Transport 2020 Bus Rapid Transit: A Cost Benefit Analysis

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December 4, 2006

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EXECUTIVE SUMMARY

Growth in transportation infrastructure has failed to keep pace with the rapid growth in population across the greater Madison metropolitan area, placing a strain on the region's public transportation system. In an effort to prevent the region's transportation troubles from reaching crisis proportions, a study called Transport 2020 was commissioned to evaluate several transportation improvement alternatives for the region. One of the alternatives considered in this study, but dismissed without a rigorous evaluation, is known as Bus Rapid Transit (BRT). In this report, we analyze the costs and benefits of implementing a BRT system in the greater Madison metropolitan area. Two BRT alternatives are evaluated in this analysis: the alternative evaluated by Transport 2020 (BRT 2020) and a modified version of the Transport 2020 alternative (BRT Plus). When all U.S. citizens are granted standing, we find that implementation of BRT 2020 would return negative net benefits of $261 million over a 30 year project life, while implementation of BRT Plus would return negative net benefits of $153 million over the same project life. Based on our findings, we conclude that implementing a BRT system in the greater Madison metropolitan area is not justified on efficiency grounds alone, but that further research is needed in important several areas.

The net present value of each BRT alternative was found to be highly dependent on standing. When all individuals in the United States are granted standing, each BRT alternative returns large negative net benefits. However, when standing is restricted to residents of the Madison metropolitan area, substantial positive net benefits are returned for each BRT alternative. These differences arise because the majority of the funding for capital and operating costs of the BRT system would come from the federal and state government.

To arrive at our estimate of the net present value of each alternative, we considered the following benefit categories: (1) reduced travel time for current bus users, (2) reduced vehicle user costs for new bus users, (3) reduced air emissions and (4) reduced vehicle accident costs. Analyzed cost categories include: (1) the capital costs of building a BRT system, (2) operations and maintenance costs of a BRT system, (3) the cost of raising local revenue.

Estimates of parameter values were primarily obtained from academic transit studies, the Wisconsin Department of Transportation, the Madison Area Metropolitan Planning Organization, and Transport 2020. Ranges of net present value were obtained by varying parameter estimates over plausible ranges by conducting both partial sensitivity analyses and Monte Carlo sensitivity analyses. Theoretical uncertainties and data limitations prevented us from monetizing all potential cost and benefit categories. As a result, we believe that our estimates of net benefits likely underestimate the true social benefits.

ACKNOWLEDGEMENTS

We are grateful for the guidance that we were given in conducting this analysis. We would like to thank Susan DeVos for her comments on our draft reports throughout the last several months. We would also like to thank Mike Cechvala for the valuable insights and data that he provided. We also appreciate the guidance and information provided by David Trowbridge, Margaret Bergamini, Bill Schaefer, Dan Seidensticker, and Karen Baker Mathu. Finally, we would like to thank Professor David Weimer for providing us with direction and answering our many questions.

INTRODUCTION

Significant population growth in the greater Madison metropolitan area has led local governments, advocacy groups, and individual citizens to question the current effectiveness and future viability of the region's public transportation system. The U.S. Census Bureau estimates that the population of the Madison metropolitan area has increased by 23 percent since 1990, a population boom that added about 100,000 residents. This growing population has resulted in increased vehicle congestion, longer travel times, and increased travel distances. Higher traffic levels have resulted in increased motor vehicle emissions and are one of the main reasons why Madison is now on the verge of becoming an air quality non-attainment area (Madison Department of Public Health, 2006). Predictions of continued rapid growth mean that the region's current transit system will be strained to meet growing needs.

In an effort to prevent the situation from reaching a crisis level, local and regional leaders assembled a group of experts and advocates to evaluate transportation improvement alternatives for the region. This study, known as Transport 2020, is scheduled to take place in several phases over multiple years. The first phase of the study, completed in 2002, evaluated the efficacy of six distinct alternatives, including Bus Rapid Transit (BRT),[1] light rail, commuter rail, and combinations of these transit modes. The BRT proposal and two other alternatives were eliminated during the first phase.

The reason for the elimination of the BRT alternative was not stated in the final report for the first phase or other publicly available materials. Using a cost-benefit analysis framework, we attempt to determine the net benefits of implementing a BRT system in the greater Madison metropolitan area.

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[1] Technical definitions are provided throughout this analysis and available in *Appendix A: Technical Definitions*.

Overview of Bus Rapid Transit

BRT systems vary in specific characteristics, but all provide a higher level of service than traditional bus transportation. This superior service is achieved in multiple ways, including bus operation on restricted-use lanes, signal prioritization, prepaid fare systems, real-time information for passengers waiting at stations, and limited stops. BRT buses are modernized to provide easier access for individuals with special needs. They may also be quieter, smoother, and more comfortable than traditional buses. A final key feature of BRT systems is the high level of integration with existing and future land use patterns. For example, routes and stations are conceived and implemented in a manner that promotes economic development, minimizes travel time, and encourages intermodal connectivity. Together, these characteristics of BRT systems serve to maximize speed, service, and convenience for passengers in a way unavailable with traditional bus services.

Several metropolitan areas have implemented BRT systems to help meet their regional transit needs. Examples of BRT systems in the U.S. are found in Cleveland, Hartford, Washington, D.C., and Miami. Internationally, cities such as Sydney, Australia and Lima, Peru have also implemented BRT systems.

ANALYTICAL FRAMEWORK

This cost-benefit analysis uses a net present value model to compare the hypothetical implementation of two BRT alternatives to a baseline alternative. To do this, we quantify changes in social surplus for all relevant cost and benefit categories, monetize these changes, and then sum the discounted costs and benefits over the 30 year life of the project.[2] A description of each alternative follows.

Baseline Alternative

The baseline alternative is defined as the current regional public transportation system together with planned improvements that already have an identified funding source. In its study, Transport 2020 labeled this the "No-Build" alternative. Whenever appropriate, our analysis uses the same parameters in order to facilitate the comparison of our analysis with that of Transport 2020.

BRT 2020 Alternative

The BRT 2020 alternative was evaluated in the first phase of the Transport 2020 study. The four main elements of this alternative are (1) an expansion of current bus service, (2) new commuter routes, (3) separated bus guideway and diamond lanes, and (4) a main BRT corridor running east-west through the isthmus. The commuter route component is composed of nine additional regional routes connecting surrounding communities with existing transfer points on the outskirts of Madison. Each transfer point would offer frequent service to downtown Madison. This alternative also includes express routes to be implemented between all transfer points. For details on the routing of the main BRT corridor, see *Appendix B: Maps of the BRT 2020 and BRT Plus Corridors*.

Bus service in the main BRT corridor would be scheduled at 15 minute intervals. The new regional commuter routes would be scheduled to make two trips per hour in each direction during times of peak demand, with hourly service provided for all other hours of operation. Service for each commuter route would commence at a park-and-ride lot and make limited stops

[2] For a more comprehensive description of cost benefit analysis methodology, please see (Boardman et al., 2006).

en route to an existing transfer point (and vice-versa). Limited-stop service would then continue from the transfer point until the bus reached the downtown area, at which point the bus would continue as a local-service bus making all marked stops.

In some areas, buses would travel in diamond lanes reserved for their exclusive use (see *Appendix B*). Implementing this would require reduction of open traffic lanes on some roadways. The building of these diamond lanes would also require removal of some sections of street parking as well as the widening of some existing roads. This plan also includes a *guideway* lane running parallel to an existing railway in west Madison. Construction of this guideway would require modification of three bridges and the removal of some railroad tracks.

BRT Plus Alternative

BRT Plus is a modification of BRT 2020. It integrates additional prototypical BRT components and more accurately reflects our client's strategic plan. BRT Plus includes modernized buses that are cleaner, quieter, more comfortable, and more accessible than those used in BRT 2020. Additional features include pre-boarding fare collection, easily interpreted route maps and a higher level of integration between bus terminals and the community. Finally, "Intelligent Transportation Systems" that provide real-time schedule information to passengers waiting at stops are also included. Components of this alternative that are shared with the BRT 2020 alternative include the diamond lanes and additional commuter routes.

Routing of the main BRT corridor is the primary distinction between the BRT 2020 and BRT Plus alternatives. Mike Cechvala, a City of Madison engineer, recommended a route that he felt would result in an improved BRT system. Accordingly, we altered the routing of the main corridor for the BRT Plus alternative. When compared to the BRT 2020 main corridor, BRT Plus has 5.5 miles of additional guideway and 1.5 fewer miles of diamond lanes. BRT 2020 and BRT

Plus have the same quantity of regional bus network mileage and each has alternative has one BRT station per mile on the main BRT route.

<u>Local, State and National Standing</u>

Our base model assumes national standing, meaning that the costs and benefits of every individual in the United States are measured when determining net social benefits. We also calculate the net social benefits under local standing and state standing. Local standing measures the net social benefits that accrue to only the residents of the greater Madison metropolitan area, while state standing expands the scope to include all Wisconsin residents.

MEASURING COSTS AND BENEFITS OF BUS RAPID TRANSIT

Implementing a BRT system would have the potential to affect several travel modes. In addition to persons traveling by automobile and bus, individuals who walk, bicycle, ride a moped or motorcycle, or drive commercial trucks could experience changes in costs and benefits due to the implementation of a BRT system. However, because of the limited data available to us and our assumption that people traveling by modes other than bus or car would experience negligible changes in net benefits, we only analyze the impacts of a BRT system on two modes of transportation: bus and automobile.

Our analysis relies on four principle assumptions found in the transportation CBA literature (Banister and Berechman, 2003; ECONorthwest *et al.*, 2002; HLB, 2002):

1. *The cost of travel involves direct marginal monetary costs, such as transit fares, fuel costs, tire deterioration and the cost of an individual's time spent traveling.*

   For example, the price of a bus fare to travel from Middleton to downtown Madison is typically less than the total costs (for example, the cost of fuel, parking, vehicle maintenance and depreciation) associated with driving a car for that same trip. However, riding the bus requires significantly more travel time, often causing the total costs of taking the bus to be higher than the costs of driving the car.

2. *The value individuals place on their travel time is influenced by many factors.*

   Some of these factors include whether individuals are traveling for work or leisure purposes, how confident they are about the expected travel time (for example, the possibility of the bus breaking down or the chances of a delay because of traffic) and the level of personal comfort during the trip.

3. *People choose their travel mode based on the total cost of travel, which includes direct monetary plus time costs.*

   Investments in new bus transit infrastructure provide faster, more dependable and more comfortable transportation. Accordingly, the total costs of travel time when traveling by bus decrease, and the bus system therefore attracts new riders.

4. *Some social costs are not reflected in the private cost of travel. By reducing these externalities, social benefits can be gained.*

   When people switch from driving their cars to riding the bus, a number of environmental costs, most notably air pollution, decrease. Accident rates and associated costs also decrease.

TRIPS, TRAVEL TIME, AND DISTANCE

The change in the total number of bus and vehicle trips determines the magnitude of benefits that accrue from a BRT investment. The first phase of the Transport 2020 study estimated the total number of trips by travel mode for the baseline and BRT 2020 alternatives. Following the guidance of the Madison Area Metropolitan Planning Organization (MPO) and the methodology used by the Transport 2020 study team, we formulated trip estimates for the BRT Plus alternative. See *Appendix C: Methodology for Estimating Daily Transit And Vehicle Trips, Travel Time And Travel Distance* for a detailed discussion of the methodology used. The annual bus ridership growth rate of 0.8 percent was taken directly from the Transport 2020 study. Table 1 summarizes the ridership estimates for the year 2020.

Table 1: 2020 Daily Ridership Projections for the Baseline and BRT Alternatives

	Transit Commuting	Vehicle Commuting	Transit Non-Commuting	Vehicle Non-Commuting	Annual Ridership Growth Rate
Baseline	17,000	274,000	20,000	926,000	0.80%
BRT 2020	20,000	272,000	23,000	922,000	0.80%
BRT Plus	23,000	270,000	26,000	919,000	0.80%

The travel time and distance of average trips are also essential in determining the magnitude of benefits. We used data from the 1990 and 2000 censuses to estimate average commuting travel times for the year 2020 as well as annual travel time growth rates. Non-commuting travel times are based on data obtained from the MPO. For bus travel, we divided trips into two categories: (1) on-the-bus and (2) walking, waiting, and transferring components. We then applied average travel speeds to estimate average travel distances. Average travel distances allow us to calculate total vehicle miles traveled (VMT) and total bus miles traveled (BMT) in the project area. Using data from the Wisconsin Department of Transportation, we estimated a yearly growth rate for VMT. See *Appendix C: Methodology for Estimating Daily Transit And Vehicle Trips, Travel Time And Travel Distance* for a detailed discussion of our methodology. Table 2 summarizes the travel time and distance estimates used in this analysis.

Table 2: 2020 Average Trip Travel Time and Distance Estimates

	Commuting		Non-Commuting				
	Vehicle Travel Time (m)	**Bus Travel Time (m)**	**Vehicle Travel Times (m)**	**Bus Travel Time (m)**	**Walking/ Waiting / Transferring Time (m)**	**Total VMT**	**Total BMT**
Baseline	26	39	19	30	15	14,122,000	18,600
BRT 2020	26	36	19	28	14	14,049,000	21,700
BRT Plus	26	34	19	27	13	13,983,000	24,500
Annual Growth Rate	1.15%	1.15%	1.15%	1.15%	N/A	1.15%	N/A

Benefit Categories

Utilizing the ridership, travel time, and trip length projections presented above, we quantified the key benefits that we expected to result from the implementation of a BRT system. Project benefits are divided into four categories: (1) the reduction in travel time costs, (2) the reduction in vehicle user costs, (3) the reduction in air emissions, and (4) the reduction in accident costs. See Table 3 for details.

Table 3: Benefit Parameters	
Variable	**Unit**
Reduced Travel Time	Value of Travel Time in Dollars per Hour
Reduced Vehicle User Costs	Marginal Vehicle User Cost per VMT
Reduced Vehicle Emissions	Cost of Emissions per VMT
Reduced Accident Costs	Cost of Accidents per VMT

<u>Reduced Travel Time Costs</u>

The average time that it takes a bus rider to make his or her trip would decrease with the implementation of a BRT system. These time savings are monetized and included as benefits in our model.

The value of a person's time while traveling depends on the purpose of the trip (commuting versus non-commuting), the mode of transit (car versus bus), and the component of the trip being considered (in-vehicle time versus "excess" time for walking, waiting or transferring). We derived the values of time in our model from accepted time-valuation theory. This line of theory is based on the gross average hourly wage rate for a worker in the area (ECONorthwest *et al.*, 2002; HLB, 2002). We calculated the average hourly gross wage rate for Madison area worker to be $15.66. For more details, see *Appendix D: Travel Time Cost Reduction.* Table 4 presents the values of time used in our model.

Table 4: Time Values of Travel Time			
Bus and BRT Users	**Percent of gross hourly wage**	**Per Hour**	**Per Minute**
In-vehicle non-work trip (local)	50	**$7.83**	$0.13
In-vehicle non-work (intercity)	70	**$10.96**	$0.18
In-vehicle work trip	100	**$15.66**	$0.26
Excess for work-trip (walking, waiting or transfer)	100	**$15.66**	$0.26
Excess for non-work-trip (walking, waiting or transfer)	100	**$15.66**	$0.26

<u>Reduced Automobile Vehicle User Costs</u>

There is a marginal cost associated with each VMT. As VMT are projected to be lower under the BRT alternatives than the baseline alternative, there would be a cost savings associated with a reduction in VMT. Components of the marginal cost of a VMT include fuel, oil, tire deterioration, maintenance, and vehicle depreciation. The total marginal cost per VMT is dependent upon speed of travel, frequency of stops, price of fuel, vehicle year, and vehicle type. Formulating accurate variable costs for automobiles in Madison would require data that are unavailable and modeling techniques beyond the scope of this analysis. Therefore, we derive our cost estimates from the Victoria Transit Policy Institute, the California Department of Transportation, the American Automobile Association, and other sources. See *Appendix E: Vehicle User Cost Reduction* for a complete discussion of literature consulted. Table 5 provides our estimate of the marginal cost of a vehicle mile traveled.

Table 5: Marginal User Cost Per VMT, 2000 dollars

Cost Categories	Fuel, Oil, Tire	Depreciation	Maintenance	Marginal User Cost	Preferred Marginal Vehicle Cost Estimate
Cost Per VMT	\$0.08 - \$0.15	\$0.05 - \$0.23	\$0.04-\$0.05	\$0.17 - \$0.43	\$0.25

Reduced Air Emissions

Vehicles and buses release hydrocarbons, nitrogen oxides, carbon monoxide, and carbon dioxide into the air (EPA, 2006). Implementing a BRT system would slightly increase air emissions by buses, but substantially decrease air emissions from automobiles. This analysis estimates the reduction in social costs caused by the net decrease of such emissions. We reach this estimate through consideration of the effects that emissions have on human health, the environment, and ability to participate in outdoor activities.[3]

Vehicle emission levels vary widely depending on make and model. Accurately determining the emissions released from vehicles in Madison requires knowledge of car type and

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[3] In addition to air pollution, implementation of the BRT alternatives would impact other types of pollution levels, including water and noise. We exclude these categories because of data limitations and expectations that the effects would be negligible.

model year for each vehicle mile traveled. Because of the complexities of gathering this information, we use average emissions cost per VMT based on estimates from the Victoria Transport Policy Institute and the California Department of Transportation (Litman, 2002; California DOT, 2006). *Appendix F: Reduced Vehicle Air Pollution Costs* provides a detailed discussion of our methodology and calculations.

The cost that society bears from bus emissions are approximated using estimates from the Victoria Transport Policy Institute and supported with evidence from the California Department of Transportation (Litman, 2002; California DOT, 2006). The 66 new buses purchased for the BRT 2020 alternative would be similar to the buses currently in use. The 66 new buses purchased for the BRT Plus alternative, however, would be approximately 20 percent more fule efficient. Our methodology is discussed in *Appendix G: Increased Air Pollution Costs from Increased Bus Travel.* Table 6 lists our estimates of vehicle and bus air pollution costs.

Table 6: Air Emissions Cost Per Mile Traveled, 2000 dollars

Type	**Estimate**	**Plausible Range**
Personal Vehicles	$0.08	$0.04 to $0.15
Traditional Diesel Bus	$0.16	$0.11 to $0.19
Advanced BRT Bus	$0.13	$0.09 to $0.15

Reduced Accident Costs

The average annual number of accidents is positively related to VMT. Accordingly, the social cost of accidents decreases when fewer vehicle miles are traveled. The social costs of accidents considered in this analysis include the cost to society of deaths, injuries, and property damage.[4] Using data provided by the Wisconsin Department of Transportation, we calculated

[4] Our accident costs estimates do not include government costs of responding to accidents. This may result in an underestimate of the benefits from reduced accidents and should be considered when evaluating the results of this study.

the average accident cost per VMT to be $0.03 (May, 2006). See *Appendix H: Reduced Accident Costs* for a detailed discussion of our methodology and calculations.

ADDITIONAL POTENTIAL BENEFITS

The following major categories of potential benefits are not included in our analysis for technical or theoretical reasons:

- *The value to vehicle drivers from changes in roadway congestion.*

  Congestion benefits are typically included in transit-oriented cost-benefit analyses (ECONorthwest *et al.,* 2002; HLB, 2002). However, we believe that the impact of the BRT system on the travel time for automobile commuters would be minimal. The validity of our assumption of minimal congestion benefits was confirmed by transportation planning staff at the MPO.[5] In addition, the BRT alternatives may actually increase congestion because the guideway and diamond lanes remove roadway lanes that would otherwise be available to automobile traffic.

- *The value that people derive from knowing that a BRT system is present if they should ever wish to use it (option value).*

  Option value is likely to be greatest in areas not previously served by transit. Under the BRT alternatives, new service would primarily be in the cities surrounding Madison. However, we do not have good estimates of the number of individuals affected by this new service or what their transit option value would be.

[5] The Madison Area MPO has investigated the impact of the Transport 2020 alternatives and concluded that there would be at most 100 less cars for a corridor for an entire peak period.

- *Benefits resulting from increased low-income mobility, such as increased employment opportunities resulting in less welfare dependence.*

  This is a major benefit category that is often included in other transit studies, but has serious risks of being double-counted (ECONorthwest *et al.*, 2006).[6] Even without the risk of double-counting, these benefits are likely to occur only in areas not currently served by transit. It is unclear how many low-income people would have access to transit under the BRT alternative that previously did not.

- *Economic development near new transit stations and economic growth due to enhanced mobility.*

  This is another benefit category with a serious risk of double-counting (ECONorthwest *et al.*, 2006). However, some analysts argue that factors such as agglomeration economy effects around transit stations result in additional economic development benefits that are not captured by travel demand (Banister and Berechman, 2003). Transport 2020 estimates property values around *train* stations may increase up to 16 percent more than would have occurred otherwise (Transport 2020, 2002). They provide no estimate of the impact from the BRT system, and the Government Accountability Office suggests that economic development benefits do not necessarily occur for bus transit (GAO, 2001).

It is highly likely that the exclusion of these benefit categories causes our calculation of the present value of net benefits to be artificially low. We are unsure, however, of the exact magnitude of this difference. See *Appendix I: Additional Potential Benefits* for a complete discussion of the reasons that we excluded these benefit categories.

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[6] Double-counting occurs when the benefit being measured has already been accounted for by other measurements. In this case double-counting would occur if the changes in travel demand already capture the value of low-income mobility benefits.

Cost Categories

Costs are broken into three categories: (1) capital costs, (2) operating costs, and (3) the costs of raising the revenues.

Capital Costs

Capital costs include costs for planning and design, as well as a large amount of investment in new infrastructure that would be needed. Total capital costs for the BRT 2020 and BRT Plus alternatives are calculated to be $64.5 million and $130.3 million above the baseline, respectively. These cost estimates are projected to cover all expenses associated with planning and designing the system, constructing the necessary infrastructure, and acquiring the required 66 new buses. The sizeable difference in capital cost estimates for the two alternatives is caused by the following features of the BRT Plus alternative: more BRT guideway mileage, enhanced BRT stations, purchase of BRT buses with greater fuel efficiency and lower air-polluting emissions per mile, and intelligent transportation systems. The costs of building the BRT system are partially offset by the salvage value of buses that would be retired and replaced under the BRT alternatives.

The capital cost estimates are based on findings from the Transport 2020 study team (Transport 2020, 2002). This study estimates the capital costs associated with implementing the BRT 2020 alternative in Madison. To arrive at an estimate of capital costs for the BRT Plus alternative, we used the BRT 2020 estimate as a base case and made cost alterations that reflect the enhanced features of BRT Plus. We confirmed the plausibility of these cost estimates by comparing them with capital costs of BRT systems already in operation across the country (U.S. GAO, 2001). Cost alterations are based on recommendations by Federal Transit Administration (FTA, 2004). See *Appendix J: Capital Costs* for the specific methodology used to calculate all capital cost estimates.

Operations and Maintenance Costs

Operations and maintenance expenses include compensating bus drivers and maintenance personnel, purchasing fuel for the buses, and procuring replacement parts and supplies from vendors. For the BRT 2020 and BRT Plus alternatives, annual operations and maintenance costs are estimated to be $19.5 million and $18.8 million above the baseline, respectively. The annual operations and maintenance budget for the BRT Plus alternative is estimated to be $700,000 lower than the budget for BRT 2020 because the buses that would be purchased under the BRT Plus alternative are approximately 20 percent more fuel efficient than the buses that would be purchased under the BRT 2020 alternative. The reliability of these estimates was confirmed through consultation with Madison Metro personnel and a comparison with the current Madison Metro operations and maintenance budget. The methodology used to calculate annual operations and maintenance costs for each of the alternatives can be found in *Appendix K: Operations and Maintenance Costs.*

Costs of Raising Local Revenue

The costs of a local transit system, including the baseline and the two alternatives, are paid for by all three levels of government: federal, state, and local. State and federal grant and subsidy programs cover the majority of both the capital costs and the operations and maintenance (O&M) costs, requiring the local budget to absorb only 25 percent or less of these expenditures. Table 7 provides the governmental sources of revenue for capital and operations and maintenance costs. See *Appendix L: Revenue Sources* for more information.

Table 7: Funding Sources

Level of Government	**Capital Costs**	**O&M Costs**
Federal	50%	43%
State	25%	37%
Local	25%	21%

The local or regional share of the capital costs and O&M must be raised through either a property or sales tax increase.[7] We adopt the conclusion of Transport 2020 that a sales tax is preferable because of widespread political opposition to property tax increases (Kopp, 2006). Therefore, the marginal excess tax burden (METB) for sales taxes is applied to the local sales tax revenue raised. The literature suggests a wide range for the METB of sales taxes (0.11 – 0.39) (Boardman *et al*., 2005). We employ the mean (0.25) in our model, but included the full range of values in our sensitivity analysis.

The second additional component of the costs of raising revenue at the local level is the expense of financing the debt necessary to generate the initial lump sum for the capital costs of the project. Again, we adopt Transport 2020's assumption that a twenty-year bond with a 5 percent interest rate would be used, borrowing against future sales tax revenues in order to make available the large initial sum for capital costs. The total amount of interest paid on the bond is thus incurred as a cost.

Finally, the revenue generated through bus fares is inflated by this same METB factor since these revenues represent funds that do not need to be raised through the sales tax and are therefore not subject to the those tax-based inefficiencies. Table 8 lists the additional costs of local financing.

The Dane County sales tax rate increases required to finance the costs for the local government are as follows: a 0.17 percent increase for BRT 2020, and a 0.21 percent increase for BRT Plus.

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[7] These are the two most common ways to generate the required revenue (Kopp, 2006). Transport 2020 provided a more complete list of possible strategies for raising revenue at the local, regional or state level (Technical Report 8).

Table 8: Local Financing Costs, Millions, 2000 dollars		
Alternative	**Category**	**Cost**
BRT 2020	Costs of raising local capital and M&O due to METB (0.25)	$21.8
	Costs of debt financing (20-year bond at 5% interest)	$7.5
	Savings due to METB of collected bus fares	-$7.8
	Total	**$21.5**
BRT Plus	Costs of raising local capital and M&O due to METB (0.25)	$25.2
	Costs of debt financing (20-year bond at 5% interest)	$15.3
	Savings due to METB of collected bus fares	-$14.9
	Total	**$25.6**

NET PRESENT VALUE: MODEL AND DISCUSSION

Our analysis makes the following assumptions:

- A real social discount rate of 3.5 percent is appropriate.
- The useful life of the project will be 30 years with construction commencing at the beginning of the year 2010 and all operations ceasing at the end of the year 2039.
- Construction will require one year, meaning that all capital costs will be incurred in year 2010 and benefits do not begin accruing until the beginning of 2011.
- The Consumer Price Index is an appropriate factor to convert cost estimates from the literature to 2000 dollars.
- In year 2039, the BRT system will have a horizon value of 15 percent of the original capital investment.
- All annual benefits are estimated by multiplying daily benefits by 280 days (the approximate number of yearly commuting days). This allows for comparison with the costs published by Transport 2020.
- All annual project benefits and costs will accrue in the middle of the year.

The table below represents the net present value (NPV) of BRT 2020 and BRT Plus using our preferred parameter estimates:

Table 9: Net Present Value of Project Benefits (Millions, 2000 dollars)						
	National Standing		**State Sanding**		**Local Standing**	
Cost and Benefit Categories	BRT 2020	BRT Plus	BRT 2020	BRT Plus	BRT 2020	BRT Plus
Capital Costs	-$64.5	-$130.3	-$32.3	-$65.2	-$16.1	-$32.6
Cost of Raising Local Revenue	-$21.5	-$25.6	-$21.5	-$25.6	-$21.5	-$25.6
Operations and Maintenance	-$345.7	-$333.3	-$197.0	-$190.0	-$70.9	-$68.3
Subtotal	***-$431.7***	***-$489.1***	***-$250.8***	***-$280.7***	***-$108.5***	***-$126.5***
Time Savings For Current Transit Riders	$32.6	$70.2	$32.6	$70.2	$32.6	$70.2
Reduced Costs for New Transit Riders	$94.2	$180.6	$94.2	$180.6	$94.2	$180.6
Reduced Vehicle Air Pollution Costs	$27.7	$54.0	$27.7	$54.0	$27.7	$54.0
Reduced Accident Costs	$12.1	$23.1	$12.1	$23.1	$12.1	$23.1
Horizon Value	$4.1	$8.2	$2.3	$4.7	$1.5	$3.0
Subtotal	*$170.7*	*$336.1*	*$168.9*	*$332.7*	*$168.1*	*$330.9*
Total Net Present Value	***-$261.1***	***-$153.0***	***-$81.9***	***$52.0***	***$59.6***	***$204.5***

The choice of standing for the cost-benefit analysis is critical. Only 25 percent of the capital costs and 21 percent of the operating and maintenance costs accrue directly to the local population. The federal and Wisconsin state governments finance the remainder of both cost categories. Therefore, the standing decision ultimately determines whether each of the alternatives return positive or negative net benefits. Under national standing, both alternatives result in large-scale negative net benefits. Under local standing, large-scale positive net benefits result. For state standing, only the BRT Plus alternative returns positive net benefits. See *Appendix O: Yearly Net Present Value* for details on costs and benefits in each year of the project.

In interpreting the results, it is important to keep in mind the potential benefits that could be derived from (1) alleviating congestion, (2) providing individuals with the option of using a higher quality bus system, (3) increasing low-income mobility, and (4) economic development and growth. While the monetization of these benefits is beyond the scope of this project, it is possible they could make the net present value of either or both of the BRT alternatives positive even with national standing.

PARTIAL SENSITIVITY ANALYSIS

We used partial sensitivity analysis to construct best and worst case scenarios, varying each of the variables in our model within a range of possible values. Most did not have a significant impact on the net present value, resulting in changes of less than $10 million. However, several variables were important. Using the best and worst case scenario method, six variables resulted in changes to the net present value on the order of $50 million and two variables resulted in very large-scale changes, on the order of $100 million. The level of sensitivity of the model to these variables is set forth in the following table:

Table 10: Partial Sensitivity Analysis, Significant Variables (Millions, 2000 dollars)

		Best Case NPV		Worst Case NPV	
Significance	**Variable**	**BRT 2020**	**BRT Plus**	**BRT 2020**	**BRT Plus**
N/A	*Baseline*	*-$261*	*-$153*	*-$261*	*-$153*
Large	Percentage of Commuters Riding in BRT Corridor	-$244	-$136	-$267	-$174
Large	Length of Bus Trip for Commuting Riders Before BRT	-$212	-$90	-$309	-$215
Large	Length of Bus Trip for Commuting Riders After BRT	-$192	-$98	-$305	-$207
Large	Average Cost of Air Pollution Per Car Vehicle Mile	-$234	-$102	-$276	-$181
Large	Social Discount Rate (Using 2% and 10%)	-$175	-$143	-$297	-$165
Large	Operating and Maintenance Costs	-$224	-$117	-$297	-$188
Very Large	Total Car Vehicle Miles Driven Before/After BRT	-$185	-$49	-$240	-$119
Very Large	Total Variable User Cost Per Mile for Car Drivers	-$193	-$23	-$291	-$210

We also conducted detailed sensitivity analysis of the impact of including congestion benefits in our analysis. Sensitivity analysis of the BRT 2020 alternative at the national level reveled that a 40 second decrease in average travel time for 50 percent of commuting trips and an 18 second decrease in average travel time for 50 percent of non-commuting trips would be necessary for net present benefits to equal zero. Likewise, analysis of the BRT Plus alternative at the national level suggests that a 20 second decrease in average trip time for 50 percent of commuters and a 9 second decrease for 50 percent of non-commuters would be necessary to bring the present value of net benefits to zero.

The magnitude of these calculated congestion benefits are comparable to those found in other studies.[8] This is particularly true for the BRT Plus alternative, for which the calculated congestion benefits would approximate the benefits found in a Seattle monorail study (DJM Consulting *et al.*, 2002). Assuming national standing, the congestion benefits required for a zero net present value for BRT Plus are less than the congestion benefits that have been found in a transit study of Madison and Milwaukee bus systems (HLB, 2003) and a Winnipeg, Canada BRT proposal (HLB, 2002). See *Appendix M: Congestion Benefits* for more details.

We also analyzed the net present value of the BRT alternatives for sensitivity to additional bus riders. Under national standing, we calculated the number of additional bus riders required to cause the net present value to break even. Under the BRT Plus alternative, the system would need to generate 7,000 riders beyond the initial 12,000 in the year 2020. This would represent nearly a 60 percent increase.

MONTE CARLO SENSITIVITY ANALYSIS

Monte Carlo analyses were completed for the BRT 2020 and the BRT Plus alternatives at the national level using our base case parameters and a 3.5 percent social discount rate.[9] The

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[8] Evaluations of transit projects have been shown to consistently overestimate benefits. This may be true for transit studies that report high congestion reduction benefits. See, for example, Flyvberg *et al.* (2005), who found an average 106 percent overestimate of travel demand in a study of 210 projects from around the world. These findings bolster our confidence in our conclusion, shared with the Madison MPO, that congestion benefits would be minimal in a Madison-area BRT project.

[9] For local and state standing, the shape of the NPV distribution would be identical, but the lower fixed capital and operating costs would shift the distribution to the right.

results of these analyses are presented separately for each alternative. See *Appendix N: Details of Monte Carlo Analysis* for Monte Carlo analyses employing other discount rates.

BRT 2020 Alternative

Monte Carlo sensitivity analyses were conducted at the national level for both the BRT 2020 and BRT Plus alternatives. These analyses illustrate variation in the net present value (NPV) of the project if 22 key parameters are allowed to vary randomly over a plausible range. We chose to hold seven variables constant because we are confident in their point estimates. See *Appendix N: Details of Monte Carlo Analysis* for parameter means and standard deviations as well as a description of the variables that were held constant.

A Monte Carlo analysis of 10,000 trials for BRT 2020 returns an expected NPV of -$262 million, which is nearly identical to our estimate of the NPV. The standard deviation associated with this expected NPV is $54 million, meaning that approximately 95 percent of NPV estimates fall between -$370 million and -$154 million (see table 11). In view of the mean and standard deviation of this Monte Carlo analysis, it is unsurprising that none of the 10,000 trials returned a positive NPV. The following histogram illustrates that the 10,000 NPV estimates are distributed normally around the expected NPV of -$262 million:

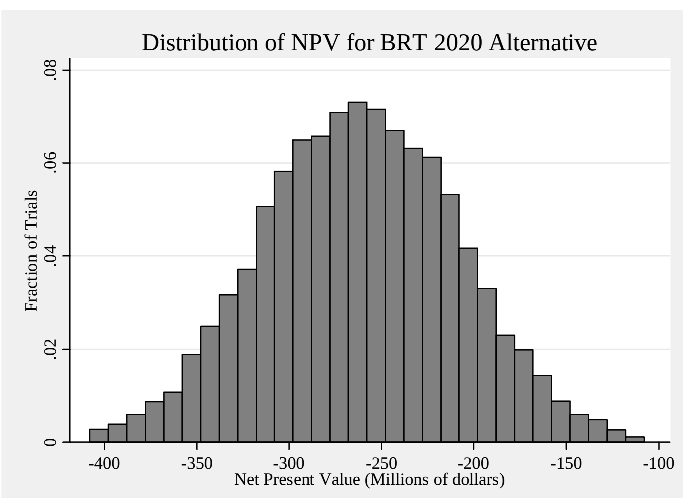

Table 11: BRT 2020 Summary Statistics, (Millions, 2000 dollars)	
Number of trials	10,000
Mean	-$261.8
Median	-$261.5
Standard deviation	$54.0
Minimum	-$472.3
Maximum	$-63.0
% of Positive NPV	0.00%

BRT Plus Alternative

The same 22 parameters were allowed to vary randomly according to their specified distribution in the Monte Carlo analysis for the BRT Plus alternative. However, the assigned ranges, means and standard deviations for some of the parameters differ between the two alternatives. See *Appendix N: Details of Monte Carlo Analysis* for parameter means and standard deviations.

For a Monte Carlo analysis of 10,000 trials, the expected NPV for the BRT Plus alternative is -$152 million, again within $1 million of our estimated NPV for this alternative. The standard deviation of this estimate is $60 million. The higher expected NPV and the slightly larger standard deviation resulted in approximately 0.75 percent of the Monte Carlo trials returning a positive NPV for BRT Plus. The histogram below illustrates that NPV estimates are distributed normally around the expected NPV of -$152 million. The accompanying table summarizes the histogram.

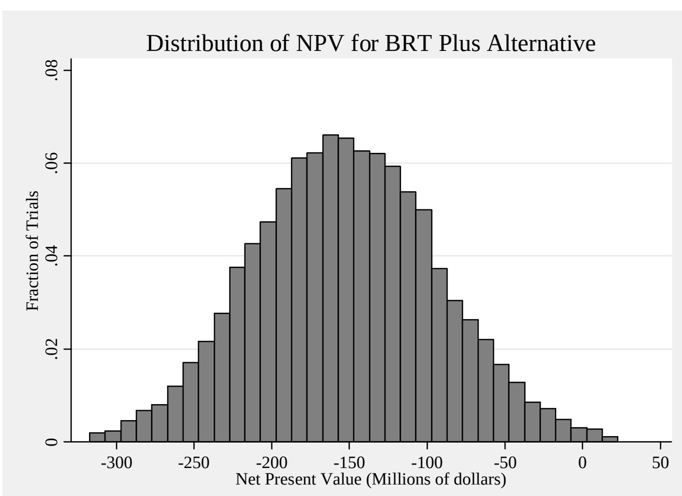

Table 12: BRT Plus Summary Statistics, (Millions, 2000 dollars)	
Number of trials	10,000
Mean	-$152.1
Median	-$152.3
Standard deviation	$60.5
Minimum	-$379.7
Maximum	$109.7
% of Positive NPV	0.72%

POLICY CONCLUSIONS

Analysis of the estimated benefits and costs included in this study demonstrates that implementation of a bus rapid transit system in the Madison metropolitan area would have a negative net present value when all residents of the U.S. are granted standing. However, the project would have large benefits for residents of the Madison area. Further analysis is necessary before the use of federal and state funding would be justified, as there is considerable uncertainty associated with most of our estimates. Further study may result in different conclusions.

We strongly recommend that research be continued on the parameters that were found to have large impacts on the net present value of the project. For example, varying the estimate of marginal cost per vehicle mile within the range found in the literature can cause a $200 million fluctuation in the NPV of the project. It would be prudent to perform a study that estimates a marginal cost per vehicle mile travel strictly for the Madison area.

As explained in *Appendix E: Vehicle User Cost Reduction*, gasoline prices were held constant in this analysis. Uncertainty in future oil supplies may result in fuel prices rising faster than the rate of inflation. At the same time, improving vehicle fuel efficiencies may dampen the overall effect of gas prices. If the net effect substantially increases or decreases marginal user costs over time, then this would drastically change our projected net benefits.

This analysis evaluates only a single transportation improvement alternative. As a result, the findings of this analysis cannot be used as a valid basis for comparison with any of the other transportation improvement alternatives examined by Transport 2020. In order to facilitate such comparisons, we recommend future evaluation of the other alternatives using a cost-benefit analysis framework.

In addition, the benefit categories that we excluded from this report because of theoretical and technical difficulties should be analyzed to determine their expected impacts for the Madison area. Valuable information could be gained from researching (1) whether future levels of congestion result in decreased vehicle travel times, (2) the value that citizens place on knowing they have the option to utilize an improved bus system, (3) benefits from increased access to jobs and medical services for low-income groups, and (4) economic development and growth benefits. Because these components are not included in our analysis, we recognize that the net present value of the project is likely underestimated.

Finally, cost-benefit analysis only looks at economic efficiency. Other important policy goals should be considered when evaluating any transit infrastructure investment, such as equity and sustainability.

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APPENDIX A: TECHNICAL DEFINITIONS

Bus Miles Traveled (BMT):

Refers to the total number of miles traveled by buses over a given time period.

Bus Rapid Transit (BRT):

A bus rapid transit or BRT system provides a higher level of service than traditional bus systems by incorporating design features that allow for faster travel times and increased rider conveniences.

BRT Corridor:

This refers to the main east-west component of the BRT including the guideway system.

Diamond Lanes:

Diamond lanes are roadway lanes reserved for buses. These are lanes typically painted with a diamond, hence their name.

Guideway:

A guideway is a fixed route that is completely separate from the roadway. In this analysis, the guideway can be thought of as a roadway build exclusively for bus travel.

Headway:

The distance in time between two buses operating the same bus route.

Minimal Operable Segment (MOS):

A term used by Transport 2020, and consistent with Federal Transportation Authority (FTA) *New Starts* funding program, that applications identify the minimum component of the project that could be funded and still perform according to expectations.

Real Time Information System:

In this analysis, real time information systems refer to bus tracking systems to be placed at bus stops for the purpose of displaying the time that the next bus will arrive.

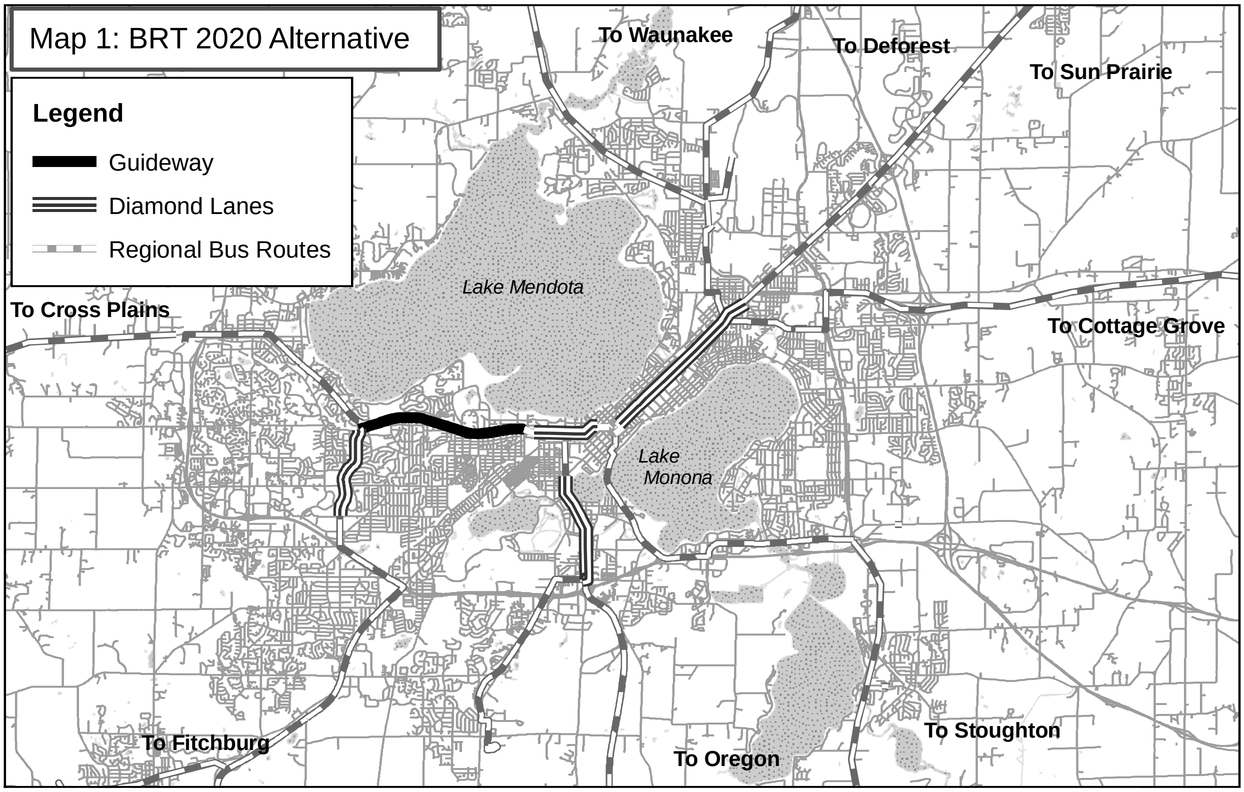
Vehicle Miles Traveled (VMT):

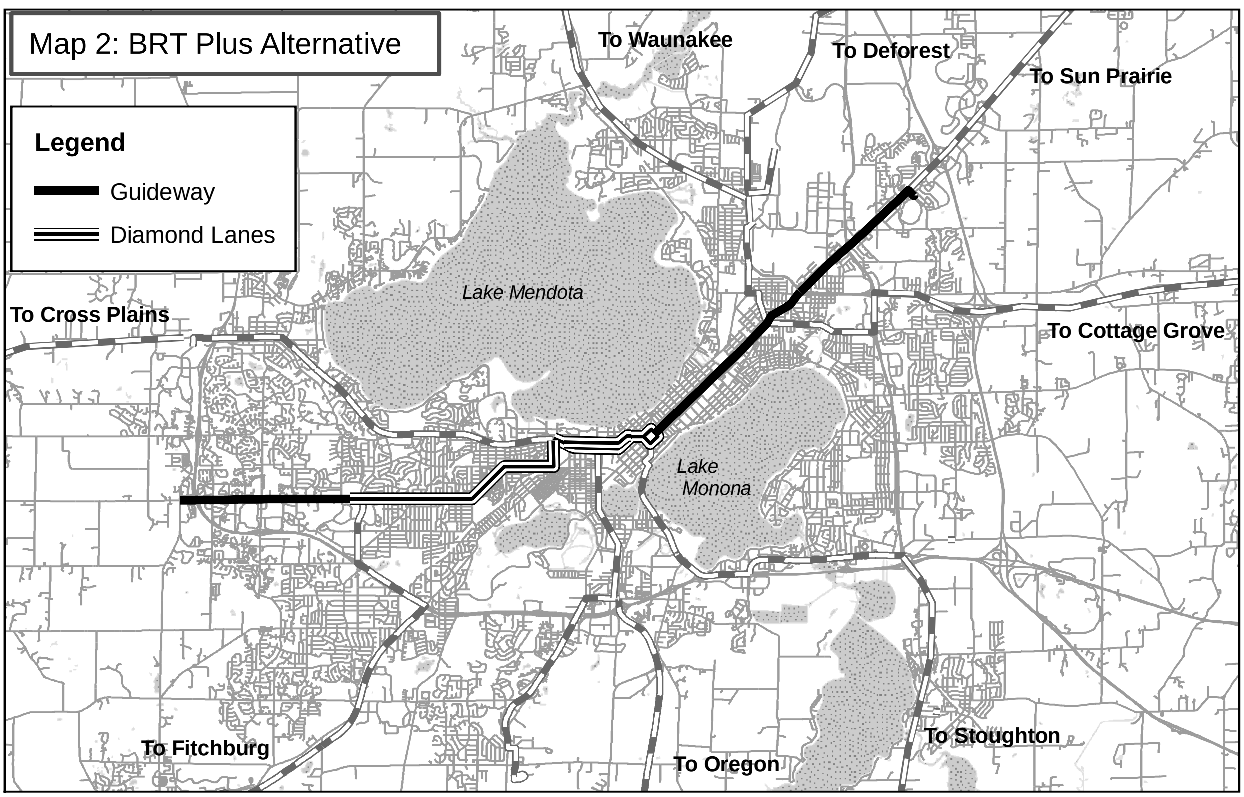
Refers to the total number of miles traveled by cars over a given time period.

Vehicle:

Vehicle refers to an average automobile

APPENDIX B: MAPS OF BRT 2020 AND BRT PLUS CORRIDOR





APPENDIX C: METHODOLOGY FOR ESTIMATING DAILY TRANSIT AND VEHICLE TRIPS, TRAVEL TIME AND TRAVEL DISTANCE

Estimating daily transit and vehicle trips, along with their expected length and travel time, is critical to determining the magnitude of benefits that arise from the BRT alternatives evaluated in this cost-benefit analysis. The purpose of this appendix is to detail the methodology used to estimate these parameters and document our estimates. In addition, we made many assumptions during this process that we discuss here.

The Transport 2020 project has been researching and evaluating proposed public transportation alternatives for the greater Madison metropolitan area for some years. The first phase of the study was called the "Transport 2020 Alternatives Analysis" and was completed in August 2002. The *Alternatives Analysis* (Transport 2020, 2002) is published on the project website and accompanying Technical Reports were provided to our project team by Transport 2020. Currently, the Transport 2020 project is undergoing a more detailed "Environmental Impact Assessment" and preparing an application to the *New Starts* program, a federal transportation funding program. As the Transport 2020 project has progressed, the project team has learned more about the alternatives being evaluated and incorporated these findings into subsequent work. This has affected our project in different manners. First, there exists relatively complete information for some components. For a second set of components, information was scarce or poorly documented, if available at all. For a third set of components, Transport 2020 is continuing their evaluation during the current phase of the project.

As part of the Transport 2020 *Alternatives Analysis,* the total daily car, bus, and train trips were estimated with a typical four-step travel demand model maintained by the Madison Area Metropolitan Planning Organization (MPO). Transport 2020 calculates daily trips on a representative weekday for the year 2020.

The travel demand model calculates the automobile flows and transit ridership for three separate purposes for the base and future years. "Home-based work," "home-based other," and "nonhome-based" trips are estimated by applying the traditional sequence of trip generation, trip distribution, and mode choice models. The projected roadway and transit network flows are then obtained by assigning the resulting vehicle and transit trips to their respective networks (Technical Report 2, 2002). For the Transport 2020 project, the mode choice module was updated using data from representative cities. The model was then tested against known Madison travel patterns in 1990. For more details on the methodology used by Transport 2020, see Technical Report 2 and 6 (2002).

Ideally, we would have had access to the travel demand model used by the MPO when performing this cost-benefit analysis. We would then be able to model the BRT alternatives more accurately and create summaries of the data in the formats that interest us: total daily trips by car and bus, total travel times by mode, and total travel distances by mode. As we do not have such access, we have used information gathered from Transport 2020 and supplemented it with information from the 1990 and 2000 Censuses, personal communication with staff from the MPO, and results from the 2001 National Household Travel Survey. As we are forced to make many assumptions, the accuracy of our estimates is unknown

Total Trips

Key Assumptions:

- The Madison travel demand model does a good job of estimating anticipated trips in the year 2020.[10]

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[10] A key component of the current phase of the Transport 2020 project is making improvements to this model.

- Where Transport 2020 does not provide trip estimates by mode and trip category, trips are distributed by mode and trip category in the same proportions as similar alternatives.
- We have assumed ridership on the BRT Plus alternative would be 50 percent less than the updated Transport 2020 estimates for the Minimal Operable Segment (MOS).

Estimates of automobile and transit trips were obtained directly from the Transport 2020 study for the BRT 2020 alternative (Phase 2). We present these estimates in Table C-1.

Table C-1: Total daily trips in 2020 by mode and trip category for the BRT 2020 alternative

Mode	Home Based Work Trips	Home Based Other Trips	Non-Home Based Trip	Total
Total vehicle trips	**320,351**	**607,430**	**314,768**	**1,242,549**
Drive Alone	271,951	275,912	152,569	700,432
Shared Drive	48,400	331,518	162,199	542,117
Total transit trips	**20,221**	**16,660**	**6,483**	**43,364**
Transit – Walk Access	14,396	16,660	6,483	37,539
Bus – P&R Access	5,825			5,825
			Total trips	**1,285,913**

Estimates for our baseline alternative[11] (called "No Build" in the Transport 2020 documentation) were obtained from a document provided by Transport 2020 (Transport 2020, n.d.) that summarized ridership projections not included in the *Alternatives Analysis.* Total transit ridership for the baseline alternative was distributed across the trip categories using the trip category ratios from the Transport 2020 Expanded Regional Bus alternative (see Table C-2)

[11] The Baseline used in this report is not the same as the "Baseline" being used in the current phase of the Transport 2020 project.

Table C-2: Total daily trips in 2020 by mode and trip category for the BRT 2020 alternative				
Mode	**Home Based Work Trips**	**Home Based Other Trips**	**Non-Home Based Trip**	**Total**
Total vehicle trips	**320,389**	**609,599**	**315,675**	**1,248,663**
Drive Alone	274,504	276,889	152,990	704,383
Shared Drive	48,885	332,710	162,685	544,280
Total transit trips	**17,183**	**14,491**	**5,576**	**37,350**
Transit – Walk Access	12,328	14,491	5,576	32,395
Bus – P&R Access	4,855			4,855
			Total trips	**1,286,013**

Estimates for the BRT Plus alternative were derived using updated estimates provided by Transport 2020 for the Minimal Operable Segment (MOS) of the locally preferred alternative (Technical Report 6, 2002). These updated estimates were the result of consultation between Transport 2020 and the Federal Transportation Authority (FTA) staff. The FTA suggested modifying some of the assumptions used in the transit demand model. These modified assumptions are based on accepted best-practices and include: shortened headway (transit frequency) times, the same fare across all transit modes, using the “Vision 2020” land use scenarios instead of adopted plans, increased parking fees in downtown Madison, and having parking fees in other areas of the city. The increased ridership modeled with these assumptions reflects an effort to maximize ridership while keeping costs down. The BRT Plus alternative we have proposed in this report is based on similar assumptions about improvements that would better serve the community. We would expect transit ridership to increase to reflect those changes. We have assumed that ridership would increase to approximately half as much (a conservative assumption) as the modelled MOS results. The number of car trips would decrease by a corresponding amount. See Table C-3 for our estimates.

Table C-3. Total daily trips in 2020 by mode and trip category for the BRT Plus Alternative				
Mode	**Home Based Work Trips**	**Home Based Other Trips**	**Non-Home Based Trip**	**Total**
Total vehicle trips	**317,723**	**605,264**	**313,926**	**1,236,913**
Drive Alone	269,720	274,928	152,161	696,809
Shared Drive	48,003	330,336	161,765	540,104
Total transit trips	**22,849**	**18,825**	**7,326**	**49,000**
Transit – Walk Access	16,267	18,825	7,326	42,418
Bus – P&R Access	6,582			6,582
			Total trips	**1,285,913**

For sensitivity analyses it can be reasonably assumed that the estimate of total transit ridership for the baseline and BRT 2020 alternatives may vary by as much as 10 percent. We are less confident in our BRT Plus estimate and therefore assume that the transit ridership estimate may vary by as much as 15 percent.

Over the last ten years, 1995-2005, transit ridership has grown by approximately 1.8 percent a year (MPO, 2006). Over that same time period, the Dane County population grew at an annual rate of about 1.5 percent. However, the growth in total trips modeled by the Transport 2020 is only projected to grow by about 0.8 percent year, which we have assumed to be the rate of annual trip growth. We have concluded that using a transit ridership growth rate of approximately 0.8 percent a year is appropriate, although there is some reason to suspect this growth rate may be a low estimate.

<u>Baseline Trip Times and Trip Distances</u>

Key Assumptions:

- The 1990 and 2000 commuting travel times collected by the Census represent a baseline for bus and car travel times in Dane County.
- Average car travel times will be about six minutes longer in 2020 than in 2000 based on past trends.

- Average bus travel times will be about eight minutes longer in 2020 than in 2000 based on past trends.
- Travel speeds in 2020 will average approximately 12 mph for buses operating during peak hours and 16 mph for non-peak hours.
- Travel speeds in 2020 will average approximately 30 mph for cars during peak time periods and 34 mph during non-peak periods.
- 2020 travel distances are a function of travel time and speed.

Despite its prominent role in the travel demand model, Transport 2020 did not have any information on average trip times by mode (Technical Report 2, 2006). Using 2000 Census data we estimated commuting times by bus to average approximately 31 minutes in 2000 and commuting times by car to average approximately 21 minutes in 2000. Using various methodologies – the ratio of 1990 to 2000 total trips, the ratio of 2000 to 2020 total trips and the ratio of 1990 to 2000 Census aggregate commuting times – we estimated that the average commuting car trip will take 26 minutes in 2020 and the average commuting bus trip will take 39 minutes. This is a crude estimating methodology and we do not have great confidence in these estimates.

Information provided by the MPO suggests that current vehicle speeds differ by approximately 4 mph for peak versus non-peak travel (Schaefer, 2006). Modeling estimates provided by the MPO suggest that average vehicle speeds are declining steadily due to increased road volumes and congestion. The MPO estimates that average vehicle speeds in 2000 were approximately 35 mph and by 2020 average speeds will have declined to approximately 32.4 mph. Dividing that figure into commuting and non-commuting speeds provides an estimate of 30 mph for peak vehicle speeds and 34 mph for non-peak vehicle speeds.

For bus vehicle speeds, we did not have access to such good data. Instead, we consulted the current Madison Metro bus schedules for peak travel periods and determined that peak bus travel speeds average approximately 14 mph. We assume that average bus travel speeds will decline at a similar rate as average vehicle speeds due to increasing road volumes and congestion. By 2020 we have estimated that average peak travel speeds will be approximately 12 mph, and non-peak bus speeds will be approximately 16 mph.

Clearly not all commuting trips occur during peak periods and not all non-commuting trips occur during non-peak periods, but we have had to make that assumption. Data included in the 2001 National Household Travel Survey (MPO, 2006) suggests that non-commuting trips are 2 miles shorter, or approximately 82 percent of the commuting distance. We use this information along with our assumption about the difference in travel speed by time of day to conclude that non-commuting car travel averages 18 minutes and non-commuting bus travel averages 29 minutes in the year 2020.

Over time, we would expect both vehicle and bus travel times to lengthen as people commute longer distances and roads become more congested. It is very difficult to estimate at what annual rate this might occur. Using our best estimate of what travel times are going to be in 2020, we expect that total travel times to increase approximately 1.15 percent a year between 2000 and 2020. We have applied that annual travel time growth rate to our travel time estimates. This travel time growth rate approximates expected population growth rates in Dane County.

Finally, average car and bus speeds are used to convert travel time into distance traveled. For car trips, we estimate an average distance of 13.0 miles for commuting and 10.7 miles for non-commuting in the year 2020. For bus travel, some component of the average bus trip is spent walking to the bus stop, waiting for the bus, transferring to another bus and walking to the final destination. We have assumed, based on our own personal experiences and consultation with the Madison Area MPO, that this walking, waiting, and transferring time may average approximately 15 minutes per rider. Based on assumed bus speeds and total trip time, we estimate that the average commuting trip on the bus will be 4.8 miles in 2020 and the average non-commuting bus trip somewhat shorter at 4.0 miles. For buses, however, there is more than one rider on a bus at a time. To estimate the total bus miles traveled (BMT) per day, we convert total bus trips into BMT using a rider per mile figure (2.0) that we obtained from a Metro audit (WDOT, 2004). We estimate that under the baseline, buses drive a total of 18,600 miles a day in the year 2020, which is equivalent to having approximately 9 passengers on the bus for each mile of bus travel over the whole system for the entire day. Table C-4 provides values that we used to estimate travel time and distance in the year 2020.

Table C-4. Variables use to calculate Baseline Trip Travel Times and Travel Distances in 2020

Variable	Commuting	Non-Commuting
Car Travel Time (minutes)	26	19
Sensitivity Range	24 – 29	16 – 23
Bus Travel Time (minutes)	39	30
Sensitivity Range	29 – 52	19 – 43
Bus Travel Time Walking/Waiting (minutes)	15	15
Sensitivity Range	10 – 20	10 – 20
Bus Travel Time On the Bus (minutes)	24	15
Sensitivity Range	19 – 32	9 – 23
Car Travel Distance (miles)	13	10.7
Sensitivity Range	11.7 – 14.3	9.6 – 11.8
Bus Travel Distance (miles)	4.8	4
Sensitivity Range	3.6 – 6.0	3.0 – 4.9
Total Travel Time Growth Rate	1.15%	1.15%
Sensitivity Range	1-3%	1-3%

BRT 2020 and BRT PLUS Travel Times and Trip Distances

Key Assumptions:

- Average travel distances by mode do not change between the BRT alternatives.

- Waiting times for bus riders will be slightly less for the BRT Plus alternative because of more predictable schedules and service frequency.
- Travel-time savings on the BRT 2020 and BRT Plus alternatives are functions of the number of riders traveling in the BRT guideway and diamond lanes on a daily basis and the difference in bus travel speeds between those lanes and congested traffic.

We have assumed that travel distances do not change under the BRT 2020 and BRT Plus alternatives. That is, people are likely to live in the same place and travel to the same locations as with the baseline bus system. This is not an entirely realistic assumption as we would expect that people might make different choices on where to live or where to travel based on available travel options. However, it is not clear that the bus rapid transit system would have much impact on land use patterns (U.S. GAO 2001), and we do not have any information with which to make any reasonable assumptions of what the result might be for average travel distances.

We expect that average walking and waiting times will decrease by 1 minute, or 7 percent, for users of the BRT 2020 system in the year 2020. This would occur because service levels on key routes would increase, but more importantly because the BRT guideway and diamond lanes would allow more predictability in bus travel times. We assume that average walking and waiting times would decrease by an additional minute, approximately 13 percent less than the baseline conditions, under the BRT Plus alternative as more mileage of BRT guideway and intelligent transportation systems would allow for even more predictable scheduling and dependable service.

Aggregate time saved by all bus riders using the BRT bus system was calculated by making estimates of the number of daily riders who would end up riding the bus within the BRT corridor. We estimated that average trip length on the BRT 2020 system would be 4 miles in the year 2020, with 30 percent of that travel occurring in the guideway and 70 percent in diamond lanes. Because of more total mileage of guideway and diamond lanes, we estimated that the average trip length within the main BRT corridor would be 6 miles for the BRT Plus in the year 2020. Approximately 60 percent of that travel would occur in the guideway and 40 percent in diamond lanes. Average travel speed in the guideway is estimated to be 28 mph (which remains constant over time) (Transport 2020, 2002). The corresponding travel speed for diamond lanes is 20 mph. Using current Metro bus schedules for the corridors served by the guideway and diamond lanes, we estimate the likely speed of congested bus travel. Finally, we estimate the number of daily trips that might occur within the busway and diamond lanes. The Madison Area MPO estimates that approximately 50 percent of current commuting transit trips are to the UW Campus (MPO, 2006). Based on that information, and how well the BRT system is designed to serve the downtown businesses and employment centers on the east-west corridor, we have estimated the percentage of peak and non-peak trips that are likely to occur on the BRT system (C-5).

Table C-5: Variables used to calculate Time Savings in the year 2020 due increased travel speed in the BRT Busway and Diamond Lanes (G&DL)

Variable	BRT 2020	BRT Plus
Average Walking, Waiting and Transferring Time (minutes)	14	13
Sensitivity Range	14 – 15	13 – 15
Total G&DL Travel Distance	4	6
Sensitivity Range	5 – 7	5 – 7
Busway to Diamond Lane Ratio	30 – 70	60 – 40
Percentage of Peak Trips in G&DL	35	45
Sensitivity Range	25 – 60	25 – 60
Percentage of Non-Peak Trips in G&DL	30	35
Sensitivity Range	20 – 50	20 – 50

Summary Parameters

Table C-6 presents some of the average summary parameters that were derived from the estimated and assumed variables presented in this appendix. These variables describe conditions in the year 2020. We assumed that vehicle miles traveled (VMT) would grow by approximately 1.5 percent a year. This figure is based on the current annual growth rate of miles travelled in Dane County according to the Wisconsin Department of Transportation (WDOT, 2006). This growth rate may prove to be artificially high if local officials are successful in implementing their vision for land use in the region. On the other hand, if current trends continue and people continue to commute longer distances, then this rate may be too conservative. As discussed earlier, travel time is assumed to grow by 1.15 percent a year for all car and bus travel in mixed vehicle lanes. Walking, waiting, and transferring times are held constant over time because these values are more dependent on scheduling accuracy, intelligent transportation systems, and bus travel in guideways and diamond lanes, which will not be subject to worsening congestion over time.

Table C-6. Daily system wide performance variables for the baseline and BRT Alternatives in the year 2020

Variable	Baseline	BRT 2020	BRT PLUS
Total Vehicle Miles Traveled (VMT)	14,122,000	14,049,000	13,982,000
Annul Vehicles Miles Growth Rate	1.50%	1.50%	1.50%
Total Bus Miles Traveled (BMT)	18,600	21,700	24,500
Total Vehicle Commuting Time (hours)	140,100	138,900	137,700
Total Vehicle Non-Commuting Time (hours)	291,700	290,700	289,800
Total Bus Commuting Time (hours)	11,200	12,200	12,700
Total Bus Non-Commuting Time (hours)	10,000	11,000	11,800

APPENDIX D: TRAVEL TIME COST REDUCTION

Time spent traveling is a cost and is important for the calculation of the benefits of travel time saved after the implementation of a BRT alternative. In order to measure these benefits, the value of time spent traveling needs to be monetized. The generally accepted methods for doing so set forth the value of time depending on a few factors including: (1) the different portions of a commute (i.e., in-vehicle time versus "excess time" of walking or waiting), and (2) whether the trip is for work or some other reason. These values are derived by multiplying the gross average hourly wage rate in the relevant region by a specific factor.

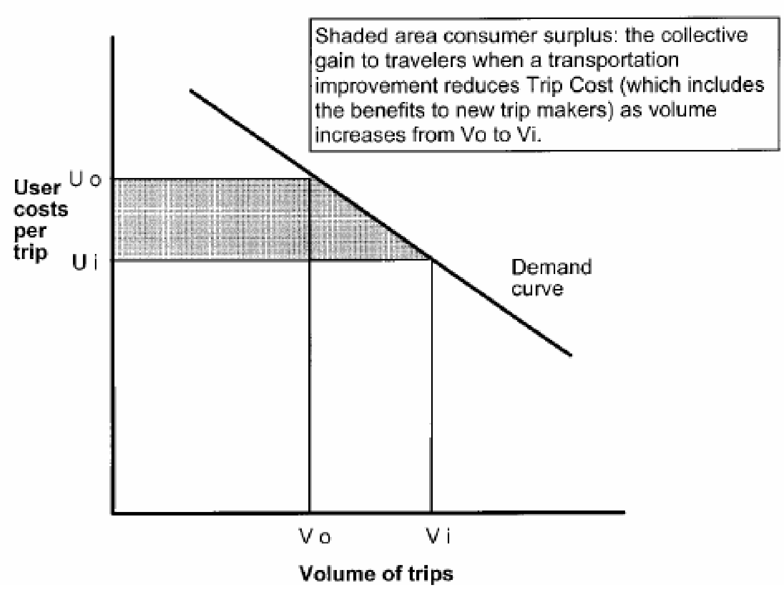
To calculate the gross average hourly wage rate for a Madison area worker, we used information from the U.S. Census Bureau to estimate median income for 2005. Averaging the data for one and two-income earner households, we deflated the income from 2005 to 2000 dollars using the Consumer Price Index. Finally, we determined the hourly rate by assuming a 40 hour workweek and 50 work weeks in the year. The resulting wage was $15.66 per hour. This value is commensurate with those provided in the transportation literature (ECONorthwest *et al.*, 2002; HLB, 2002).

Using the models suggested by transportation literature addressing cost benefit analyses (ECONorthwest *et al.*, 2002; HLB, 2002), we derived the following values by calculating the average gross hourly wage rate multiplied by the appropriate factor (percent of gross hourly wage). Table D-1 presents the resulting time values employed in our model:

Table D-1: Time Values of Travel Time (2000 $)			
Bus and BRT Users	**Percent of gross hourly wage**	**Per Hour**	**Per Minute**
In-vehicle non-work trip (local)	50	**$7.83**	$0.13
In-vehicle non-work (intercity)	70	**$10.96**	$0.18
In-vehicle work trip	100	**$15.66**	$0.26
Excess for work-trip (walking, waiting or transfer)	100	**$15.66**	$0.26
Excess for non-work-trip (walking, waiting or transfer)	1	**$15.66**	$0.26
Automobile users	**Percent of gross hourly wage**	**Per Hour**	**Per Minute**
In-vehicle non-work trip (local)	50	**$7.83**	$0.13
In-vehicle non-work (intercity)	70	**$10.96**	$0.18
In-vehicle work trip	100	**$15.66**	$0.26
Carpool driver	60	**$9.40**	$0.16
Carpool passenger	40	**$6.26**	$0.10
Excess for work-trip (walking, waiting or transfer)	100	**$15.66**	$0.26
Excess for non-work-trip (walking, waiting or transfer)	100	**$15.66**	$0.26

We employed the "Basic Benefit Calculation" method to measure the change in consumer surplus created by the reduction in travel time for bus riders (ECONorthwest *et al.*, 2002). The gain in consumer surplus equals the change in user costs (here, reduced by the reduction in travel time) multiplied by the average of the volume of transit rides (baseline volume plus volume after BRT alternative is implemented).

Figure D-1: User Benefits from Transportation Improvements (taken from ECONorthwest et al., 2002)



APPENDIX E: VEHICLE USER COST REDUCTION

Vehicle miles traveled (VMT) are expected to decrease with improvements in the bus system. We assume that the total amount spent by drivers on marginal vehicle costs decreases with the decline in VMT. Marginal costs in this analysis include fuel, oil, tire deterioration, vehicle depreciation, and maintenance. Due to uncertainty in the future price of oil and gasoline, this analysis holds real prices constant. Holding the real prices of oil and gasoline constant understates the benefits in savings from decreased VMT and should be considered in evaluating the results of this analysis. The studies analyzed in the formation of our parameter estimates are discussed below.

The Victoria Transport Policy Institute (VTPI) estimates marginal vehicle user costs and presents estimates from numerous other studies (Litman, 2002). VTPI cost projections are based on *average automobiles*, formulated by taking the weighted average of the marginal cost of operating cars, sport utility vehicles, light trucks, and vans. Averages are weighted by the prevalence of each type of vehicle throughout the United States. VTPI suggests that the minimum cost of gas, oil, and tire deterioration per vehicle mile is $0.10 and the maximum cost is $0.15 (Litman, 2002). VTPI’s variable cost estimate does not include depreciation and maintenance. It is, therefore, lower than the total cost that we are attempting to capture. VTPI does not offer these costs separate from the fixed costs that are not relevant to our analysis.

The Wisconsin Department of Transportation website uses the American Automotive Association’s (AAA) data for vehicle costs. Depreciation and maintenance are the only costs provided per vehicle mile. AAA suggests a cost of $0.05 per mile for maintenance and $0.23 for depreciation (WisDOT, 2006). VTPI suggests that the depreciation rate proposed by AAA is too high because estimates are based only on cars that are six years old or newer. VTPI offers estimates made by Edmunds and Kelly's Blue Book (vehicle pricing guides). Both companies suggest a lower depreciation rate of \$0.05 to \$0.15 cents per VMT (Litman, 2002).

ECONorthwest and Parsons Brinckerhoff Quade & Douglas, Inc. (EPBDQ) published a 2002 report through the Transportation Research Board, which allows us to verify the findings of VTPI and gather data on depreciation and maintenance costs. For a mid-size car, EPBQD estimate fuel, oil, and tire costs per VMT to be \$0.08 and depreciation to be \$0.14 per VMT. Maintenance is estimated to be \$0.04 per VMT. Total marginal vehicle cost is therefore estimated at \$0.26 for a mid-size car.

Findings from the California Department of Transportation (2006) are similar to those found by VTPI and EPBQD. The California DOT estimates the cost of oil, tires, maintenance and repairs, and depreciation to be \$0.165 per mile and the cost of gas at 35 miles per hour to be 0.037 multiplied by the price of fuel. For October of 2006, the Consumer Price Index repots that the average price of fuel was \$2.396 per gallon. The total variable cost per VMT is therefore equal to:

$$\$0.165 + 0.037 \, X \, \$2.396 = \$0.253$$

We are confident with this estimate because it is similar to the findings of VTPI and EPBQD and because this estimate includes recent fuel prices. For these reasons, a variable cost of \$0.25 will be the value of marginal costs per vehicle mile traveled used in our preferred model. The following equation is used to calculate marginal vehicle costs:

$$\textit{Marginal Vehicle Cost} = \textit{Annual VMT} * \textit{Marginal cost of VMT}$$

We are interested in the decreased marginal vehicle costs of the BRT alternatives relative to the baseline alternative. The cost savings for the BRT 2020 alternative relative to the baseline alternative is calculated by multiplying the difference in annual VMT by \$0.25. The change in cost for BRT Plus relative to the baseline is calculated in the same manner. These benefits are included in the calculation of the net present value of each alternative.

APPENDIX F: REDUCED VEHICLE AIR POLLUTION COSTS

Fuel combustion in vehicle engines creates air emissions that have social costs. This analysis estimates the social costs as including damages caused by vehicle emissions related to human health, environmental damage, and restrictions created on outdoor activities. Vehicle emissions vary depending on vehicle make and model. Due to the complexities of gathering information on vehicle emissions in Dane County, we use average emissions costs per VMT based on the literature discussed below.

The Federal Highway Administration website does not offer emission costs per VMT, but the site directs researchers to the Victoria Transport Policy Institute (VTPI) for information on costs and benefits of transportation related projects (FHWA, 2006). VTPI quantifies the damages caused by vehicle emissions related to human health, environmental damage, and restrictions created on outdoor activities (Litman, 2002). All cost estimates presented are in U.S. dollars. VTPI suggests that for an average car, air pollution costs are $0.04 per vehicle mile. Given variance in the environmental sensitivity of locations, air pollution costs may range from $0.01 to $0.20 per vehicle mile traveled (Litman, 2002). Because Madison is on the verge of becoming an air quality non-attainment zone for ground level ozone we suggest that a value higher than the average of $0.04 be used in our preferred model (Madison Department of Public Health, 2006). We use $0.08 as our preferred estimate. Values between $0.04 and $0.15 are considered plausible. We believe it is inappropriate to use a value higher than $0.15 because Dane County does not have a smog problem.

Other studies have also been analyzed to strengthen our confidence in the parameter estimates. The California Department of Transportation does not offer values for vehicle emissions in terms of VMT. They do provide data on cost per ton of pollutant that is similar to the values used by VTPI (California DOT, 2006).

The decreased cost of air pollution is a benefit derived from having a bus system that attracts more riders and therefore decreases the vehicle miles traveled each day. The following equation is used to calculate changes in air pollution costs for each year:

*Reduction in Vehicle Air Pollution Cost = Change in Annual VMT * Air Pollution Cost per VMT*

Change in annual VMT in the above equation refers to the difference between each BRT alternative and the baseline alternative. The reduction in vehicle air pollution costs is a benefit for both the BRT 2020 and the BRT Plus alternative and is included in the calculation of net benefits for each alternative.

Appendix G: Increased Air Pollution Costs from Increased Bus Travel

Similar to automobiles, fuel combustion in bus engines also creates air emissions that have social costs. This analysis estimates the social costs as including damages caused by vehicle emissions related to human health, environmental damage, and restrictions created on outdoor activities. Air pollution costs are estimated for standard diesel buses by the Victoria Transport Policy Institute to be $0.2 per BMT in urban peak traffic conditions. Cost per BMT in urban off-peak is suggested to be $0.18, and cost per BMT in rural areas is estimated to be $0.08. VTPI suggests an average cost of $0.14 per BMT (Litman, 2002).

Costs of $0.08 and $0.2 refer to extremes that we do not believe are appropriate for Madison because it is a small city. We have therefore decreased the range of parameter values to be $0.11 to $0.19 per BMT. We use $0.16 in our preferred model. This is slightly above the mean of our range due to the decreasing air quality in Dane County (Madison Department of Public Health, 2006).

As with air pollution costs for automobiles, the California Department of Transportation does not offer values for bus emissions in terms of BMT. They do provide data on cost per ton of pollutant that is similar to those used by VTPI (California DOT, 2006).

The BRT Plus alternative would utilize buses that would decrease air pollution by approximately 20 percent. Pollution costs for these buses have therefore been decreased by 20 percent, resulting in our estimate of $0.13 cost per BMT with a range of $0.09 to $0.15 cost per BMT.

The following equation is used to calculate changes in air pollution costs for each year:

*Total Air Pollution Cost = Additional Annual BMT * Cost of Air Pollution per BMT*

Pollution costs for BRT 2020 are calculated by multiplying annual BMT by $0.16 because all bus miles are traveled with traditional diesel buses. Calculating pollution costs for

BRT Plus is a two-step process. Only 66 of the buses in this alternative are advanced BRT buses. Bus miles that would be traveled with traditional diesel buses are multiplied by $0.16, and miles that would be traveled with advanced BRT buses are multiplied by $0.13. The addition of these two components provides a measure of the total bus air pollution cost for the BRT plus alternative.

We are interested in the marginal change in cost of the BRT 2020 and BRT Plus alternatives relative to the baseline alternative. The bus air pollution costs from the BRT alternatives are therefore compared to the baseline alternative. The air pollution costs of the BRT alternatives in excess of the baseline alternative are included as a cost in this analysis.

APPENDIX H: ACCIDENT COST REDUCTIONS

Accidents place significant costs on society. The average annual number of accidents is positively related to VMT. Accordingly, the social cost of accidents decreases when fewer vehicle miles are traveled. Accident costs from buses are very low and, for simplicity, they are assumed to be zero. We use the methodology explained below to capture the benefit of reduced vehicle accident costs from the implementation of the BRT alternatives.

All accident cost information was gathered from the Wisconsin Department of Transportation (WisDOT). WisDOT produces a report every five years with an estimated annual cost of accidents (WisDOT, 2006). The estimate includes the cost of deaths, injury, and property damage. WisDOT relies on the National Safety Council for quantifying accident costs (May, 2006). See Table H-1 for values used to calculate accident costs.

Table H-1: Accident Costs

Incident	Cost per incident (2000 $)
Death	$1,026,323
Incapacitating injury	$53,168
Non-incapacitating evident injury	$17,194
Possible injury	$9,700
Property Damage	$6,700

We use the following formulas to capture the decrease in accident costs as VMT decreases.

Table H-2: Calculating Average Accident Cost per VMT

Cost Category	Equation
Accident Rate Per VMT	Average Annual Accidents in Dane County *divided by* Vehicle Miles Traveled in Dane County
Average Cost Per Accident	Average Annual Cost for Accidents in Dane County *divided by* Average Annual Number of Accidents
Average Accident Cost Per VMT	Accident Rate Per VMT *multiplied by* Average Cost Per Accident

The average number of annual accidents in Dane County was gathered from the years 2000 through 2005. The average is used to prevent an unusual event from altering the results. The

VMT in Dane county was taken from 2005. The accident growth rate is assumed to be constant, meaning average annual accidents are expected to grow at the same rate as VMT.

Due to limited data, two different ranges of years were used to calculate the average cost per accident. The annual average of total accidents was taken from the years 2000 through 2004. The average annual economic cost of accidents, however, comes from the years 1997 through 2001. All values have been converted to 2000 dollars.

The following equation is used to calculate annual accident costs:

*Annual Accident Cost = Annual VMT * Accident Cost per VMT*

The accident costs of the BRT 2020 and BRT Plus alternative are compared to the baseline alternative. The decreased accident costs relative to the baseline alternative provide us with the cost savings measure that is incorporated into our cost-benefit analysis.

The Victoria Transport Policy Institute suggests that accident costs range between $0.05 and $0.15 per VMT (Litman, 2002). We incorporate this estimate into our range of estimates for conducting sensitivity analysis. We are confident in our estimate of $0.03 per VMT because recent local data was used in calculating the cost estimate. We believe that lower accident costs per VMT are due to specific characteristics of the transportation system in Madison. The formula used by VTPI to calculate their range is unavailable, and no other literature was found offering accident costs in the units of interest.

APPENDIX I: ADDITIONAL POTENTIAL BENEFITS

Potential benefits from implementing a bus rapid transit system are discussed below. Reasons for consideration of each benefit as well as reasoning for its exclusion are provided.

Congestion Benefits

Congestion benefits are typically included in transit-oriented cost-benefit analyses (ECONorthwest *et al.*, 2002; HLB, 2002). However, we believe that the impact of the BRT system on the travel time for automobile commuters in the Madison area would be minimal. The validity of our assumption of minimal congestion benefits was confirmed by the transportation planning officials at the MPO (Schaefer, 2006) who found that there would be at most a 100 car reduction per peak period for any given road segment. Each of these road segments have 5,000 to 10,000 cars traveling along them during the same period. The reduction in the number of cars represents a fraction of the total and is likely to have minimal impact on congestion. In addition, the BRT alternatives may actually increase congestion because the guideway and diamond lanes remove roadway lanes that would otherwise be available to automobile traffic. Congestion benefits are more likely to occur when transit improvements result in large increases in transit ridership along a narrow corridor, rather than diffusely over a large transit system. See *Appendix M: Congestion Benefits* for a further discussion of this issue.

Option Value

Many people in Madison use the bus system infrequently, if at all, but nevertheless place some value on having the bus available as a travel option. Such preferences are known as option values. Methods exist for estimating these option values, including contingent valuation studies (Carson, 2000), and techniques similar to those used to calculate financial options (ECONorthwest *et al.*, 2002). We believe, however, that both techniques are beyond the scope of our analysis. In addition, the fact that the BRT system represents only an incremental improvement in the bus system would make it difficult to determine an individual's option value for transit system *improvements* rather than the option of simply having a bus to take, which exists already in most places. For places where bus service currently does not exist, mostly in cities served by the new regional express routes, we are unable to estimate the value that people would place on having the option to ride the bus.

Low Income Mobility Benefits

We also do not attempt to measure benefits attributable to improvements in low-income mobility, although such benefits are sometimes measured in transit cost-benefit analyses (HLB, 2002; HLB, 2003). When included in a transit CBA, these benefits are measured in a two-stage process. In the first stage, the gain in consumer surplus experienced by low-income people due to the availability of a less expensive transportation option, such as a bus instead of taxi, is calculated. In the second stage, savings to society attributable to the reduced need for social services, such as welfare or home-based healthcare, are calculated. These savings accrue because, as a result of the transit improvements, low-income people experience a wider range of employment opportunities, resulting in welfare cost savings, and can afford to travel to the hospital or doctor, resulting in home-based healthcare cost savings. However, attempting to measure these benefits often results in double counting because these benefits are already measured by lower transit-travel costs and increased transit ridership (Banister and Berechman, 2003; ECONorthwest *et al*, 2002). Moreover, the BRT expansion in Madison would not increase the *availability* of transit, but instead would increase the *speed* of travel along the main commuting corridors. In areas where there would be completely new bus service, mostly in the cities surrounding Madison, we do not have good data on how many people are being served and how many of these people are low income residents. For these reasons we do not measure low-income mobility benefits in our analysis.

Economic Development and Growth

Lastly, we do not measure increases in economic development that may be attributable to the existence of transit stations or economic growth from enhanced mobility (Banister and Berechman, 2003; HLB, 2002; Litman, 2002; Cambridge Systematics, 1998). Some argue that increases in economic activity and property values around transit stations are not simply the result of the capitalization of travel savings. Rather, the argument goes, they represent "agglomeration economies" (also called "clustering" or "proximity economies") that allow exploitation of economies of scale, reduced labor costs, and better communication and innovation. While strong evidence suggests that such agglomeration economies exist for some transit modes, such as train and other fixed-route transit systems (Banister and Berechman, 2003; ECONorthwest *et al.*, 2002), the evidence is mixed as to whether there are *any* increases in development near BRT stations (U.S. GAO, 2001; 35). Because of the risk of double-counting, the challenge of separating agglomeration economic effects from travel savings effects, and mixed evidence on the impacts of BRT stations, we do not include transit station-induced economic development benefits in this study.

Susan DeVos of the Madison Area Bus Advocates brought economic growth from enhanced mobility to our attention. If access to jobs is more convenient, then individuals may be more willing to travel to work part-time. Stores may be able to stay open later due to an increase in labor supply. The housing and apartment markets in Madison may see long term benefits if the bus system were improved because people may make decisions on where to live based on mobility options, especially elderly individuals making retirement decisions. We find this category of benefits intuitively appealing, but do not have access to data that would allow us to quantify these benefits.

APPENDIX J: CAPITAL COSTS

Key Assumptions:

- Capital cost of BRT guideway: $8.8 million per mile
- Capital cost of non-guideway road: $584,000 per mile
- The two alternatives, BRT 2020 and BRT Plus, have the same amount of regional bus network mileage
- One BRT station per mile of BRT route
- Each of the 66 BRT buses purchased cost $200,000 more than traditional diesel buses

The estimated capital cost for expanded regional bus service, which serves as the baseline for this cost-benefit analysis, is $20.0 million. Transport 2020 estimated the capital costs for the BRT 2020 alternative to be $84.5 million. Based on these estimates, the added capital cost for the BRT 2020 alternative is calculated at $64.5 million.

The BRT 2020 alternative proposes 3.0 miles of guideway at a cost of $26.4 million, or $8.8 million per mile (Technical Report 3, 2002). We confirmed the plausibility of this figure by comparing it to per mile capital costs of similar BRT systems currently in operation (U.S. GAO 2001). The BRT 2020 also proposes 7.4 miles of BRT mileage that runs in either street traffic or diamond lanes, and 92.1 miles of regional bus routes that would run in traffic.

Subtracting the $26.4 million cost of the guided busway from the $84.5 million total leaves a cost of $58.1 million spread over 99.5 miles of roads that would not require guideways. The average capital cost for non-guideway roads is about $584,000 per mile. We assume this to be the per mile capital cost for all non-guideway roads in our alternatives. This estimate closely mirrors the actual capital costs for similar BRT systems currently in operation (U.S. GAO 2001).

The BRT Plus alternative has 8.2 miles of guideway. Using the per mile construction figure of $8.8 million, the overall cost of constructing this guideway would be $72.2 million. This figure, however, is only the cost of construction and does not include any of the other features of a prototypical BRT system.

The BRT Plus alternative also proposes an additional 98.4 miles of route—the 92.1 miles of the regional bus network and 6.3 miles of BRT route that does not require a guideway. To get the total capital cost of these routes, we multiplied the 98.4 miles by $584,000. This returned a cost of $57.5 million. Adding this $57.5 million to the $72.2 million provides a capital cost of $129.7 million. Again, this number does not include the cost of prototypical BRT features such as advanced stations, better vehicles, fare collection systems, intelligent transportation plans, and service and operating plans.

To account for this, we applied a BRT Plus premium to each of the 14.5 miles of our BRT route. Using documents published by the Federal Transit Authority (2004) and a transportation trade association (Weststart and CALSTART, 2006), we came up with the following estimates:

- An average of one station per mile at a cost of $200,000 per station;
- Spending $450,000 instead of $250,000 for each of 66 BRT vehicles. This averages out to $850,000 per mile of the BRT route.
- A pair of fare collection machines per station at a cost of $125,000 per pair. So $125,000 per mile.
- Intelligent transportation systems at each station and on each vehicle at a cost of $250,000 per mile. This also includes the cost of the service and operating plans (system maps, etc.)

These features sum to a BRT Plus premium of $1.425 million per mile. Multiplying this $1.425 million by the 14.5 miles of BRT Plus route gives us $20.7 million. Adding this premium cost to the $129.6 million discussed above gives us a total capital cost of $150.3 million, or about $10.4 million per mile. According to a report on bus rapid transit published by the U.S. GAO (2001), and other sources, this number conforms nicely with capital cost estimates from other BRT projects. To arrive at the excess capital costs of BRT Plus, compared to the baseline, we subtracted $20.0 million from $150.3 million, which leaves us with an excess capital cost of $130.3 million.

APPENDIX K: OPERATIONS AND MAINTENANCE COSTS

Key Assumptions:

- Labor, maintenance, and supply costs are identical for BRT 2020 and BRT Plus.
- BRT Plus buses have 20 percent greater fuel efficiency than BRT 2020 buses

Transport 2020 estimates annual operations and maintenance costs for the baseline alternative to be $31.7 million, a number consistent with the current operations budget at Madison Metro (Technical Report 3, 2002). For the BRT 2020 alternative, the estimated annual operations and maintenance costs are $51.2 million, meaning that there is an additional $19.5 million annually in operation and maintenance costs for BRT 2020 when compared to the baseline alternative.

We used the estimated annual operations and maintenance budget for BRT 2020 as the basis for the estimate of annual operations and maintenance costs for the BRT Plus alternative. As stated above, we assume the vast majority of operations and maintenance costs to be identical across the two alternatives. Specifically, we assume labor costs to be equal, maintenance costs for the new buses to be comparable, and the number of miles driven to be similar under each alternative. The one difference that would likely arise is in the area of fuel costs. A new, diesel-fueled Madison Metro bus, which would be used under the BRT 2020 alternative, averages 3.3 to 3.5 miles per gallon. The buses that would be used under the BRT Plus alternative average approximately 4.2 miles per gallon, or 20 percent more. As a result, we adjust the annual operations and maintenance budget for BRT Plus to account for this difference.

An empirical basis for this adjustment was found in the Madison Metro operations budget. Through examination of the budget and a conversation with a budget analyst, we ascertained that Madison Metro spends approximately 7 percent of its operations and maintenance budget on bus fuel. Using this point estimate of 7 percent, we calculate that approximately $3.6 million of the $51.2 million operating budget for BRT 2020 would be spent on fuel. To find the fuel savings that would be associated with BRT Plus buses, we multiplied the $3.6 million that would be spent on fuel by 20 percent. This calculation reveals that $700,000 would be saved annually due to the operation of buses with greater fuel efficiency. Therefore, instead of an annual operations and maintenance budget of $51.2 million, BRT Plus is estimated to have an annual budget of $50.5 million, which is $18.8 million above the estimate for the baseline.

APPENDIX L: REVENUE SOURCES

Capital Costs

The capital costs of a local transit system, including the baseline and the two alternatives, are paid for by all three levels of government: federal, state, and local. The following assumptions are based primarily on those adopted by Transport 2020 and the Wisconsin Legislative Council. The federal funds are made available under two Federal Transit Administration programs, the “Section 5309 New Starts program” and the “Section 5307 formula program” (Technical Report 8, 2002; Salm, 2006).[12] Together, these programs would cover 50 percent of the capital costs of any of the systems analyzed – the baseline, BRT 2020 and BRT Plus (Technical Report 8, 2002; Salm, 2006). The Wisconsin state government would provide 25 percent of the capital costs pursuant to two transit assistance programs (Technical Report 8, 2002). Section 85.20 addresses operating expenses while section 85.21 addresses capital and operating expenses, among others (Technical Report 8, 2002). The remaining 25 percent of the capital costs must be covered by the city government(s) of Madison and, possibly, the other municipalities served by the BRT system (Technical Report 8, 2002). In summary, the capital costs are financed in the following manner:

Table L-1: Capital Cost Funding Sources

Level of Government	Percentage
Federal	50
State	25
Local	25

[12] Because of the multiple citations to documents produced by Transport 2020, we refer to them using the (possibly abbreviated) title of the document (e.g., “Technical Report 8”) rather than the author’s name (“Transport 2020”).

Operations and Maintenance Costs

The local share of the operations and maintenance (O&M) costs for the bus system are likewise small compared to that shouldered by the state and federal government. Sources provided consistent proportions for these relative shares, which are as follows (Parry, 2002; Technical Report 8, 2002; Salm, 2006):

Table L-2: O&M Cost Funding Sources

Level of Government	Percentage
Federal	43
State	37
Local	21

APPENDIX M: CONGESTION BENEFITS

Congestion benefits are a benefit category included in many transportation cost-benefit analyses (ECONorthwest *et al*., 2003). However, as discussed in *Appendix I: Additional Potential Benefits*, the validity of using congestion benefits in this CBA study is questionable. Nevertheless, we calculated congestion benefits to ascertain the magnitude of congestion benefits necessary for the BRT project to break even. Congestion benefits were calculated using a widely accepted model (see *Appendix D: Travel Time Cost Reduction*). The gain in consumer surplus equals the change in user costs (here, reduced by the reduction in travel time) multiplied by the average of the volume of automobile rides (baseline volume minus volume after BRT alternative is implemented).

Because our model uses three different categories of automobile trips – commuting trips, non-home based trips and home-based non-commuting trips – we calculated the consumer surplus separately for each of these categories. The congestion benefits are considerable. We calculated that the following improvements in automobile transportation times would be required in order to break even:

- For BRT 2020, a 40 second average trip time improvement for 50 percent of the commuters and a 20 second average trip time improvement for 50 percent of the non-commuters.
- For BRT Plus, a 20 second average trip time improvement for 50 percent of the commuters and a 12 second average trip time improvement for 50 percent of the non-commuters.

Interestingly, the magnitude of these calculated congestion benefits are comparable to those found in other studies. For example, for the BRT Plus alternative we estimate a benefit from reduction in congestion to be $5.5 million in the year 2020. A study evaluating a proposed monorail project in Seattle used a marginal congestion price of $0.15 per vehicle mile, which is based on analysis of optimal roadway toll rates (DJM Consulting *et al.*, 2002). Using this rate and our estimate of approximately 139,000 fewer vehicle miles traveled on a daily basis in 2020 yields an annual benefit of $5.8 million.

Other cost-benefit analyses we have consulted do not publish their assumptions on congestion reduction numbers, but simply report the total dollar value of congestion benefits. For example, a study evaluating transit in Madison and Milwaukee estimated that congestion benefits were approximately equal to vehicle cost savings benefits (HLB, 2003), while a study of a BRT project in Winnipeg, Canada estimated that congestion benefits would be over three times as large as vehicle cost savings (HLB, 2002). For the BRT Plus alternative we have estimated the vehicle cost savings to be approximately $9.7 million in 2020. Our estimate of $5.5 million for congestion benefits is thus conservative compared to these two studies.

However, simply comparing the results of our study to other published literature may not be the best evaluation of the plausibility of our results. Evaluations of transit projects are documented to consistently overestimate benefits, which may be the case in the studies we have consulted. For example, Flyvberg *et al*. (2005) found an average 106 percent overestimate of travel demand in a study of 210 transportation infrastructure projects around the world.

APPENDIX N: DETAILS OF MONTE CARLO ANALYSIS

As noted in the body of this report, parameters were allowed to vary over either a uniform distribution or a normal distribution. When a parameter is allowed to vary over a uniform distribution there is an equal probability that a trial will take on any value within the range. Assigning a normal distribution to a randomly varying parameter implies that a trial has a higher probability of being assigned the mean than any other value. The probability of being assigned a specific value decreases the further that specific value is from the mean. Within a normal distribution, about 95 percent of trials will be assigned a value within plus or minus two standard deviations from the mean. Our decisions regarding the assignment of distributions to parameters were informed by both the existing literature and our confidence in the point estimates. The following tables detail the parameter estimates used in our analysis.

Table N-1: Parameters varied uniformly in Monte Carlo analysis of BRT 2020 Alternative

Variable	Minimum	Maximum
Annual growth rate of vehicle miles traveled (VMT)	1%	2%
Emissions cost per VMT	$0.07	$0.09
Accident cost per VMT	$0.02	$0.04
Emissions cost per bus mile traveled (BMT)	$0.14	$0.18
Transit ridership growth rate	0.30%	1.30%
Annual growth rate of trip length	0.65%	1.65%
Value of time, commuting	0.23	0.29
Value of time, noncommuting	0.11	0.17

Table N-2: Parameters varied normally in Monte Carlo analysis of BRT 2020 Alternative		
Variable	**Mean**	**Standard deviation**
VMT after BRT 2020 implementation	14,049,142	21,074
User cost per VMT	$0.25	$0.01
BMT after BRT 2020 implementation	21,682	1,084
Transit ridership—commuting	17,183	859
Percent of commuters riding in BRT corridor	35	5
Commute trip length prior to BRT 2020 (round trip)	39	2.925
Commute trip length after BRT 2020 (round trip)	36.204	2.175
Transit ridership—noncommuting	20,067	1,505
Percent of noncommuters riding in BRT corridor	30	5
Noncommuter trip length prior to BRT 2020 (round trip)	14.841	1.113
Noncommuter trip length after BRT 2020 (round trip)	14.46	1.085
Walking and waiting time prior to BRT2020	15 minutes	1 minute
Walking and waiting time after BRT2020	14 minutes	1 minute
METB of fares collected	$1,529	$77

Table N-3: Parameters varied uniformly in Monte Carlo analysis of BRT Plus Alternative		
Variable	**Minimum**	**Maximum**
Annual growth rate of vehicle miles traveled (VMT)	1%	2%
Emissions cost per VMT	$0.07	$0.09
Accident cost per VMT	$0.02	$0.04
Emissions cost per bus mile traveled (BMT)	$0.11	$0.15
Transit ridership growth rate	0.30%	1.30%
Annual growth rate of trip length	0.65%	1.65%
Value of time, commuting	0.23	0.29
Value of time, noncommuting	0.11	0.17

Table N-4: Parameters varied normally in Monte Carlo analysis of BRT Plus Alternative		
Variable	**Mean**	**Standard deviation**
VMT after BRT 2020 implementation	13,982,736	20,974
User cost per VMT	$0.25	$0.01
BMT after BRT 2020 implementation	24,500	1,225
Transit ridership—commuting	17,183	859
Percent of commuters riding in BRT corridor	45	5
Commute trip length prior to BRT 2020 (round trip)	39	2.925
Commute trip length after BRT 2020 (round trip)	34.41	2.581
Transit ridership—noncommuting	20,067	1,505
Percent of noncommuters riding in BRT corridor	35	5
Noncommute trip length prior to BRT 2020 (round trip)	14.841	1.113
Noncommute trip length after BRT 2020 (round trip)	14.217	1.066
Walking and waiting time prior to BRT2020	15 minutes	1 minute
Walking and waiting time after BRT2020	13 minutes	1 minute
METB of fares collected	$2,938	$147

The following tables present the variables that were held constant, and their point estimates used, in the Monte Carlo analysis due to our high level of confidence in their point estimates.

Table N-5: Non-varying parameters in Monte Carlo analysis of BRT 2020 Alternative	
Variable	**Point estimate**
Operating costs- federal and state contributions	$15,502,500
Operating costs- local contributions	$4,996,875
Capital costs	$76,079,901
Horizon value	$4,065,844
Vehicle miles traveled (VMT) prior to BRT 2020 implementation	14,121,607
Bus miles traveled (BMT) prior to BRT 2020 implementation	18,625
Social discount rate	3.5%

Table N-6: Non-varying parameters in Monte Carlo analysis of BRT Plus Alternative	
Variable	**Point estimate**
Operating costs- federal and state contributions	$14,946,000
Operating costs- local contributions	$4,817,500
Capital costs	$153,693,195
Horizon value	$8,213,635
Vehicle miles traveled (VMT) prior to BRT 2020 implementation	14,121,607
Bus miles traveled (BMT) prior to BRT 2020 implementation	18,625
Social discount rate	3.5%

Monte Carlo Analyses Employing Various Social Discount Rates

While the Monte Carlo analyses presented in the body of the report allow several parameters to vary over specified distributions, the social discount rate is held constant at 3.5 percent. This appendix presents additional Monte Carlo analyses for each alternative with social discount rates of two percent and five percent. All Monte Carlo analyses were conducted under the assumption of national standing. These two social discount rates were selected because they provide a range around the base rate of 3.5 percent. The results of these Monte Carlo analyses are presented below.

Results of Monte Carlo Analyses for BRT 2020 Alternative using three social discount rates

The results of these Monte Carlo analyses illustrate that the choice of social discount rate can have a substantial impact on the expected NPV of our BRT 2020 alternative. Table N-7 presents the results of a Monte Carlo analysis using our base case estimates and a social discount rate of 3.5 percent. The results are identical to what was presented in the body of the report. Table N-8 illustrates how setting the social discount rate at 5 percent impacts the results of the Monte Carlo analysis. For our BRT 2020 alternative, setting the social discount rate at 5 percent, as opposed to 3.5 percent, increases the expected NPV by approximately $30 million, from -$261 million to -$231 million. In addition, setting the social discount rate at 5 percent slightly tightens the distribution, as can be seen by the lower standard deviation. Despite the slightly higher expected NPV, there are still zero trials returning a positive NPV.

While setting the social discount rate at five percent yielded a higher expected NPV than the base case scenario, lowering the social discount rate to two percent resulted in a substantial drop in the expected NPV. Table N-9 illustrates that selecting a social discount rate of two percent results in an expected NPV of approximately -$300 million, about $40 million lower than the expected NPV if a social discount rate of 3.5 percent is chosen. In addition, the lower discount rate results in a wider distribution, but the Monte Carlo analysis again yielded zero trials with a positive NPV. The tables and histograms below provide the summary statistics and distributions for each of the three social discount rates selected for Monte Carlo analysis.

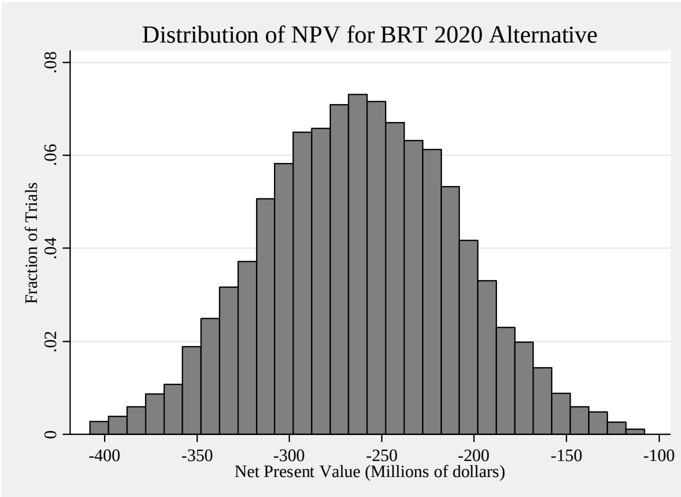


Table N-7: BRT 2020 Summary Statistics (Millions, 2000 dollars)	
Social discount rate	3.5%
Number of trials	10,000
Mean	-$261.8
Median	-$261.5
Standard deviation	$54.1
Minimum	-$472.3
Maximum	$-63.1
% of Positive NPV	0.00

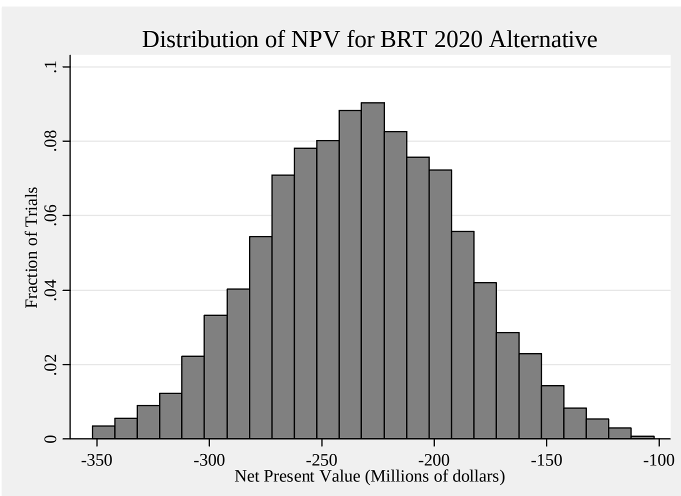


Table N-8: BRT 2020 Summary Statistics (Millions, 2000 dollars)	
Social discount rate	5%
Number of trials	10,000
Mean	-$231.2
Median	-$232.1
Standard deviation	$44.4
Minimum	-$405.2
Maximum	$-68.9
% of Positive NPV	0.00

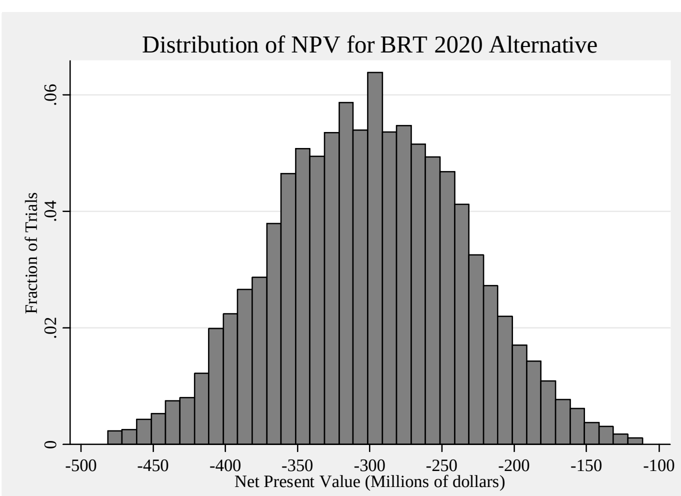


Table N-9: BRT 2020 Summary Statistics (Millions, 2000 dollars)	
Social discount rate	2%
Number of trials	10,000
Mean	-$300.3
Median	-$299.8
Standard deviation	$67.1
Minimum	-$561.0
Maximum	$-54.4
% of Positive NPV	0.00

Results of Monte Carlo Analyses for BRT Plus Alternative using three social discount rates

The Monte Carlo analyses show that the expected NPV of the BRT Plus alternative is not as dependent on the value of the social discount rate as NPV of the BRT 2020 alternative. Table N-10 presents the results of a Monte Carlo analysis using our base case estimates and a social discount rate of 3.5 percent. The results are identical to what was presented in the body of the report. Using the same parameter estimates, but selecting a social discount rate of five percent results in a $3 million decrease in the expected NPV of BRT Plus. These Monte Carlo results run contrary to the comparable results for the BRT 2020 alternative. For BRT 2020, increasing the social discount rate increased the expected NPV of the project while an identical increase in the social discount rate for the BRT Plus alternative resulted in a slight decrease. However, as was the case with the BRT 2020 results, increasing the social discount rate tightened the distribution of NPV trials for BRT Plus. This is illustrated by the fact that the standard deviation decreased between table N-10 and table N-11. This tightened distribution resulted in a lower percentage of trials returning a positive NPV.

As illustrated in table N-12, lowering the social discount rate to two percent slightly increased the expected NPV of BRT Plus, as it went from -$152 million when using a social discount rate of 3.5 percent to -$148 million under a social discount rate of two percent. Using a lower discount rate also widened the distribution, illustrated by the increased standard deviation compared to the base case. The slight increase in BRT Plus' expected NPV combined with a wider distribution resulted in 2.74 percent of the 10,000 trials returning positive NPVs. The tables and histograms below provide the summary statistics and distributions for each of the three social discount rates selected for Monte Carlo analysis.

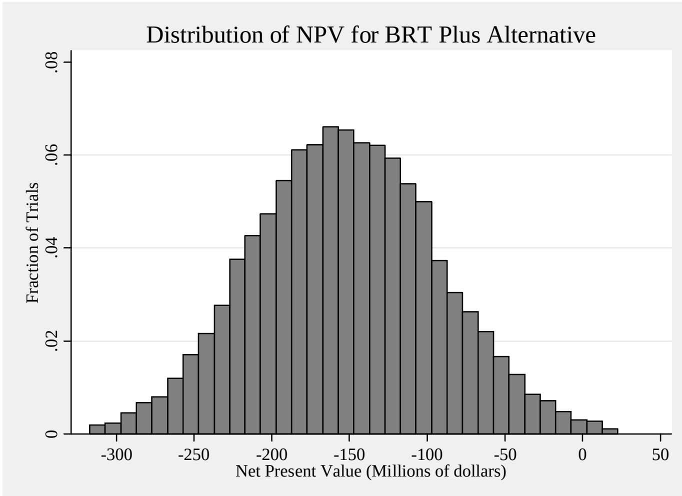


Table N-10: BRT Plus Summary Statistics (Millions, 2000 dollars)	
Social discount rate	3.5%
Number of trials	10,000
Mean	-$152.1
Median	-$152.3
Standard deviation	$60.5
Minimum	-$377
Maximum	$110.0
% of Positive NPV	0.72

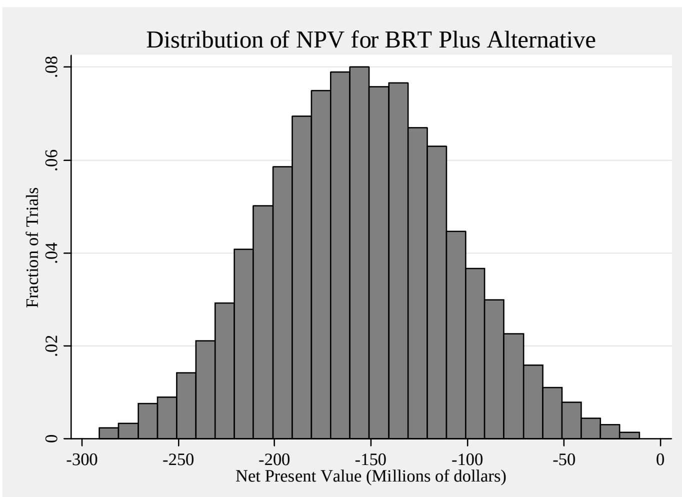


Table N-11: BRT Plus Summary Statistics (Millions, 2000 dollars)	
Social discount rate	5%
Number of trials	10,000
Mean	-$155.5
Median	-$155.8
Standard deviation	$50.3
Minimum	-$343.9
Maximum	$29.2
% of Positive NPV	0.13

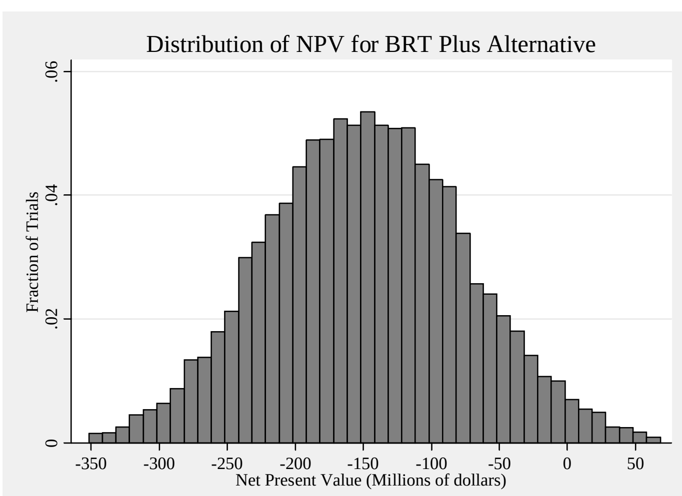


Table N-12: BRT Plus Summary Statistics (Millions, 2000 dollars)	
Social discount rate	2%
Number of trials	10,000
Mean	-$147.7
Median	-$148.4
Standard deviation	$75.3
Minimum	-$432.4
Maximum	$155.0
% of Positive NPV	2.74

APPENDIX O: YEARLY NET PRESENT VALUE

BRT 2020: National Standing, 2000 Dollars									
	Cost Categories			Benefit Categories					NPV
Year	Capital Costs	Cost of Raising Local Revenue	Operations and Maintenance	Time Savings For Current Transit Riders	Reduced Costs for New Transit Riders	Reduced Air Pollution Costs	Reduced Accident Costs	Horizon Value	Annual NPV
2010	-$64,500,000	-$4,031,250	$0	$0	$0	$0	$0	$0	-$68,531,250
2011	$0	-$1,349,771	-$18,519,280	$1,464,306	$4,213,292	$1,218,188	$539,301	$0	-$12,433,963
2012	$0	-$1,278,440	-$17,893,024	$1,434,628	$4,131,876	$1,196,533	$528,880	$0	-$11,879,547
2013	$0	-$1,209,268	-$17,287,946	$1,405,658	$4,052,033	$1,175,233	$518,660	$0	-$11,345,630
2014	$0	-$1,142,175	-$16,703,329	$1,377,377	$3,973,733	$1,154,283	$508,638	$0	-$10,831,474
2015	$0	-$1,077,083	-$16,138,482	$1,349,765	$3,896,946	$1,133,678	$498,809	$0	-$10,336,368
2016	$0	-$1,013,919	-$15,592,736	$1,322,805	$3,821,642	$1,113,414	$489,170	$0	-$9,859,624
2017	$0	-$952,610	-$15,065,446	$1,296,479	$3,747,794	$1,093,486	$479,718	$0	-$9,400,580
2018	$0	-$893,086	-$14,555,986	$1,270,769	$3,675,373	$1,073,889	$470,448	$0	-$8,958,594
2019	$0	-$835,281	-$14,063,755	$1,245,658	$3,604,351	$1,054,619	$461,357	$0	-$8,533,051
2020	$0	-$779,129	-$13,588,169	$1,221,131	$3,534,702	$1,035,671	$452,442	$0	-$8,123,353
2021	$0	-$724,568	-$13,128,666	$1,197,171	$3,466,399	$1,017,041	$443,699	$0	-$7,728,924
2022	$0	-$671,536	-$12,684,701	$1,173,763	$3,399,415	$998,725	$435,125	$0	-$7,349,210
2023	$0	-$619,976	-$12,255,750	$1,150,892	$3,333,726	$980,717	$426,717	$0	-$6,983,674
2024	$0	-$569,829	-$11,841,304	$1,128,545	$3,269,306	$963,013	$418,471	$0	-$6,631,798
2025	$0	-$521,042	-$11,440,874	$1,106,706	$3,206,131	$945,610	$410,385	$0	-$6,293,084
2026	$0	-$473,561	-$11,053,984	$1,085,363	$3,144,177	$928,502	$402,455	$0	-$5,967,049
2027	$0	-$427,335	-$10,680,178	$1,064,503	$3,083,420	$911,685	$394,678	$0	-$5,653,228
2028	$0	-$382,313	-$10,319,013	$1,044,112	$3,023,837	$895,155	$387,051	$0	-$5,351,172
2029	$0	-$338,450	-$9,970,060	$1,024,178	$2,965,405	$878,907	$379,572	$0	-$5,060,448
2030	$0	-$295,696	-$9,632,909	$1,004,689	$2,908,103	$862,938	$372,237	$0	-$4,780,638
2031	$0	-$254,009	-$9,307,158	$985,634	$2,851,907	$847,244	$365,044	$0	-$4,511,338
2032	$0	-$243,696	-$8,992,423	$967,001	$2,796,798	$831,819	$357,990	$0	-$4,282,510
2033	$0	-$233,776	-$8,688,332	$948,780	$2,742,754	$816,661	$351,072	$0	-$4,062,841
2034	$0	-$224,236	-$8,394,523	$930,959	$2,689,754	$801,764	$344,288	$0	-$3,851,994
2035	$0	-$215,061	-$8,110,651	$913,528	$2,637,778	$787,126	$337,636	$0	-$3,649,644
2036	$0	-$206,238	-$7,836,377	$896,478	$2,586,806	$772,741	$331,111	$0	-$3,455,479
2037	$0	-$197,753	-$7,571,379	$879,798	$2,536,820	$758,606	$324,713	$0	-$3,269,195
2038	$0	-$189,595	-$7,315,342	$863,479	$2,487,799	$744,718	$318,438	$0	-$3,090,503
2039	$0	-$181,751	-$7,067,963	$847,513	$2,439,725	$731,072	$312,285	$4,065,844	$1,146,724
Totals	**-$64,500,000**	**-$21,532,435**	**-$345,699,740**	**$32,601,668**	**$94,221,798**	**$27,723,036**	**$12,060,390**	**$4,065,844**	**-$261,059,438**

BRT Plus: National Standing, 2000 Dollars									
	Cost Categories			Benefit Categories					NPV
Year	Capital Costs	Cost of Raising Local Revenue	Operations and Maintenance	Time Savings For Current Transit Riders	Reduced Costs for New Transit Riders	Reduced Air Pollution Costs	Reduced Accident Costs	Horizon Value	Annual NPV
2010	-$130,300,000	-$8,143,750	$0	$0	$0	$0	$0	$0	-$138,443,750
2011	$0	-$1,761,637	-$17,854,485	$3,168,759	$8,074,269	$2,383,796	$1,033,506	$0	-$4,955,791
2012	$0	-$1,650,462	-$17,250,710	$3,103,202	$7,918,245	$2,340,630	$1,013,535	$0	-$4,525,560
2013	$0	-$1,542,527	-$16,667,353	$3,039,242	$7,765,235	$2,298,201	$993,950	$0	-$4,113,252
2014	$0	-$1,437,709	-$16,103,722	$2,976,835	$7,615,182	$2,256,497	$974,743	$0	-$3,718,174
2015	$0	-$1,335,888	-$15,559,152	$2,915,937	$7,468,029	$2,215,507	$955,908	$0	-$3,339,660
2016	$0	-$1,236,950	-$15,032,997	$2,856,507	$7,323,719	$2,175,221	$937,436	$0	-$2,977,065
2017	$0	-$1,140,784	-$14,524,635	$2,798,503	$7,182,198	$2,135,628	$919,321	$0	-$2,629,770
2018	$0	-$1,047,283	-$14,033,464	$2,741,886	$7,043,412	$2,096,717	$901,557	$0	-$2,297,175
2019	$0	-$956,342	-$13,558,902	$2,686,618	$6,907,307	$2,058,479	$884,135	$0	-$1,978,705
2020	$0	-$867,861	-$13,100,389	$2,632,661	$6,773,833	$2,020,902	$867,051	$0	-$1,673,803
2021	$0	-$781,743	-$12,657,380	$2,579,979	$6,642,937	$1,983,977	$850,296	$0	-$1,381,933
2022	$0	-$697,894	-$12,229,353	$2,528,538	$6,514,571	$1,947,694	$833,865	$0	-$1,102,578
2023	$0	-$616,224	-$11,815,800	$2,478,304	$6,388,686	$1,912,043	$817,752	$0	-$835,240
2024	$0	-$536,644	-$11,416,232	$2,429,243	$6,265,233	$1,877,013	$801,950	$0	-$579,437
2025	$0	-$459,070	-$11,030,176	$2,381,324	$6,144,166	$1,842,595	$786,453	$0	-$334,708
2026	$0	-$383,420	-$10,657,175	$2,334,516	$6,025,438	$1,808,780	$771,256	$0	-$100,606
2027	$0	-$309,615	-$10,296,787	$2,288,788	$5,909,004	$1,775,557	$756,353	$0	$123,301
2028	$0	-$237,577	-$9,948,586	$2,244,113	$5,794,821	$1,742,918	$741,737	$0	$337,426
2029	$0	-$167,232	-$9,612,161	$2,200,461	$5,682,844	$1,710,854	$727,404	$0	$542,170
2030	$0	-$98,508	-$9,287,112	$2,157,805	$5,573,030	$1,679,354	$713,348	$0	$737,917
2031	$0	-$31,336	-$8,973,055	$2,116,120	$5,465,339	$1,648,410	$699,563	$0	$925,041
2032	$0	-$26,964	-$8,669,618	$2,075,378	$5,359,728	$1,618,013	$686,045	$0	$1,042,582
2033	$0	-$22,826	-$8,376,443	$2,035,555	$5,256,159	$1,588,155	$672,788	$0	$1,153,387
2034	$0	-$18,913	-$8,093,181	$1,996,626	$5,154,590	$1,558,825	$659,788	$0	$1,257,735
2035	$0	-$15,213	-$7,819,499	$1,958,569	$5,054,985	$1,530,017	$647,038	$0	$1,355,897
2036	$0	-$11,719	-$7,555,072	$1,921,361	$4,957,304	$1,501,720	$634,535	$0	$1,448,130
2037	$0	-$8,420	-$7,299,586	$1,884,978	$4,861,511	$1,473,928	$622,273	$0	$1,534,684
2038	$0	-$5,309	-$7,052,740	$1,849,400	$4,767,568	$1,446,631	$610,249	$0	$1,615,800
2039	$0	-$2,377	-$6,814,242	$1,814,606	$4,675,441	$1,419,822	$598,457	$8,213,635	$9,905,343
Totals	**-$130,300,000**	**-$25,552,196**	**-$333,290,006**	**$70,195,811**	**$180,564,786**	**$54,047,883**	**$23,112,293**	**$8,213,635**	**-$153,007,794**