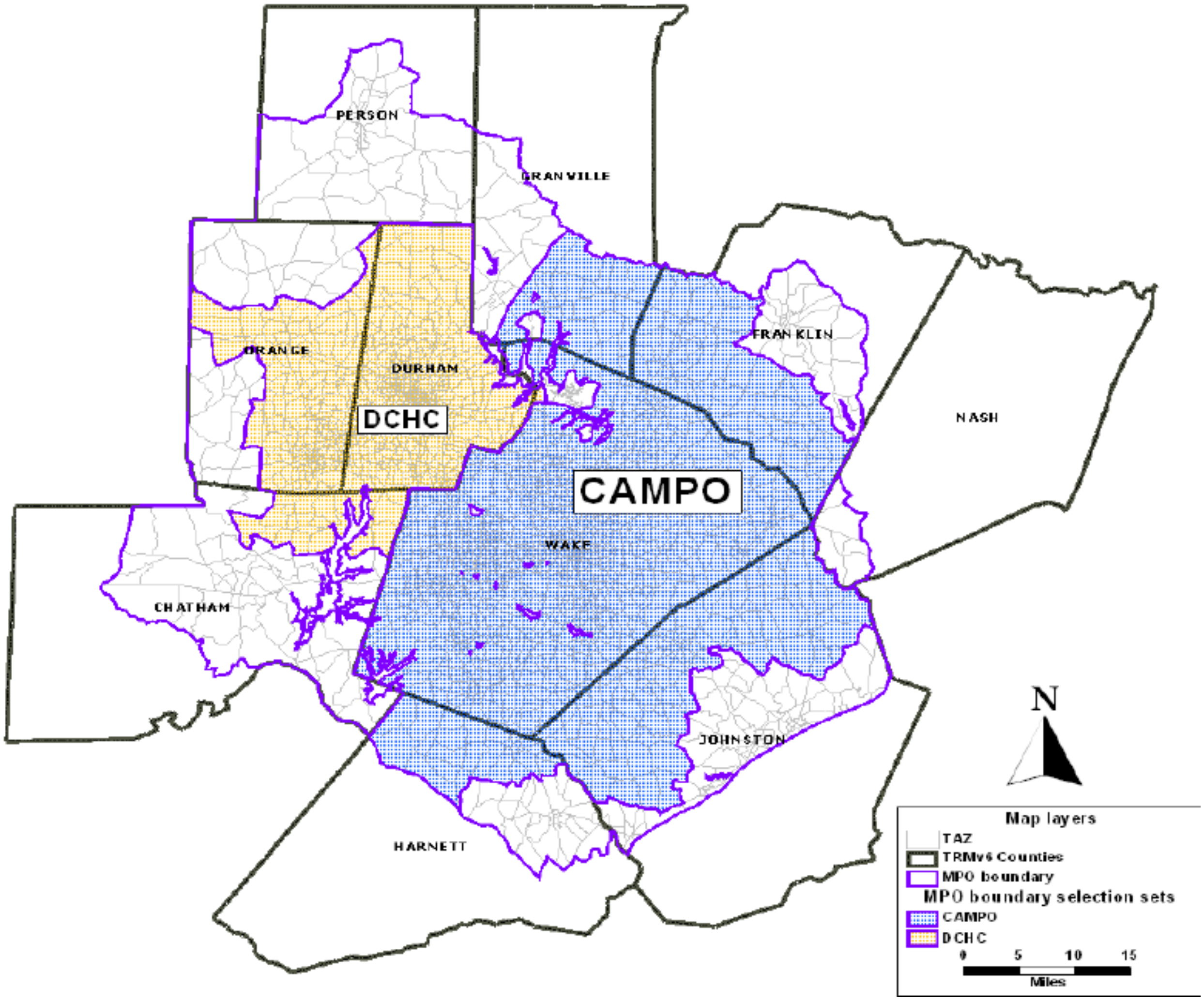
Raleigh Union Station Phase II: RUS Bus will become the second major transportation hub in downtown, complimenting the existing facility, and providing direct connections to various modes and destinations on the west side of Downtown. The planned design for the new facility will be able to accommodate up to 8 buses at once in an off-street facility with on-street bus bays for additional capacity. It will also connect to one or more BRT lines planned as part of the Wake Transit Plan implementation and to Commuter Rail (CRT) and existing AMTRAK service via the adjacent Raleigh Union Station Phase I.

The potential infusion of BUILD funding affords GoTriangle, and its partners an opportunity to replace an obsolete fleet and get ahead of the region's dramatic population growth over the lifecycle of the project. The funding will act as a catalyst to the implementation of critical transportation investments and growth plans to enhance the quality of life in Raleigh, the Triangle, and the Southeastern US region.

2.0 Study Area

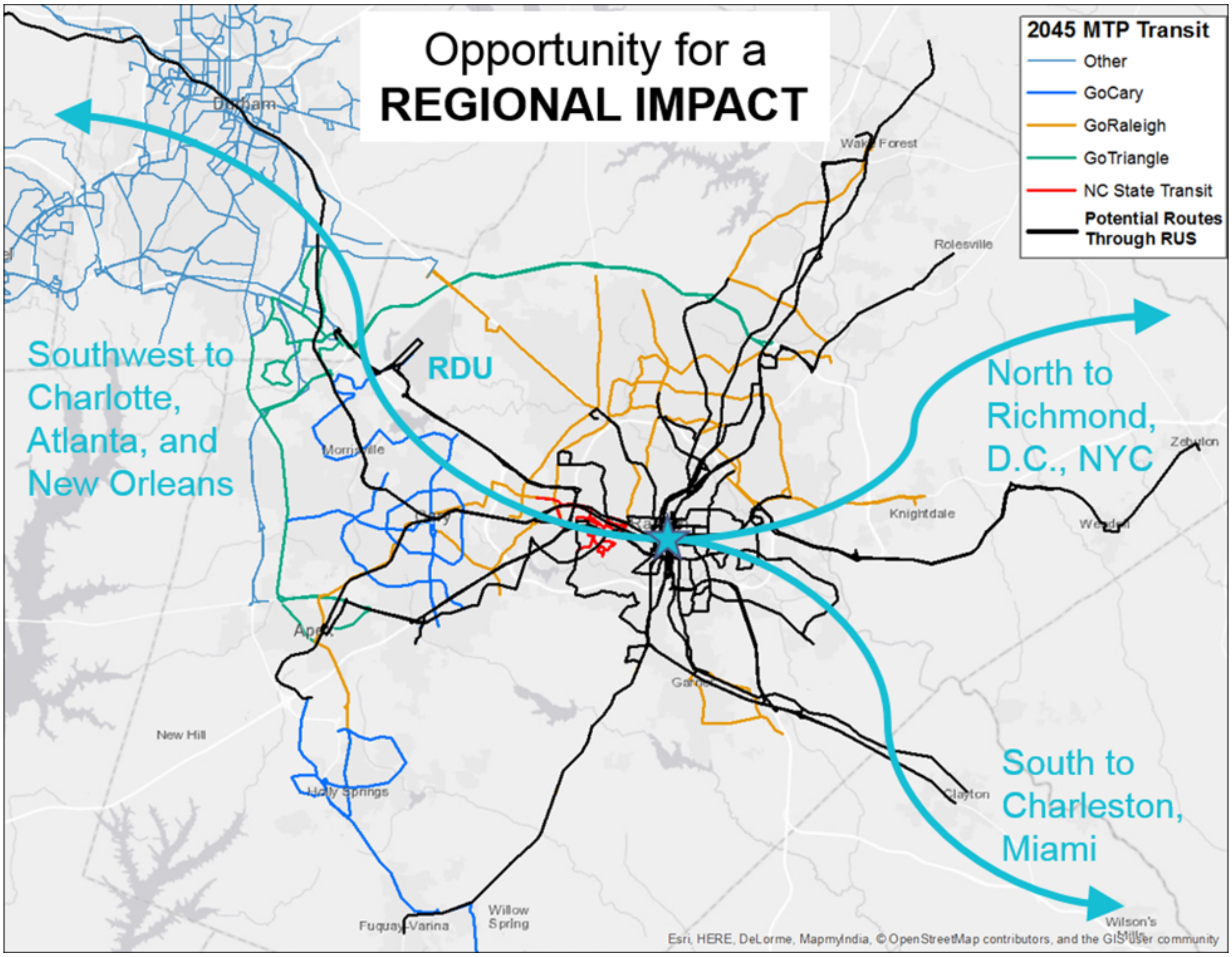
This analysis estimates the travel efficiencies to be generated by the proposed RUS Bus within the entire Triangle region (Figure 2.1). For the purposes of this BCA, the Triangle region is consistent with the boundaries of the Triangle Regional Model which is utilized by both the Capital Area MPO (CAMPO) and Durham-Chapel Hill-Carrboro MPO (DCHCMPO) to support metropolitan transportation plan analysis and air quality assessments.

Figure 2.1 Boundary Map of Triangle Region / Triangle Regional Model



The regional and inter-regional transit and commuter rail connections facilitated by RUS and RUS Bus are strong justifications supporting a regional scaled analysis rather than a Downtown Raleigh focused analysis. As described in Figure 2.2, RUS and RUS Bus collectively facilitate connections between local, regional, interregional, and interstate passenger services, with Downtown Raleigh serving as a multimodal hub for these connections. The benefits of RUS Bus are anticipated to spread to travelers throughout the region, particularly for cost savings associated with the mode shift from driving alone to transit. There are also benefits that are uniquely focused on the project location, for example safety benefits accruing to passengers transferring between service at RUS and RUS Bus and passengers accessing RUS or RUS Bus by foot or bicycle. The market impacted by each benefit category is detailed within Section 4.

Figure 2.2 Regional, Interregional, and Interstate Connections



3.0 Analytical Assumptions

3.1 Discount Rates

For project investments, dollar figures in this analysis are expressed in constant 2017 dollars. In instances where certain cost estimates or benefit valuations are expressed in dollar values in other (historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers (CPI-U) in U.S. cities is used to adjust them. The real discount rate used for this analysis is 7.0 percent, consistent with U.S. DOT Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs, June 2018.

3.2 Evaluation Period

The evaluation period includes the Project construction period during which capital construction activities are undertaken, as well as the operations period after Project completion, when benefits/disbenefits are accrued to the public.

- The construction is planned to start in 2021, with procurement expected to begin in August 2020, and end in late 2023 (with anticipated project closeout by December 2023).
- The project opening year is 2024 and the period of the economic analysis is the 30-year period from 2024 to 2053.
- Unlike typical roadway projects with a 20-year analysis period, this BCA estimates benefits for the 30-year analysis period as the major project components, such as the actual RUS Bus structure, pedestrian bridge, bus bays, and bus rapid transit (BRT) stops are anticipated to be maintained and used beyond the typical 20-year period.

3.3 Transit Ridership Analysis

The RUS Bus transit center in Downtown Raleigh is anticipated to enhance transit ridership, improve infrastructure conditions, and enhance active transportation access to Go Triangle and Go Raleigh bus and future BRT and CRT services, in addition to existing AMTRAK service at RUS. Changes in the transportation system have direct and indirect impacts on the users as well as the level of economic activity. The potential changes in travel efficiencies and costs will result in benefits/disbenefits to the economy. To analyze changes in transit ridership and travel patterns, the bus transfer center and its subsequent bus services are coded in the Triangle region travel demand model (TDM). The TDM is used to model the Build and No-Build conditions for the following analysis years:

- No-Build Condition 2025 – consistent with implementation of DCHCMPO and CAMPO 2045 Metropolitan Transportation Plans (MTP);
- No-Build Condition 2045 – consistent with implementation of DCHCMPO and CAMPO 2045 MTP; and
- Build Condition 2045

The outputs of the TDM are used to generate daily metrics of transit boardings, transit passenger miles traveled (PMT), transfers rates in transit stations, vehicle-miles traveled (VMT), vehicle-hours traveled (VHT), and daily volume among other metrics. The TDM analysis also yields travel metrics for highway users (autos and trucks) by various trip purposes, such as commute, business, and other purposes. Specifically, the TDM results yield the following important outputs for the Build and No-Build conditions:

- Transit boardings and alightings by mode of access and transfer rates;
- Transit PMT
- VMT by vehicle type (passenger cars and trucks) and trip purpose (commute, business and other purposes)
- VHT by vehicle type (passenger cars and trucks) and trip purpose (commute, business and other purposes)
- Trip volume by vehicle type (passenger cars and trucks) and trip purpose (commute, business and other purposes)

To estimate project benefits/disbenefits the daily metrics are converted to annual trips based on the follow assumptions for various vehicles and trip purposes:

- 265 days per year for auto business trips;
- 260 days per year for auto commute trips;
- 315 days per year for auto leisure trip purposes; and
- 365 days per year for truck trips.

The estimation of the highway user impacts involved establishing the following scenarios:

- No-Build Scenarios:
  - Scenario A: 2025 No-Build (including committed projects within the CAMPO and DCHCMPO MTP)
  - Scenario B: 2045 No-Build (including committed projects within the CAMPO and DCHCMPO MTP)
- Build Scenarios:
  - Scenario C: 2055 No-Build plus Committed Projects plus the RUS Bus Build Alternative

2045 Metropolitan Transportation Plan (2045 No-Build)

Both MPOs adopted the region's 2045 MTP in late 2017/early 2018. The overall process and outcomes of this multiyear planning effort is well summarized through an Executive Summary.

The jointly developed MTP covering both MPOs includes assumptions for continued economic growth throughout the region, including both on the fringes and within the centers of Raleigh, Durham, and Chapel Hill in addition to other activity centers such as the Research Triangle Park. In total, the population of the region covered by the TDM (inclusive of areas within both MPO boundaries, plus areas outside the MPO as presented in Figure 2.1) is forecasted to grow as highlighted below:

- Population: **1.68 million in 2013 to 2.96 million in 2045** (76 percent growth)
- Jobs: **860,000 in 2013 to 1.53 million in 2045** (78 percent growth)

The region has a common vision of what it wants its transportation system to be: "*a seamless integration of transportation services that offer a range of travel choices to support economic development and are compatible with the character and development of our communities, sensitive to the environment, improve quality of life, and are safe and accessible for all.*"

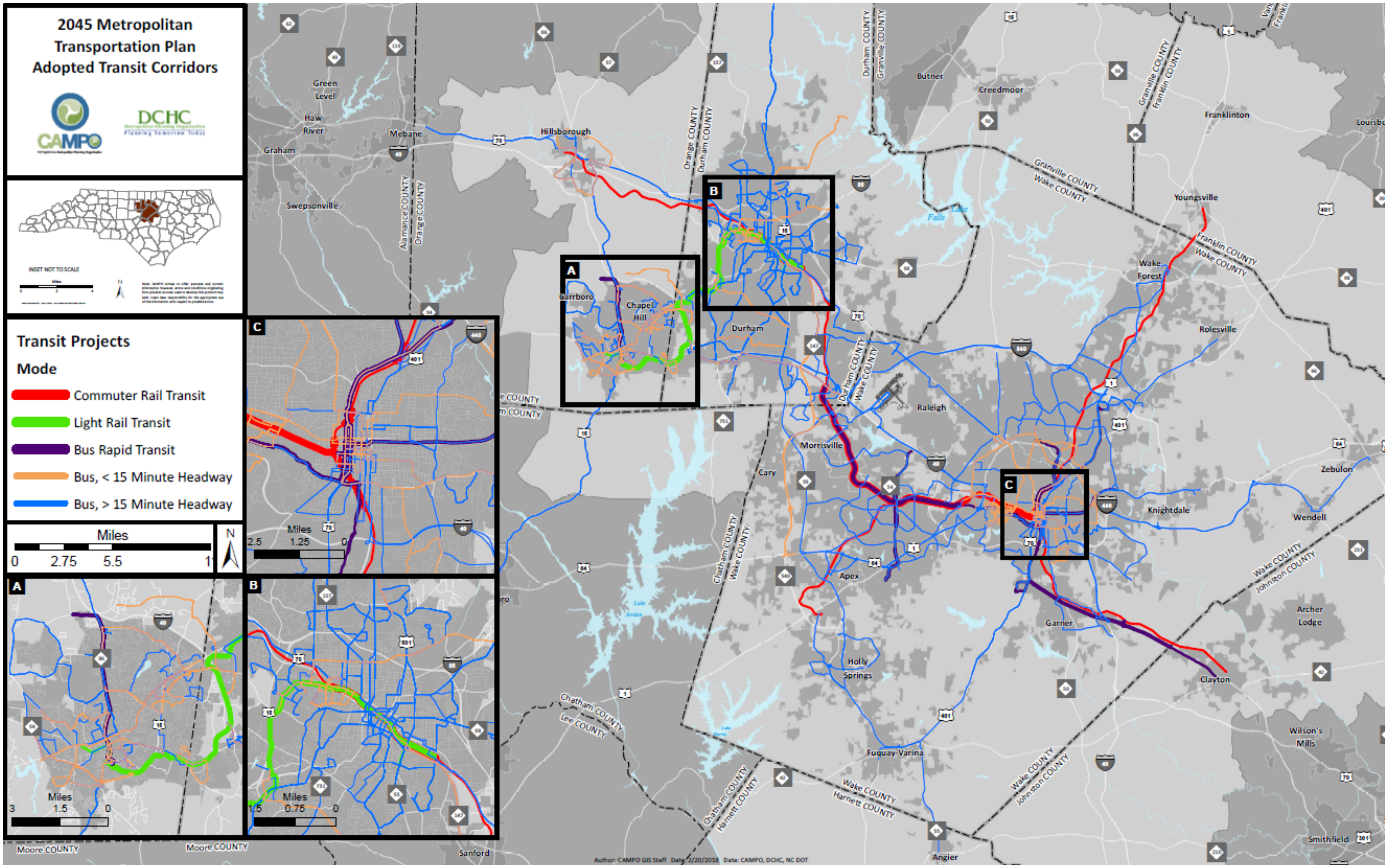
The plan matches a significant focus on transit station area development, safe and healthy streets, and major roadway access management with a historic commitment to high-quality transit service that emphasizes:

- Connecting the regions main centers with fast, frequent, reliable rail and bus services;

- Offering transit service to all communities that have adopted local transit revenues;
- Providing frequent transit service in urban transit markets; and
- Supplying better transit access, from “first mile/last mile” circulator services within key centers to safe and convenient cycling and walk access to transit routes.

The transit network included within the 2045 No-Build scenario, consistent with the MTP assumptions, are presented in Figure 3.1.

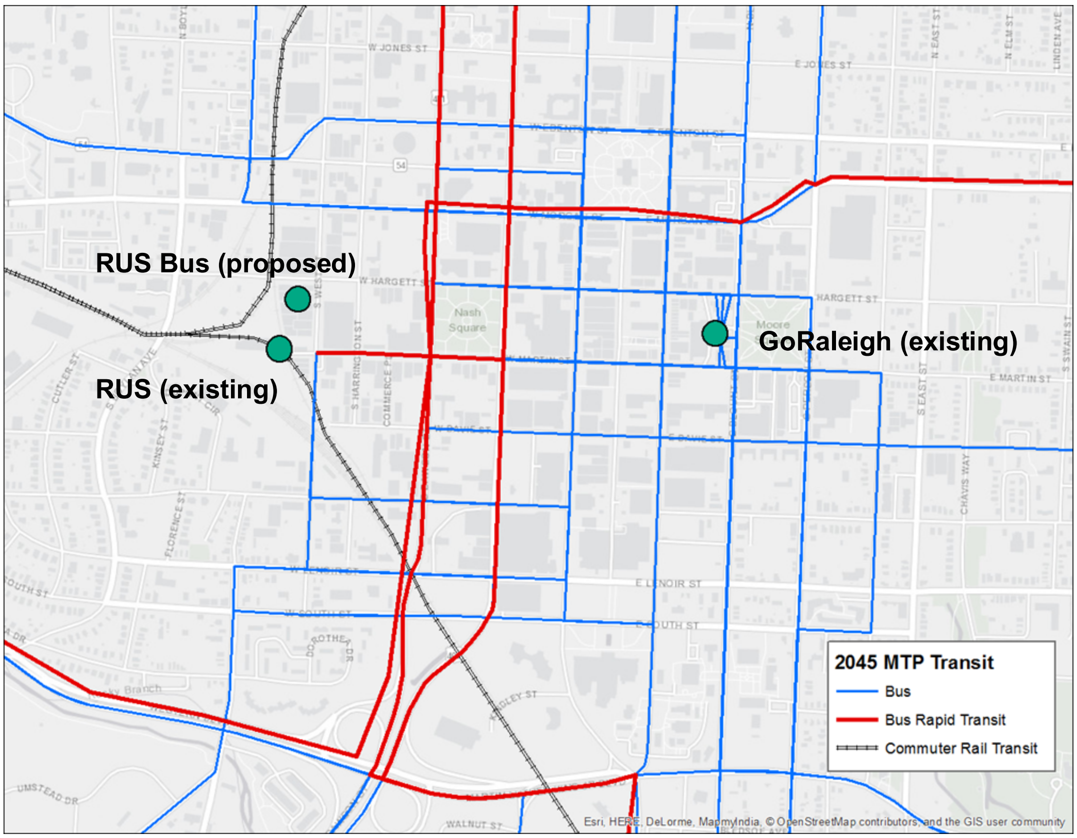
Figure 3.1 2045 MTP Transit Network



The 2045 No-Build does not include RUS Bus focuses most transfers at the existing Go Raleigh station and adjacent to Nash Square where four the proposed BRT corridors intersect, as depicted in Figure 3.2. The 2045 MTP includes:

- Two commuter rail corridors at RUS;
- Four BRT corridor accessing downtown destinations and enabling transfers along Dawson and McDowell Streets, with a single corridor providing access to RUS; and
- 21 local and regional routes serving the GoRaleigh station, with 3 routes serving both the GoRaleigh station and RUS.

Figure 3.2 Downtown Raleigh – 2045 MTP Transit Network



2045 Build

The 2045 Build scenario adjusts the coding of the bus and bus rapid transit system to optimize access and frequency through the additional transfer capacity enabled by RUS Bus. By effectively increasing revenue service capacity in Downtown by approximately 50 percent (an additional 8 bus bays at RUS plus on-street capacity on West Street for BRT service), an optimal service routing, frequency, and transfer approach was tested and coded for the 2045 Build. This included up to 38 buses per hour serving RUS Bus plus 10 minute BRT frequency on West Street. The impacts of this shift in transit operations is tested through use of the TDM and model post-processing techniques.

The post-processing technique accounted for inclusion of transfers to and from AMTRAK service at RUS. AMTRAK ridership projections are sourced from the NCDOT Rail Division based on build out and completion of the Piedmont Improvement Program. The analysis did not assess the potential longer term impact of Southeast High-Speed Rail. To determine the potential growth in AMTRAK associated with the new attractiveness and last mile connection provided through RUS Bus, the same transit growth factors from the TDM between the no-build and build were applied to the forecasted AMTRAK ridership.

Modeling Results Summary

The results provided by these scenarios are used to estimate the travel efficiencies associated with the Build Condition (relative to the No-Build Condition). The scenario results for variables of interest, such as VMT, PMT, VHT, etc. are processed for the base year (2025) and future year (2045). The variables for intermediate analysis years are interpolated using the cumulative annual growth rate (CAGR) as presented in Equation 1.

Equation (1):

$$CAGR^{No-Build} = \left(\frac{VMT_{2045}^{No-Build}}{VMT_{2025}^{No-Build}}\right)^{\left(\frac{1}{2045-2025}\right)} - 1$$

$$CAGR^{Build} = \left(\frac{VMT_{2045}^{Build}}{VMT_{2025}^{No-Build}}\right)^{\left(\frac{1}{2045-2025}\right)} - 1$$

The CAGRs for the No-Build and Build Scenarios are then applied to the base values in 2025, to generate the series of values for the 30-year analysis period (2024 – 2053) as shown in Equation 2 and Equation 3. The changes between Build and No-Build Scenarios for various variables are the basis for estimating benefits/disbenefits over the 30-year period from 2024 to 2053.

Equation (2):

$$VMT_t^{No-Build} = VMT_{2025}^{No-Build} \times (1 + CAGR^{No-Build})^{(t-2025)} \qquad Where: 2024 \leq t \leq 2053$$

Equation (3):

$$VMT_t^{Build} = VMT_{2025}^{No-Build} \times (1 + CAGR^{Build})^{(t-2025)} \qquad Where: 2024 \leq t \leq 2053$$

Table 3.1 show the daily values of VMT, VHT, and volume for the Triangle region.

Table 3.1 Daily VMT, VHT, Volume, and Delay: 2025 and 2045

	Scenarios		
TDM Outputs	**No-Build 2025**	**No-Build 2055**	**Build 2055**
Transit Boardings	185,869	321,745	331,375
Transit PMT	966,018	2,310,129	2,389,214
Highway User VMT (Auto + Truck)	69,534,743	96,274,155	96,266,788
Highway User VHT	1,784,303	2,688,669	2,688,370
Volume	7,330,547	9,911,169	9,908,862
RUS/RUS Bus Quarter-Mile (Bike-Ped) Transfers	1,448	2,358	4,526

4.0 Benefits Categories

The benefit categories to be included in the benefit-cost analysis of the proposed RUS Bus Facility are depicted in Table 4.1. The proposed RUS Bus Facility will provide connectivity to intercity passenger rail, commuter rail and future higher speed rail in the Southeast Corridor; facilitate the Wake County Transit Plan improvements; support mixed-use development around the Raleigh Union Station multimodal campus; and provide connectivity and mobility to the Warehouse district. As a result, the facility will support greater transit ridership by attracting new rides as well as by shifting private auto users to public transit.

As this multimodal transit center attracts traffic away from the roadway network, those remaining on the roadways, should realize travel efficiency gains. Diversion of roadway users to transit will reduce vehicular traffic (decongestion) on the roadways, in turn, producing user benefits such as travel-time savings, vehicle-operating cost savings, air-pollution reductions, and safety benefits. The RUS Bus Facility will also generate public benefits in the form of reduced pavement tear and wear. Overall, these travel efficiency gains resulting from the proposed transit investment will lead to efficiency improvements in the movements of people, goods, and services, and generate positive economic impacts, contributing to the economic competitiveness of the region.

Table 4.1 Benefit Categories Included in the Benefit-Cost Analysis of the Build Alternatives

Benefit Category	Benefit Sub-Category	Metrics
Safety	Motor Vehicle Traffic Safety	Traffic Crash Costs
	Non-Motorized User Safety	Traffic Crash Costs
State of Good Repair	Pavement Maintenance	Pavement Maintenance Costs
Economic Competitiveness	Congestion Relief	Travel Delay Costs
	Transportation Expenditure Value	Transportation Cost Expenditures
Environmental Sustainability	Air Pollutants	Non-Carbon Emissions Costs Carbon Emission Costs

Benefits are estimated for the entire project analysis period and discounted to obtain the net present value (NPV). All benefits are assumed to (1) occur at the end of each year and (2) begin in the calendar year immediately following the final construction year.

4.1 Traffic Safety

The reduction (or increase) of traffic accidents depends on the reduction (or increase) of vehicle-miles traveled by passenger cars and buses under the Build Scenario (compared to the No Build). The method to assess traffic safety benefits/disbenefits resulting from the implementation of the RUS Bus Facility also involves segmenting motorized crashes from non-motorized crashes. For non-motorized crashes, first crash rates for the whole region are developed using regional crash data and walk/bike trips. The regional rates will then be adjusted to reflect traffic safety impacts of the Build Alternative. Using adjusted rates, Traffic safety crash costs for non-motorized travel are estimated and capitalized for the 30-year analysis period.

4.1.1 Motorized Safety Benefits Approach

There are no specific safety improvements associated with RUS Bus that will directly improve safety for motorized users. As a result, the primary benefits are associated with the VMT reduction between the No Build and Build Alternatives using CAMPO region crash rates and average monetized value of crashes in 2017$ consistent with the values in Table A-1 and A-2 in the Benefit-Cost Analysis for Discretionary Grant Programs, USDOT, June 2018. See Table 4.2 for results.

Table 4.2 Motorized Traffic Costs Benefits/Disbenefits Resulting from RUS Bus

Year	Calendar Year	Monetary Value of Reduced/Additional Non-Motorized Vehicle Crashes (in 2017$)	Net Present Value (7%)
7	2024	$12,189	$7,591
8	2025	$24,740	$14,399
9	2026	$37,661	$20,485
10	2027	$50,959	$25,905
11	2028	$64,643	$30,712
12	2029	$78,723	$34,954
13	2030	$93,205	$38,677
14	2031	$108,100	$41,923
15	2032	$123,416	$44,732
16	2033	$139,162	$47,139
17	2034	$155,349	$49,179
18	2035	$171,984	$50,884
19	2036	$189,080	$52,282
20	2037	$206,644	$53,401
21	2038	$224,688	$54,265
22	2039	$243,221	$54,898
23	2040	$262,255	$55,322
24	2041	$281,800	$55,556
25	2042	$301,867	$55,619
26	2043	$322,467	$55,527
27	2044	$343,612	$55,298
28	2045	$365,313	$54,944
29	2046	$387,582	$54,480
30	2047	$410,431	$53,917
31	2048	$433,873	$53,268
32	2049	$457,919	$52,542
33	2050	$482,584	$51,750

Year	Calendar Year	Monetary Value of Reduced/Additional Non-Motorized Vehicle Crashes (in 2017$)	Net Present Value (7%)
34	2051	$507,879	$50,899
35	2052	$533,819	$49,999
36	2053	$560,416	$49,056
Total		**$7,575,579**	**$1,369,601**

Source: Cambridge Systematics Benefit-Cost Analysis

4.1.2 Non-Motorized Safety Benefits Approach

The assessment of safety benefits accruing to users of non-motorized modes of travel involves estimating crash reduction with respect to pedestrian and bicycle crashes that might be expected from the implementation of pedestrian and bicyclist infrastructure improvements. For example, pedestrian infrastructure such as a pedestrian bridge between RUS and RUS Bus, elevated pedestrian sidewalks, raised crossings, crosswalks, and speed humps, are anticipated to ensure safe, high-quality access to and from the RUS Bus Facility by pedestrians. This analysis will use the crash modification factors (CMFs) to estimate the reduction in the number of pedestrian and bicycle crashes that can be expected with the implementation of the proposed pedestrian and bicyclist infrastructure improvements (see Table 4.3).

Table 4.3 Examples of CMFs for Selected Countermeasures

Geometric Countermeasures	Crash Severity	CMF (Pedestrian Crashes)	Source
*Install sidewalk (to avoid walking along roadway)	All	0.12	McMahon, P., Zegeer, C., Duncan, C., Knoblauch, R., Stewart, R., and Khattak, A., “An Analysis of Factors Contributing to ‘Walking Along Roadway’ Crashes: Research Study and Guidelines for Sidewalks and Walkways,” FHWA-RD-01-101, (March 2002)
Install raised median (marked crosswalk) at unsignalized intersection	All	0.54	Zegeer, C., Stewart, R., Huang, H., and Lagerwey, P., “Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines,” FHWA-RD-01-075, (March 2002).
Install raised median (unmarked crosswalk) at unsignalized intersection	All	0.61	Zegeer, C., Stewart, R., Huang, H., and Lagerwey, P., “Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines,” FHWA-RD-01-075, (March 2002).
Install pedestrian bridge	All	0.14	http://www.pedbikeinfo.org/collateral/PSAP%20Training/gettraining_references_pedToolboxofCountermeasures2013.pdf

Signalization Countermeasures	Crash Severity	CMF (Pedestrian Crashes)	Source
Add exclusive pedestrian phasing	All	0.66	Institute of Transportation Engineers, "Toolbox of Countermeasures and Their Potential Effectiveness to Make Intersections Safer." Briefing Sheet 8, ITE, FHWA, (2004).
Improve signal timing	Fatal/Injury	0.63	Retting, R. A., Chapline, J. F., and Williams, A. F., "Changes in Crash Risk Following Re-timing of Traffic Signal Change Intervals." Accident Analysis and Prevention, Vol. 34, No. 2, Oxford, N.Y., Pergamon Press, (2002) pp. 215–220.

Signalization Countermeasures	Crash Severity	CMF (Pedestrian and Bicycle Crashes)	Source
Modify signal change interval	All	0.37	Retting, R. A., J. F. Chapline, and A. F. Williams. Changes in Crash Risk Following Re-timing of Traffic Signal Change Intervals. In Accident Analysis and Prevention, Vol. 34, No. 2, Pergamon Press, Oxford, NY, 2002, pp. 215–220.

The assessment of the contribution of the RUS Bus Facility to non-motorized user safety in Downtown Raleigh over the 20-year analysis period entitles the following steps:

- Step 1: Collect historical pedestrian and bicycle crash rates by crash severity for the CAMPO region on a per Million Bike-Walk trip basis (pedestrian and bicycle crash rates adjacent to the Go Raleigh station were also investigated, however total numbers were too low to develop reliable 5-year average crash rates by crash type)
- Step 2: Identify appropriate crash modification factors (CMFs) based on the proposed safety improvements for pedestrian and bicycle travel and estimate updated crash rates for the Build Alternative in 1 Million trip units.
- Step 3: Estimate total pedestrian and bicycle trips for the RUS Bus facility from the Travel Demand model outputs by focusing on walk and bike transfer boardings from transit nodes within a half-mile buffer of the RUS Bus facility. The walk and bike trips are annualized for both the Build and No-Build Alternatives.
- Step 4: Apply Build and No-Build crash rates (in 1 million trip units) to total walk and bike trips and estimate non-motorized traffic safety impacts.

The crash rates for walk and bike trips are presented on a per million trip basis. The crash rates are adjusted using CMF values obtained from the CMF Clearinghouse database. The ratios for proposed improvements under the Build Alternative are presented in Table 4.4. The average CMF value obtained from the CMF clearinghouse is applied to the No-Build crash rates to estimate crash rates for the Build Alternative. The pedestrian bridge CMF is applied separately to reflect the benefit accruing to the projected RUS to RUS Bus transfers.

Table 4.4 Crash Improvement Ratios

Improvement Type	CMF Value	Average CMF	Source
Intersection Signalization with pedestrian signal phasing	59%		Fayish, A.C. and F. Gross, "Safety Effectiveness of Leading Pedestrian Intervals Evaluated by a Before–After Study with Comparison Groups." Transportation Research Record: Journal of the Transportation Research Board, No. 2198, Transportation Research Board of the National Academies, Washington, D.C., 2010, pp. 15–22.
Install Raised Pedestrian Crosswalk	46%	64%	Zegeer, C. V., Stewart, R., Huang, H., and Lagerwey, P., "Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines." FHWA-RD-01-075, McLean, Va., Federal Highway Administration, (2002).
Median Treatment for Bike-Ped Safety	86%		Zhang, L., S. Ghader, A. Asadabadi, M. Franz, C. Xiong, and J. Litchford. "Analyzing the Impact of Median Treatments on Pedestrian/Bicyclist Safety." Report No. MD-17-SHA/UM/4-28. Maryland State Highway Administration. Baltimore, MD. (May 2017).
Pedestrian bridge		14%	http://www.pedbikeinfo.org/collateral/PSAP%20Training/gettraining_references_pedToolboxofCountermeasures2013.pdf

Source: CMF Clearinghouse.

The proposed Build Alternative is anticipated to improve pedestrian and bicycle travel by making major improvements to sidewalks, bike-lanes, and crosswalks across the RUS Bus intersections in downtown Raleigh and providing a pedestrian bridge enabling a complete off-street, grade separated connection between RUS and RUS Bus (by crossing over the railroad tracks at the wye). The non-motorized crash rates for pedestrian and bicycle travel are presented in Table 4.5. This table also presents the crash rates used for the Build alternative following application of CMFs.

Table 4.5 CAMPO Region Non-Motorized Crash Rates for Pedestrian and Bicycle Travel per 1 Million Trips (2008-2016)

Year	Fatalities	A Injuries	B Injuries	C Injuries	PDO Crashes
2008	0.090	0.076	0.654	0.516	0.180
2009	0.047	0.047	0.656	0.512	0.130
2010	0.055	0.050	0.685	0.598	0.210
2011	0.067	0.099	0.717	0.654	0.166
2012	0.062	0.150	0.761	0.651	0.172
2013	0.078	0.108	0.652	0.821	0.238
2014	0.072	0.068	0.691	0.670	0.208
2015	0.083	0.096	0.671	0.629	0.137
2016	0.078	0.131	0.626	0.646	0.290
5-Year Average (No-Build)	**0.075**	**0.110**	**0.680**	**0.684**	**0.209**
5-Year Average (Build)	**0.007**	**0.010**	**0.061**	**0.061**	**0.019**

Source: North Carolina State DOT Traffic Safety Database, Area: Capital Area Metropolitan Planning Organization, https://connect.ncdot.gov/resources/safety/Pages/Crash-Data.aspx

In order to estimate total walk and bike trips, the results of the TDM for downtown Raleigh are further analyzed within a 0.5 mile buffer zone of the RUS Bus facility. The TDM outputs provide walk and bike transfers from transit nodes in the study area in terms of a daily metric of total walk and bike trips. The total walk and bike trips in proximity of RUS Bus to benefit from the proposed safety improvements are estimated. The crash rates for pedestrian and bicycle travel are applied to total annual walk and bike trips under the Build and No-Build Alternatives to estimate changes in non-motorized crashes.

4.1.3 Results

The changes in crashes across the KABCO categories are then multiplied by dollar value of crash costs to yield the total benefits/disbenefits to be generated by the RUS Bus Facility. Table 4.6 presents the motorized and non-motorized traffic costs benefits/disbenefits, respectively, resulting from the proposed transit facility in Downtown Raleigh.

Table 4.6 Non-Motorized Traffic Costs Benefits/Disbenefits Resulting from RUS Bus

Year	Calendar Year	Monetary Value of Reduced/Additional Non-Motorized Vehicle Crashes (in 2017$)	Net Present Value (7%)
7	2024	$379,338	$236,233
8	2025	$386,662	$225,041
9	2026	$394,088	$214,358
10	2027	$401,615	$204,161
11	2028	$409,241	$194,427
12	2029	$416,964	$185,137
13	2030	$424,784	$176,270
14	2031	$432,698	$167,808
15	2032	$440,704	$159,731
16	2033	$448,799	$152,024
17	2034	$456,981	$144,668
18	2035	$465,246	$137,650
19	2036	$473,592	$130,952
20	2037	$482,014	$124,562
21	2038	$490,509	$118,464
22	2039	$499,070	$112,647
23	2040	$507,695	$107,097
24	2041	$516,377	$101,802
25	2042	$525,109	$96,751

Year	Calendar Year	Monetary Value of Reduced/Additional Non-Motorized Vehicle Crashes (in 2017$)	Net Present Value (7%)
26	2043	$533,887	$91,933
27	2044	$542,702	$87,337
28	2045	$551,547	$82,954
29	2046	$560,414	$78,773
30	2047	$569,295	$74,787
31	2048	$578,178	$70,985
32	2049	$587,054	$67,359
33	2050	$595,913	$63,903
34	2051	$604,741	$60,607
35	2052	$613,526	$57,465
36	2053	$622,255	$54,469
Total		**$14,911,000**	**$3,780,354**

Source: Cambridge Systematics Benefit-Cost Analysis

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

4.2 State of Good Repair of the Roadway Infrastructure

Changes (increase or decrease) in auto and transit VMT resulting from the proposed transit facility will lead to increase or decrease in pavement wear and tear. The method to assess the state of good repair (SOGR) of the highway infrastructure involves estimation of the marginal external cost associated with pavement maintenance by vehicle type and highway functional class.

4.2.1 Marginal External Pavement Cost

This analysis uses the average marginal external pavement unit costs for urban highways provided by the Federal Highway Administration (FHWA) (Table 4.7) which represent the additional spending (or saving) in all costs of maintaining pavements, including resurfacing and reconstruction, resulting from a unit increase/decrease in VMT borne by public agencies responsible for highway maintenance.

Table 4.7 Marginal External Pavement Cost by Vehicle Class

	Road Pavement Maintenance Cost	
Vehicle Class	In 1997$ / VMT	In 2017$ / VMT
Autos	$0.0010	$0.002
Trucks	$0.1820	$0.280

Notes:

1. Marginal external pavement unit costs by vehicle class are provided by the Victoria Transport Policy Institute, *Transportation Cost and Benefit Analysis II – Roadway Costs,* Table 5.6.4-3 Roadway Cost Responsibility per Mile (1997 Dollars), based on data from Tables II-6, IV-11, V-21 of the FHWA, 1997 Federal Highway Cost Allocation Study.

2. The marginal pavement cost was inflated from 1997 to 2017 dollars using the U.S. Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers (CPI-U) in U.S. cities.

4.2.2 Approach

The method to estimate the SOGR impacts assumes that change in roadway network capacity can affect the overall number of auto trips passing through the corridor. As shown in Equation (4), the marginal external pavement cost is multiplied by the annual change in VMT over the 30-year period to estimate the marginal change in SOGR benefits/disbenefits.

Equation (4)

$$Change\ in\ SOGR_t = Unit\ Cost\ of\ Vehicle\ Impacts\ on\ Pavement\ Maintenance \times (VMT_t^{Build} - VMT_t^{No-Build})$$
$$2024 \leq t \leq 2053$$

4.2.3 Results

Using the marginal external pavement cost of autos and trucks shown in Table 4.7 and the annual changes in VMT by vehicle type, the impact of the RUS Bus Facility on pavement maintenance is calculated for the 2024 to 2053 period. The monetary value of reduced/additional pavement maintenance costs are reported in 2017 dollars and are also discounted using a 7 percent discount rate. Table 4.8 presents the SOGR benefits/disbenefits resulting from the RUS Bus Facility.

Table 4.8 SOGR Benefits/Disbenefits Resulting from the RUS Bus Facility

Year	Calendar Year	Reduced/Additional Miles Traveled	Monetary Value of SOGR (in 2017$)	Net Present Value (7%)
7	2024	-71,655	$110	$69
8	2025	-145,436	$224	$130
9	2026	-221,389	$340	$185
10	2027	-299,563	$460	$234
11	2028	-380,007	$584	$277
12	2029	-462,771	$711	$316
13	2030	-547,906	$842	$349
14	2031	-635,465	$977	$379
15	2032	-725,500	$1,115	$404
16	2033	-818,066	$1,257	$426
17	2034	-913,218	$1,404	$444
18	2035	-1,011,012	$1,554	$460
19	2036	-1,111,506	$1,708	$472
20	2037	-1,214,758	$1,867	$482
21	2038	-1,320,829	$2,030	$490
22	2039	-1,429,778	$2,198	$496
23	2040	-1,541,668	$2,370	$500

Year	Calendar Year	Reduced/Additional Miles Traveled	Monetary Value of SOGR (in 2017$)	Net Present Value (7%)
24	2041	-1,656,563	$2,546	$502
25	2042	-1,774,526	$2,727	$503
26	2043	-1,895,624	$2,914	$502
27	2044	-2,019,924	$3,105	$500
28	2045	-2,147,493	$3,301	$496
29	2046	-2,278,402	$3,502	$492
30	2047	-2,412,721	$3,708	$487
31	2048	-2,550,523	$3,920	$481
32	2049	-2,691,882	$4,137	$475
33	2050	-2,836,872	$4,360	$468
34	2051	-2,985,571	$4,589	$460
35	2052	-3,138,057	$4,823	$452
36	2053	-3,294,409	$5,064	$443
Total		**-44,533,091**	**$68,447**	**$12,375**

Source: Cambridge Systematics Benefit-Cost Analysis

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

4.3 Congestion Relief and Travel Time Saving

Congestion relief benefits resulting from the RUS Bus Facility over the 30-year analysis period are assessed based on travel time savings resulting from the improved transit service offered by the RUS Bus Facility (Build) Alternative and its subsequent operational improvements.

4.3.1 Travel Time Savings

Changes in travel speeds under the Build Alternative (compared to the No-Build Alternative) result in decreased travel time for highway users. The estimation of travel time cost benefits involves multiplying the value of time (VOT) by trip purpose and average vehicle occupancy (AVO) by the corresponding changes in VHT).

4.3.2 Key Parameters

This analysis uses the value of time (VOT) by trip purpose provided by the U.S. DOT Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs, June 2018, the average vehicle occupancy (AVO) by trip purpose from the CAMPO Travel Demand Model, and the annualization factors shown in Table 4.9.

Table 4.9 VOT and AVO Parameters

Trip Type	Value of Time (VOT) (in 2017$/person-hour)	Average Vehicle Occupancy (AVO)	Annualization Factor
Auto, Commute	$14.2	1.52	260
Auto, Business	$26.5	1.15	265

Auto, Leisure	$14.8	1.74	315
Truck, Business	$28.6	1.07	365

Source: CAMPO Travel Demand Model

Notes: (1) The average vehicle occupancies by vehicle type/trip purpose come from the CAMPO TDM; (2) The annualization factors by vehicle type/trip purpose come from Texas Transportation Institute (TTI) Urban Mobility Report Methodology (https://mobility.tamu.edu/ums/)

4.3.3 Approach

To estimate travel time cost benefits/disbenefits, this analysis uses the following equation to estimate the change in travel time savings/increases:

Equation (5):

$$Value\ of\ Travel\,Time\ Savings_t = AVO \times VOT \times \left[VHT_t^{Build} - VHT_t^{No-Build}\right] \qquad 2024 \leq t \leq 2053$$

Changes in VMT and VHT in the Triangle region will affect travel speed and travel time. Through the use of the TDM and some post-processing adjustments to account for unrelated network VMT and VHT changes within the network assignment process, total change in regional highway travel time is estimated. The travel time changes are quantified to reflect the time savings for all travelers using VOT and AVO values. Using the value of travel time (VOT) unit costs, the impact of travel time savings is capitalized for the 2024 to 2053 period. **The project is assumed to have no net impact on truck travel times.**

4.3.4 Results

The monetary value of reduced/additional travel time costs are reported in 2017 dollars and are also discounted using a 7 percent discount rate. Table 4.10 presents the travel time cost savings benefits/disbenefits resulting from the RUS Bus Facility.

Table 4.10 Travel Time Benefits/Disbenefits Resulting from the RUS Bus Facility

Year	Calendar Year	Reduced/Additional Travel Time (in hours)	Monetary Value of Travel Time Cost Saved/Wasted (in 2017$)	Net Present Value (7%)
7	2024	-2,680	$68,037	$42,370
8	2025	-5,461	$138,623	$80,680
9	2026	-8,345	$211,832	$115,223
10	2027	-11,335	$287,736	$146,271
11	2028	-14,434	$366,411	$174,079
12	2029	-17,645	$447,934	$198,888
13	2030	-20,972	$532,384	$220,920
14	2031	-24,417	$619,842	$240,385
15	2032	-27,984	$710,391	$257,478
16	2033	-31,677	$804,116	$272,382
17	2034	-35,497	$901,105	$285,267

Year	Calendar Year	Reduced/Additional Travel Time (in hours)	Monetary Value of Travel Time Cost Saved/Wasted (in 2017$)	Net Present Value (7%)
18	2035	-39,450	$1,001,447	$296,292
19	2036	-43,538	$1,105,233	$305,606
20	2037	-47,766	$1,212,558	$313,348
21	2038	-52,137	$1,323,518	$319,647
22	2039	-56,655	$1,438,211	$324,623
23	2040	-61,325	$1,556,738	$328,389
24	2041	-66,149	$1,679,203	$331,049
25	2042	-71,132	$1,805,711	$332,701
26	2043	-76,279	$1,936,371	$333,434
27	2044	-81,594	$2,071,294	$333,334
28	2045	-87,082	$2,210,595	$332,478
29	2046	-92,746	$2,354,390	$330,940
30	2047	-98,593	$2,502,798	$328,785
31	2048	-104,625	$2,655,941	$326,078
32	2049	-110,850	$2,813,946	$322,875
33	2050	-117,271	$2,976,941	$319,231
34	2051	-123,893	$3,145,057	$315,196
35	2052	-130,723	$3,318,428	$310,814
36	2053	-137,765	$3,497,194	$306,128
Total		**-1,800,022**	**$45,693,985**	**$8,144,893**

Source: Cambridge Systematics Benefit-Cost Analysis

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

4.4 Vehicle Operating Costs Benefits/Disbenefits

Reduction in VMT generates savings in the cost associated with the operation and maintenance of passenger cars and trucks. In contrast, increased VMT would lead to increased vehicle operating costs (VOC). VOC include fuel and non-fuel costs. The non-fuel cost component is comprised of all the necessary replacement items on the vehicle and regular maintenance (e.g., oil and fluid changes, tire rotations, tire replacements, and wiper replacement) as well as truck/trailer lease or purchase payments, permits and licenses, and other related costs to owners of commercial vehicles.

4.4.1 Approach

The method to assess VOC benefits/disbenefits involves estimation of the VOC per vehicle type. In this method the fuel costs are separated from the remainder of VOCs. Average per-mile VOC for passenger vehicles and trucks is provide by the U.S. DOT Benefit Cost Analysis Guidance as shown in Table 4.11.

Table 4.11 Average Marginal Vehicle Operating Costs (Fuel and Non-Fuel Components)

Vehicle Type	VOC (in 2017$/VMT)
Passenger Vehicles	0.39
Trucks	0.90

Source: U.S. DOT 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs

It should be noted that the average cost of fuel is subtracted from these values to estimate non-fuel VOCs. In order to find the non-fuel costs related portion of VOCs, this study subtracts the unit cost of fuels provided by the American Automobile Association (AAA), from the overall unit cost of VOCs for passenger vehicles (Table 4.12). For trucks, this study subtracts the unit cost of fuels provided by the American Transportation Research Institute (ATRI), from the overall unit cost of VOCs (Table 4.12).

Table 4.12 Average Marginal Vehicle Operating Costs (Fuel/Non-Fuel Component)

Vehicle Type	Fuel Component of VOCs (in 2017$/VMT)	Non-Fuel Component of VOCs (in 2017$/VMT)
Passenger Vehicles[1]	0.103	0.287
Trucks[2]	0.342	0.558

[1] Source: Estimated by CS based on vehicle operating costs provided by AAA, Your Driving Costs, 2017 Edition.
[2] Estimated by CS based on vehicle operating costs provided by ATRI, An Analysis of the Operational Costs of Trucking: 2016 Update (Sep 2016), Table 18, p. 29.

Non-fuel based VOC benefits/disbenefits are estimated by multiplying the average marginal VOC by vehicle type by its corresponding annual changes in VMT over the 2025-2055 analysis period. The following equation is used to estimate the change in Non-fuel based VOC benefits/disbenefits:

Equation (6):

$$Non - Fuel\ Based\ VOC_t = \left(VMT_t^{Build} - VMT_t^{No-Build}\right) \times (Unit\ Cost\ of\ VOCs) \qquad 2024 \leq t \leq 2053$$

The fuel cost component is estimated by evaluating the fuel consumption of vehicles in each alternative through estimation of traveling speeds for various trip purposes. The fuel consumption rates for this analysis are provided by California Air Resources Board Emission Factor (EMFAC) 2011 Model, which is approved by the U.S. Environmental Protection Agency (EPA)[1]. The fuel consumption rates per EMFAC are provided in 5 miles per hour increments and this analysis interpolates fuel consumption for various speeds for each year of the analysis.

The fuel use rates are reported in gallon per vehicle-miles and are multiplied by total VMT to estimate total fuels used for the Build and No-Build Alternatives. The average price of gas and diesel for North Carolina in 2017 is provided by the AAA[2] ($2.71 for gasoline, $3.08 for diesel). To estimate fuel based VOC benefits/

[1] Official Release of EMFAC2014 Motor Vehicle Emission Factor Model for Use in the State of California, Notice of Availability (80 FR 77337), https://www.federalregister.gov/documents/2015/12/14/2015-31307/official-release-of-emfac2014-motor-vehicle-emission-factor-model-for-use-in-the-state-of-california

[2] AAA, State Gas Prices, http://gasprices.aaa.com/

disbenefits, the difference in fuel consumption is then normalized by the total volume using the following equation:

Equation (7):

$$Fuel\ Based\ VOC_t = [\left(Total\ Fuel\ Consumption_t^{Build} - Total\ Fuel\ Consumption_t^{No-Build}\right) \times (Cost\ of\ Fuel)$$
$$2024 \leq t \leq 2053$$

4.4.2 Results

The fuel and non-fuel component of VOCs are then combined and reported for the 2025-2055 period. The monetary value of reduced/additional VOCs are reported in 2017 dollars and are also discounted using a 7 percent discount rate. Table 4.13 presents the VOC benefits/disbenefits resulting from the RUS Bus Facility.

Table 4.13 Vehicle Operating Costs Benefits/Disbenefits Resulting from RUS Bus

Year	Calendar Year	Monetary Value of Non-Fuel VOCs Saved/Wasted (in 2017$)	Monetary Value of Fuel-Based VOCs Saved/Wasted (in 2017$)	Monetary Value of Total VOCs Saved/Wasted (in 2017$)	Net Present Value (7%)
7	$20,594	$20,594	$10,028	$30,622	$19,070
8	$41,798	$41,798	$20,373	$62,171	$36,184
9	$63,627	$63,627	$31,041	$94,669	$51,493
10	$86,094	$86,094	$42,042	$128,136	$65,138
11	$109,214	$109,214	$53,381	$162,595	$77,248
12	$133,000	$133,000	$65,068	$198,068	$87,945
13	$157,468	$157,468	$77,110	$234,578	$97,341
14	$182,633	$182,633	$89,515	$272,147	$105,543
15	$208,509	$208,509	$102,291	$310,800	$112,648
16	$235,112	$235,112	$115,447	$350,559	$118,747
17	$262,459	$262,459	$128,992	$391,451	$123,923
18	$290,565	$290,565	$142,935	$433,499	$128,257
19	$319,447	$319,447	$157,283	$476,730	$131,820
20	$349,122	$349,122	$172,048	$521,169	$134,680
21	$379,606	$379,606	$187,237	$566,844	$136,900
22	$410,918	$410,918	$202,861	$613,780	$138,538
23	$443,075	$443,075	$218,930	$662,005	$139,648
24	$476,096	$476,096	$235,452	$711,548	$140,279
25	$509,999	$509,999	$252,439	$762,438	$140,479
26	$544,802	$544,802	$269,900	$814,703	$140,288
27	$580,526	$580,526	$287,847	$868,373	$139,748
28	$617,189	$617,189	$306,290	$923,479	$138,893
29	$654,813	$654,813	$325,239	$980,052	$137,759

Year	Calendar Year	Monetary Value of Non-Fuel VOCs Saved/Wasted (in 2017$)	Monetary Value of Fuel-Based VOCs Saved/Wasted (in 2017$)	Monetary Value of Total VOCs Saved/Wasted (in 2017$)	Net Present Value (7%)
30	$693,416	$693,416	$344,707	$1,038,123	$136,375
31	$733,020	$733,020	$364,704	$1,097,725	$134,771
32	$773,647	$773,647	$385,243	$1,158,890	$132,972
33	$815,317	$815,317	$406,335	$1,221,652	$131,003
34	$858,053	$858,053	$479,116	$1,337,169	$134,010
35	$901,878	$901,878	$504,211	$1,406,089	$131,698
36	$946,813	$946,813	$529,987	$1,476,800	$129,272
Total		**$12,798,810**	**$6,508,052**	**$19,306,862**	**$3,472,672**

Source: Cambridge Systematics Benefit-Cost Analysis
Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

4.5 Transportation Expenditure Benefits

A potential benefit of public transit is a reduction in transportation costs to those who use transit in place of another mode of travel to satisfy their transportation needs (e.g., trips to work, shop, school, etc.). The underlying assumption for estimation of transportation expenditures is that modal diversion to transit modes under the Build Alternative will result in lower travel expenditures to the public.

4.5.1 Key Parameters

There are two key parameters that have to be estimated as part of the estimation of modal diversion impacts. These parameters are as follows:

- **Mode Shift:**

  The mode shift factor is the ratio of transit passenger-miles traveled (PMT) to displaced private vehicle-miles traveled (VMT).To account for the avoided auto VMT attributable to the provision of the RUS Bus Facility, this analysis applies the mode shift factor for medium urban areas provided by the Federal Transit Administration (FTA) and the American Public Transit Association (APTA) as part of the transit performance monitoring system (TPMS) project that collected data on transit customers through the use of on-board surveys (Table 4.14).

  Riders' response to a question on alternative modes of travel were transit unavailable for that trip is used to estimate the mode shift factor. The shift factors used in this analysis comprise riders (%) stating they would drive alone + riders (%) stating that someone else would drive them + riders (%) shifting to taxi + riders (%) stating they would carpool divided by the average carpool occupancy. The TPMS project recommends the average carpool occupancy of 2.5 when local data is unavailable since this value provides a conservative estimate, assuming a mix of two- and three-person carpools. These mode shift factors are utilized to estimate the breakdown of trips from transit to non-transit modes.

Table 4.14 Mode Shift Factors for Medium Urban Areas

Urban Area	Drive Alone	Walk	Ride with Someone	Taxi	Bicycle	Not Make Trip

	(a)	(b)	(c)	(d)	(e)	(f)
Medium (500,000 to 1,250,000)	26.4%	18.2%	22.2%	7.5%	5.0%	20.7%

Source: The mode shift factors comes from the Transit Performance Monitoring System (TPMS) Results, Phases I and II (2002) and Phase III (2004), prepared by McCollom Management Consulting for the American Public Transit Association (APTA) and the Federal Transit Administration (FTA).

Notes: (1) The mode shift factor is the ratio of transit passenger-miles traveled (PMT) to displaced private vehicle-miles traveled (VMT). (2) Two estimates were derived from TPMS, one for agencies included in Phases I and II of the survey work, and one for agencies included in Phase III. The more conservative (lower) mode shift factors are used in this analysis.

- **User Cost per Mile for Alternative Transportation Modes**

  The assessment of the expenditure value benefit to be generated by the RUS Bus Facility involves the estimation of the transportation cost expenditures that would result when transit riders shift to other modes of travel in the absence of the RUS Bus Facility. Table 4.15 presents the estimated user costs (in dollars per mile) for alternative transportation modes to be used in this analysis.

  In order to estimate modal diversion impacts, it is necessary to estimate average transit trip lengths for transit riders and evaluate the costs of the same trips using non-transit modes. To estimate average trip length, total PMTs for the Build and No-Build Scenarios are divided by total boardings for every year of the analysis period.

Table 4.15 User Cost per Mile for Alternative Transportation Modes

User Cost (2017$/VMT)					
Solo Driving	**Carpool**	**Technology-enabled Shared Mobility Services**	**Taxi**	**Biking**	**Walking**
$0.39	$0.20	$4.51	$4.51	$0.10	$0.00

Notes:

1. Technology-enabled shared mobility services refer to vehicle-sharing services that enable travelers to arrange for rides by private cars on as-needed basis using information and communication technologies, combined with smartphone applications and location data from global positioning systems. Examples of these services in the City of Raleigh are Uber and Lyft.
2. Cost per mile for “solo driving” in 2017$/VMT is provided by the U.S. DOT Benefit-Cost Analysis (BCA) Guidance for Discretionary Grant Programs, June 2018.
3. Marginal cost per mile for carpooling is assumed to be 50 percent of the marginal cost for “solo driving”.
4. Cost per mile for taxis corresponds to the rate per mile charged by Taxi Fare Finder in the City of Raleigh and represents the typical short fare. It should be noted that the flat fee charged at the beginning of the ride of $1.95 plus the cost per mile of $2.50 totals $4.45, which is lower than the typical short fare.
5. Cost per mile for technology-enabled shared mobility services corresponds to the rates charges by UberX and Lyft. This cost includes: a base fare of $1.0 (i.e., a flat fee charged at the beginning of the ride), a booking fee of $2.75, and the cost per mile of $0.76.
6. Cost of biking is the mid-point of $0.05 - $0.015 per mile provide by the Victoria Transport Institute.

Data Sources:

1. U.S. Census Bureau, *Modes Less Traveled, Bicycling and Walking to Work in the United States: 2008-2012*, American Community Survey Reports, by Brian McKenzie, Issued May 2014
2. TaxiFareFinder: US Taxi Cab Rate Ranking Chart. Available at https://www.taxifarefinder.com/rates.php.

3. Littman, Todd*, Transportation Cost and Benefits Analysis II - Vehicle Costs*, Victoria Transport Policy Institute, December 2015.

4.5.2 Approach

The assessment of the transportation expenditure benefits that are anticipated to be generated by the proposed transit facility over the 30-year analysis period includes the following steps:

- Step 1: Estimation of annual transit boardings that could potentially shift to alternative transportation modes in the absence of the RUS Bus Facility. This is estimated by multiplying the annual transit boardings by corresponding mode shift factor for each alternative transportation mode.
- Step 2: Estimation of annual transit fares paid by transit riders who would have to shift to alternative transportation modes in the absence of the RUS Bus Facility. This is accomplished by multiplying the proposed transit fares by the transit boardings that could potentially shift to alternative transportation modes in the absence of the RUS Bus Facility (estimated in Step 1).
- Step 3: Estimation of the annual transportation costs borne by transit riders using alternative transportation modes in the absence of the RUS Bus Facility. This will be accomplished by distributing the number of transit trips among the alternatives transportation modes based on the shares associated with the selected shift factors that are shown in Table 4.14. Resulting shares are multiplied by the corresponding cost per mile for the alternative transportation mode shown in Table 4.15 and by the average transit passenger trip length estimated by dividing PMT over transit boardings.
- Estimation of the annual net expenditure value benefits by subtracting the transit fares paid by transit riders shifting to alternative transportation modes in the absence of The RUS Bus Facility (estimated in Step 2) from the annual transportation costs borne by transit riders using alternative transportation modes in the absence of the RUS Bus Facility (estimated in Step 3).

This estimation excludes the monetized impact of the shift from solo driving to transit as much of this benefit is already accounted for within the vehicle operating cost benefits estimation.

4.5.3 Results

The monetary value of transit travel costs, non-transit travel costs, and the transit diversion impacts are reported for the 2024-2053 period. The monetary value of transit diversion costs are reported in 2017 dollars and are also discounted using a 7 percent discount rate. Table 4.16 presents the transportation expenditure value benefits/disbenefits resulting from the RUS Bus Facility.

Table 4.16 Transit Mode Diversion Benefits/Disbenefits Resulting from the RUS Bus Facility

Year	Calendar Year	Monetary Value of Transit Travel Costs (in 2017$)	Monetary Value of Non-Transit Travel Costs (in 2017$)	Reduction in Travel Costs (in 2017$)	Net Present Value (7%)
7	2024	$39,603	$234,631	$195,028	$121,454
8	2025	$84,837	$488,653	$403,816	$235,025

Year	Calendar Year	Monetary Value of Transit Travel Costs (in 2017$)	Monetary Value of Non-Transit Travel Costs (in 2017$)	Reduction in Travel Costs (in 2017$)	Net Present Value (7%)
9	2026	$136,060	$763,268	$627,208	$341,160
10	2027	$193,647	$1,059,744	$866,097	$440,280
11	2028	$257,992	$1,379,418	$1,121,426	$532,781
12	2029	$329,507	$1,723,703	$1,394,196	$619,040
13	2030	$408,623	$2,094,085	$1,685,462	$699,407
14	2031	$495,793	$2,492,135	$1,996,343	$774,216
15	2032	$591,489	$2,919,507	$2,328,019	$843,781
16	2033	$696,205	$3,377,944	$2,681,739	$908,398
17	2034	$810,460	$3,869,284	$3,058,824	$968,345
18	2035	$934,794	$4,395,464	$3,460,670	$1,023,887
19	2036	$1,069,774	$4,958,525	$3,888,750	$1,075,272
20	2037	$1,215,992	$5,560,615	$4,344,623	$1,122,733
21	2038	$1,374,065	$6,204,000	$4,829,935	$1,166,493
22	2039	$1,544,641	$6,891,065	$5,346,425	$1,206,758
23	2040	$1,728,394	$7,624,321	$5,895,928	$1,243,728
24	2041	$1,926,029	$8,406,413	$6,480,384	$1,277,586
25	2042	$2,138,284	$9,240,125	$7,101,841	$1,308,508
26	2043	$2,365,926	$10,128,387	$7,762,461	$1,336,661
27	2044	$2,609,760	$11,074,286	$8,464,526	$1,362,199
28	2045	$2,870,623	$12,081,068	$9,210,445	$1,385,271
29	2046	$3,149,389	$13,152,150	$10,002,761	$1,406,016
30	2047	$3,446,971	$14,291,128	$10,844,157	$1,424,566
31	2048	$3,764,321	$15,501,784	$11,737,463	$1,441,044
32	2049	$4,102,431	$16,788,098	$12,685,667	$1,455,568
33	2050	$4,462,337	$18,154,255	$13,691,918	$1,468,249
34	2051	$4,845,118	$19,604,659	$14,759,541	$1,479,192
35	2052	$5,251,901	$21,143,941	$15,892,040	$1,488,495
36	2053	$5,683,858	$22,776,968	$17,093,110	$1,496,253
Total		**$58,528,823**	**$248,379,626**	**$189,850,803**	**$31,652,364**

Source: Cambridge Systematics Benefit-Cost Analysis

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

4.6 Air Emissions

This category of project benefits (or disbenefits) captures the savings (or additional expenditures) in emission damage costs resulting from reduced (or increased) VMT and changes in average speeds under the Build alternative (compared to the No-Build). This analysis applies the running emission rates to Volatile Organic

Compounds (VOC), Nitrogen Oxides (NOx), Particular Matter (PM) and Sulfur Dioxide (SOx) for passenger cars and trucks on urban restricted access roads using MOVES2014 (Table 4.17). The 2025 running emission rates are used to estimate the emission damage costs over the 2025-2055 period.

Table 4.17 Running Emission Rates in 2025

2025 Running Emission Rates (g/mile)				2025 Running Emission Rates (g/mile)			
Pollutant	Speed (mph)	Light Duty Vehicles	All Trucks	Pollutant	Speed (mph)	Light Duty Vehicles	All Trucks
		4-Urban Restricted Access	4-Urban Restricted Access			4-Urban Restricted Access	4-Urban Restricted Access
NOx	2.5	0.0913	2.7348	VOC	2.5	0.26	0.33
NOx	5	0.0705	1.4759	VOC	5	0.14	0.19
NOx	10	0.0566	0.8743	VOC	10	0.08	0.1
NOx	15	0.0472	0.7189	VOC	15	0.06	0.08
NOx	20	0.043	0.6142	VOC	20	0.04	0.06
NOx	25	0.044	0.5526	VOC	25	0.04	0.05
NOx	30	0.0467	0.5268	VOC	30	0.03	0.05
NOx	35	0.0534	0.4569	VOC	35	0.03	0.04
NOx	40	0.0582	0.4363	VOC	40	0.03	0.04
NOx	45	0.0616	0.4206	VOC	45	0.03	0.04
NOx	50	0.063	0.4012	VOC	50	0.03	0.03
NOx	55	0.0635	0.3838	VOC	55	0.03	0.03
NOx	60	0.0649	0.3855	VOC	60	0.03	0.03
NOx	65	0.0703	0.4004	VOC	65	0.03	0.03
NOx	70	0.0802	0.4133	VOC	70	0.03	0.03
NOx	75	0.0929	0.4314	VOC	75	0.03	0.03
$PM_{2.5}$	2.5	0.0368	0.0862	SOx	2.5	0.0091	0.0598
$PM_{2.5}$	5	0.0217	0.073	SOx	5	0.005	0.0334
$PM_{2.5}$	10	0.014	0.0425	SOx	10	0.003	0.0206
$PM_{2.5}$	15	0.0113	0.0298	SOx	15	0.0024	0.0182
$PM_{2.5}$	20	0.0089	0.0228	SOx	20	0.002	0.016
$PM_{2.5}$	25	0.0074	0.0204	SOx	25	0.0018	0.015
$PM_{2.5}$	30	0.0066	0.0178	SOx	30	0.0017	0.0147
$PM_{2.5}$	35	0.0063	0.0142	SOx	35	0.0016	0.0126
$PM_{2.5}$	40	0.0061	0.0125	SOx	40	0.0016	0.0123
$PM_{2.5}$	45	0.0059	0.0111	SOx	45	0.0016	0.0121
$PM_{2.5}$	50	0.0054	0.0095	SOx	50	0.0015	0.0116
$PM_{2.5}$	55	0.0048	0.0079	SOx	55	0.0015	0.0111
$PM_{2.5}$	60	0.0044	0.007	SOx	60	0.0015	0.0112
$PM_{2.5}$	65	0.0041	0.0069	SOx	65	0.0015	0.0118
$PM_{2.5}$	70	0.004	0.0068	SOx	70	0.0016	0.0123
$PM_{2.5}$	75	0.0042	0.0068	SOx	75	0.0016	0.013

Sources: 1) U.S. DOT, Federal Transit Administration. New and Small Starts Evaluation and Rating Process. Final Policy Guidance. August 2013. 2) Emission rates estimated by Cambridge Systematics using MOVES2014.

4.6.1 Approach

The emissions rates (in grams per mile) of non-carbon emissions (VOC, NOx, PM and SOx) are multiplied by the annual changes in VMT resulting from the implementation of RUS Bus. The emission rates in short tons are function of average travel speeds derived from the TDM. A linear forecasting model is developed to estimate the emission outputs using average speeds, and the emission rates are then multiplied by VMT to find total emissions generated from all modes of travel. Due to differences in pollutant damage costs, each pollutant emission rates and final emission output is calculated separately. The emission estimates are converted to short tons, and then multiplied by the emission cost per short ton as depicted in Table 4.18.

Table 4.18 Emission Damage Cost Rates for Major Pollutants

Emission Type	Emission Damage Cost ($ per Short Ton) in 2017$
VOCs	$1,905
NOx	$7,508
PM	$344,442
SOx	$44,373

Source: Source: U.S. DOT 2018 Benefit-Cost Analysis Guidance for Discretionary Grant Programs; Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII 16, "Economic Values Used for Benefits Computations (2010 dollars). Available at https://www.transportation.gov/fastlanegrants/bca-resource-guide.

The project also replaces five high-mileage diesel vehicles in operation for the minimum useful life with new zero emission electric vehicles. This investment also includes the purchase and installation of fast charger for each bus at the RUS Bus facility. USDOE's GREET Model Fleet Footprint Calculator suggests that replacing one diesel bus with one Proterra Catalyst battery electric bus will reduce annual tailpipe emissions by the following amounts (over the assumed 15 year useful life of the vehicle):

- 59 pounds of NOx
- 11 pounds of VOCs
- 1 pound of PM

4.6.2 Results

The emission cost category captures the changes in emissions generated by autos for the Build alternative in comparison to the No-Build alternative. The emission amounts for various pollutants are first estimated using travel speeds and VMT for each alternative. The change in emission amounts are then multiplied by unit cost of impacts for different pollutants. The total cumulative 30-year reduction in emissions from both the VMT reduction and the savings from the five electric buses are:

- NOx = 4.05 short tons
- VOC = 2.18 short tons
- PM = 0.38 short tons
- SOx = 0.08 short tons

The total cost of emissions is then capitalized for the 2024-2053 period. The monetary value of reduced/ additional emissions costs are reported in 2017 dollars and are also discounted using a 7 percent discount rate. Table 4.19 presents the emission costs benefits/disbenefits to be generated by RUS Bus.

Table 4.19 Non-Carbon Emission Costs Benefits/Disbenefits Resulting from RUS Bus

Year	Calendar Year	Total VOC, NOx, Sox, PM Emission Damage Cost (2017$)	Net Present Value (7%)
7	2024	$2,253	$1,403
8	2025	$2,490	$1,449
9	2026	$2,734	$1,487
10	2027	$2,986	$1,518
11	2028	$3,245	$1,541
12	2029	$3,511	$1,559
13	2030	$3,785	$1,571
14	2031	$4,068	$1,577
15	2032	$4,358	$1,579
16	2033	$4,656	$1,577
17	2034	$4,964	$1,571
18	2035	$5,279	$1,562
19	2036	$5,604	$1,550
20	2037	$5,938	$1,534
21	2038	$6,280	$1,517
22	2039	$4,610	$1,041
23	2040	$4,972	$1,049
24	2041	$5,344	$1,054
25	2042	$5,726	$1,055
26	2043	$6,118	$1,054
27	2044	$6,521	$1,049
28	2045	$6,934	$1,043
29	2046	$7,359	$1,034
30	2047	$7,794	$1,024
31	2048	$8,241	$1,012
32	2049	$8,700	$998
33	2050	$9,171	$983
34	2051	$9,693	$971
35	2052	$10,191	$954
36	2053	$10,701	$937
Total		**$174,226**	**$38,255**

Source: Cambridge Systematics Benefit-Cost Analysis

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

Carbon Emissions

USDOE's GREET Model Fleet Footprint Calculator suggests that replacing one diesel bus with one Proterra Catalyst battery electric bus will reduce annual fuel consumption and CO2 emissions by 230,720 pounds annually (over the assumed 15 year useful life of the vehicle). This value can be converted to metric tons and then multiplied by an estimate of the social cost of carbon consistent with previous BCA guidance, subsequently rescinded. The monetary value of reduced carbon emissions costs are reported in 2017 dollars and are also discounted using a 7 percent discount rate (see results in Table 4.20 for the 15 year useful life of the five buses).

Table 4.20 Non-Carbon Emission Costs Benefits/Disbenefits Resulting from RUS Bus

Year	Calendar Year	Total CO2 Emission Damage Cost (2017$)	Net Present Value (7%)
7	2024	$27,733	$17,271
8	2025	$28,257	$16,446
9	2026	$28,780	$15,654
10	2027	$28,780	$14,630
11	2028	$29,827	$14,170
12	2029	$30,350	$13,476
13	2030	$30,873	$12,811
14	2031	$31,396	$12,176
15	2032	$31,920	$11,569
16	2033	$32,443	$10,990
17	2034	$32,966	$10,436
18	2035	$33,489	$9,908
19	2036	$34,536	$9,549
20	2037	$35,059	$9,060
21	2038	$35,583	$8,594
22	2039 - 2053	$0	$0
	Total	**$471,992**	**$186,741**

Source: Cambridge Systematics Benefit-Cost Analysis

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

Note, inclusion or removal of the social cost of carbon within the BCA does on impact the overall BCA ratio, internal rate of return, or payback period for RUS Bus given its relatively low benefit value compared to total overall benefits and costs.

5.0 Cost Categories

In the benefit-cost analysis (BCA), the term “cost” refers to the additional resource costs or expenditures required to implement and maintain the investments associated with the proposed RUS Bus Facility. The BCA uses costs that have been estimated for the Project on an annual basis. All up-front and lifecycle costs are initially expressed in real 2017 dollars and remain so for purposes of this analysis.

5.1 Project Capital Costs

The RUS Bus Facility Project capital costs include expenditures on engineering design, land acquisition and preparation, and construction. The total project costs are estimated to be $50,720,000 in 2017 dollars. The total costs are split among:

- $4,619,700 for design and engineering;
- $9,660,000 for Right of Way Acquisition; and
- $36,440,300 for construction including:
  - Site work including demolition of existing buildings and utility work
  - 8-bay off-street bus transfer facility (RUS Bus)
  - Pedestrian bridge
  - BRT platforms and improvements on West Street
  - West Street pedestrian improvements
  - Traffic signal prioritization for transit vehicles (12 adjacent intersections)
  - Five Proterra Catalyst buses
  - Tactile wayfinding and ADA enhancements
  - General conditions including project mobilization, permits, and insurance
  - Public art and SHPO allocation (2.5 percent)
  - General contingency (10 percent)
  - Escalation (5%).

The net present value of total project capital costs discounted at 7 percent is $36,217,861.

5.2 Project Operating and Maintenance Costs

Annual project operating and maintenance (O&M) expenditures comprise yearly expenditures to operate and maintain the RUSBus Facility. The O&M expenditures are estimated to be $250,000 annually over the 30-year period. **The total project O&M costs are estimated to be $7.5 million in 2017 dollars and $2,205,002 discounted at 7 percent discount rate**.

The O&M cost for the Build Alternative is included as a disbenefits in the numerator of the BCA calculations, due to the fact that the No-Build Alterative has no O&M costs for upkeep of the RUS Bus facility.

5.3 Asset Residual Value

The asset residual value accounts for the asset service life beyond the 30-year analysis period. To find the residual value of the bus rapid transit (BRT) platforms, bus bays, and the pedestrian bridge components at the end of the 2024-2053 analysis period, the following formula is used per U.S. DOT BCA Guidance:

$$Residual\ Value = \left(\frac{Useful\ Service\ Life - Analysis\ Period}{Useful\ Service\ Life}\right) \times (Estimated\ Capital\ Cost\ in\ \$2017)$$

The estimated capital costs of the major components that are anticipated to be used beyond 30 years is $13 million (8 bus bay transfer facility, BRT platforms, and pedestrian bridge). The useful service life of these components is estimated to be 50 years. Hence the asset residual value is estimated to be:

$$Residual\ Value = \left(\frac{50-30}{50}\right) \times (\$11{,}400{,}000) = \$4{,}333{,}333\ in\ 2017\ Dollars$$

The asset residual value at the end of the 30-year analysis period is valued at $651,743 when discounted using a 7 percent discount rate. The asset residual value is considered a benefit and is included in the numerator of the BCA analysis.

6.0 Benefit-Cost Ratio

The aggregation of all benefits expected to be generated by the RUS Bus facility, as well as their costs are shown in Table 6.1, with discount rates of 7% and undiscounted in 2017 dollars. Table 6.2 presents the overall flow of costs and benefits from the start of construction through the end of the analysis period.

Table 6.1 Summary of Quantitative Impacts of Build Alternative

Impact Category	Benefits/ Disbenefits ($2017)	Benefits/ Disbenefits (7%)
State of Good Repair of the Highway Infrastructure	$68,447	$12,375
Travel Time Benefits/Disbenefits	$45,693,985	$8,144,893
Vehicle Operating Costs (Non-Fuel Based) Benefits/Disbenefits	$12,798,810	$2,313,918
Vehicle Operating Costs (Fuel Based) Benefits/Disbenefits	$6,508,052	$1,158,754
Non-Carbon Emission Costs Benefits/Disbenefits	$174,226	$86,271
Carbon Emission Costs Benefits/Disbenefits	$471,992	$186,741
Non-Motorized Traffic Safety Benefits/Disbenefits	$7,575,579	$1,369,601
Transportation Expenditure Benefits/Disbenefits	$14,911,000	$3,780,354
Asset Residual Value	$189,850,803	$31,652,364
Total Benefits/Disbenefits	**$282,386,227**	**$49,357,013**
Capital Costs	$50,720,000	$36,217,861
Annual Operating and Maintenance Costs	$7,500,000	$2,205,002
Total Costs	**$58,220,000**	**$38,422,863**
Benefit-Cost Ratio	**4.85**	**1.28**

Source: Cambridge Systematics Economic Modeling

Note: Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

Table 6.2 Summary of Benefits and Costs for RUS Bus Lifecycle

Calendar Year	Costs ($2017)	Benefits ($2017)	Cumulative ($2017)
2021	$16,906,667	0	($16,906,667)
2022	$16,906,667	0	($33,813,333)
2023	$16,906,667	0	($50,720,000)
2024	$250,000	$715,310	($50,254,690)
2025	$250,000	$1,046,983	($49,457,707)
2026	$250,000	$1,397,312	($48,310,394)
2027	$250,000	$1,766,769	($46,793,625)
2028	$250,000	$2,157,972	($44,885,654)
2029	$250,000	$2,570,457	($42,565,197)
2030	$250,000	$3,005,913	($39,809,283)
2031	$250,000	$3,465,569	($36,593,714)
2032	$250,000	$3,950,721	($32,892,993)
2033	$250,000	$4,462,732	($28,680,261)
2034	$250,000	$5,003,043	($23,927,218)
2035	$250,000	$5,573,170	($18,604,048)
2036	$250,000	$6,175,234	($12,678,813)
2037	$250,000	$6,809,874	($6,118,940)
2038	$250,000	$7,479,386	$1,110,447
2039	$250,000	$8,147,515	$9,007,961
2040	$250,000	$8,891,962	$17,649,924
2041	$250,000	$9,677,201	$27,077,125
2042	$250,000	$10,505,419	$37,332,544
2043	$250,000	$11,378,920	$48,461,464
2044	$250,000	$12,300,133	$60,511,597
2045	$250,000	$13,271,615	$73,533,211
2046	$250,000	$14,296,060	$87,579,271
2047	$250,000	$15,376,306	$102,705,577
2048	$250,000	$16,515,341	$118,970,918
2049	$250,000	$17,716,314	$136,437,232
2050	$250,000	$18,982,538	$155,169,771
2051	$250,000	$20,368,669	$175,288,439
2052	$250,000	$21,778,915	$196,817,354
2053	$250,000	$27,598,873	$224,166,227
TOTAL	**$58,220,000**	**$282,386,227**	

Note: Positive $ values represent savings/benefits and negative $ values in parenthesis represent losses/disbenefits.

7.0 Short-Term Jobs

The expenditure of public sector dollars is expected to create short-term jobs in the development and construction phases and maintenance of the RUS Bus Facility. The benefit of increase in the job-years as a result of the Project during development and construction will be computed as a product of the undiscounted project cost and the value on government dollars spent to create a single job-year (i.e., $76,900 in 2015$)[3]. These benefits are not counted in the B/C calculation.

Table 7.1 Summary of Jobs Impacts of the Build Alternative

Job Creation	Jobs Impact
Increase in short-term jobs due to construction (Job-Years)	640
Increase in short-term jobs due to construction and O&M (Job-Years)	737
Average No. of short-term jobs created due to construction (Jobs/Year)	213

Source: Cambridge Systematics Benefit-Costs Analysis

[3] U.S. DOT Benefit-Cost Analysis (BCA) Resource Guide (November 2016) supplement to the 2016 Benefit-Cost Analysis Guidance for Grant Applicants, Updated November 17, 2016.