Benefit Cost Analysis

Introduction

This memorandum summarizes the approach used for conducting benefit-cost analysis (BCA) for the Arkansas I-49 corridor project. Table 1 – the project matrix - summarizes the components of the project. The project matrix describes baseline conditions; proposed alternatives; and types of anticipated impacts.

This appendix describe the method used for estimating benefits and life cycle costs of the proposed I-49 improvements. In calculation of project life cycle costs we used the planning level estimate of the project costs. In calculation of project benefits we use the guidelines provided by USDOT for TIGER grant applications. The benefits were estimated using two methodologies- one for the impacts of the intersection and interchange improvements and one for the mainline improvements. For the intersection and interchange improvements, a benefit calculator developed for operational improvements that do not lend themselves to being analyzed via a travel demand model was employed. For the mainline improvement, the statewide travel demand model was utilized.

Table 1. Project Matrix

Project Component	Current Status or Baseline	Change to Baseline with Greatest Impact	Type of Impact
Highway 16/112 Spur Interchange	Capacity for existing and future traffic resulting in poor Level of Service (LOS) Safety concerns at intersections along the corridor	Adding a Turning Lane	Increased capacity Reduced delay Reduced vehicle operating costs Improved safety
Porter Road Interchange	Safety concerns at intersections along the corridor Increase traffic leading to lower LOS	Adding a Traffic Signal	Reduced delay Reduced vehicle operating costs Improved safety
Hwy 112/71B Interchange	Capacity for existing and future traffic resulting in poor Level of Service (LOS) Safety concerns at intersections along the corridor	Adding a Turning Lane	Increased capacity Reduced delay Reduced vehicle operating costs Improved safety
Highway 71 B Interchange	Capacity for existing and future traffic resulting in poor Level of Service (LOS) Safety concerns at intersections along the corridor	Interchange Reconstruction	Increased capacity Reduced delay Reduced vehicle operating costs Improved safety
Highway 62/102 Interchange	Safety concerns at intersections along the corridor Increase traffic leading to lower LOS	Adding a Traffic Signal	Reduced delay Reduced vehicle operating costs Improved safety
Highway 72 Interchange	Capacity for existing and future traffic resulting in poor Level of Service (LOS) Safety concerns at intersections along the corridor	Interchange Reconstruction	Increased capacity Reduced delay Reduced vehicle operating costs Improved safety
8th Street Interchange	Capacity for existing and future traffic resulting in poor Level of Service (LOS) Safety concerns at intersections along the corridor	Interchange Reconstruction	Increased capacity Reduced delay Reduced vehicle operating costs Improved safety

Project Benefits

The primary benefits of the Project are:

- Improved the condition of the corridor by lessening pavement maintenance
- Reduced travel time for passengers cars and trucks
- Reduced vehicle operating costs (fuel and non-fuel costs)
- Reduced air emissions generated by motor vehicles
- Greater safety for users in the corridor

Consistent with USDOT grant methodology and guidance, the benefits resulting from the I-49 Corridor Project (see Table 2) are broken down into the following major categories: a) State of Good Repair, b) Economic Competitiveness, c) Environmental Sustainability, and d) Safety. The benefits of the I-49 Corridor Project are calculated in 2015 dollars over a time horizon of 20 years, starting in 2020 and ceasing in 2040.

Table 2 Direct Benefits Resulting from the I-49 Corridor Project

Benefit Category	Metrics
A. State of Good Repair	Pavement Maintenance Costs
B. Economic Competitiveness	Travel Time Costs Vehicle Operating Costs (VOC) Logistics Costs
C. Environmental Sustainability	Social Cost of Carbon (SCC) Emissions Non-Carbon Emissions Costs
D. Safety	Traffic Accident Costs

Intersection and Operational Improvements

Benefit estimation of these components include value of time associated with decreased delay and changes in safety costs due to a reduction in the number of crashes.

Value of Time Savings

Delay and user benefits are based on AADT data for the base year and the default assumptions regarding the improvement type and impact. The assumptions and approach for operational and safety projects are presented below.

- *Annual VOT Savings-* The delay per vehicle is assumed to depend on the level of service in the No-Build condition and build scenario. The delay per vehicle is converted to the total daily delay for all the vehicles in the influence area based on AADT, annual growth rate and annualization factors. The delay, presented as vehicle hours traveled (VHT), is monetized based on trip purpose and the VOT variables prescribed on the TIGER BCA resource guide. Key assumptions are summarized in Table 3.

Table 3 Key Assumptions Used to Monetize User Benefits

Parameter	Default Value	Source
Annualization Factor		
Auto	260	Industry Standard
Truck	365	
AADT Annual Growth Rate		AHTD Projections
Washington County	1.411%	
Benton County	1.427%	
Average Truck %	5%-6%	Interchange Justification Report

- No Build Level-of-Service (LOS): LOS is defined in terms of the average total vehicle delay of all movements. Existing LOS, provided in the Interchange justification reports (IJR), was used for each project component.

- Delay per Vehicle (sec): This is a quantitative measure for the impact LOS has on operations. Benchmark values for delay based on LOS are derived from Institute of Transportation Engineers (ITE) guidelines. Table 4 lists the assumptions used for all levels of service.

Table 4 Default Values for Delay per Vehicle based on LOS

LOS	Range of Delay per Vehicle	Default Delay/vehicle Assumption
A	< 10	0
B	10-20	10
C	20-35	20
D	35-55	35
E	55-80	55
F	>80	80

Source: Calculations based on ITE guidelines

- The Planning Analysis Hour Factor: The Planning Analysis Hour Factor, or K Factor, is the ratio of the traffic volume in the study hour to the AADT. Standard K value varies based on the selected area and facility type and ranged from 10% to 10.5%. The K factor generally drops as an area becomes more urbanized and high traffic volumes are spread out over longer time periods.

- Number of congested hours/day: This is an indication of how many hours per day a facility is congested.

These default values used in the calculations were developed based on general traffic engineering parameters and are shown in Table 5.

Table 5 Assumptions Used in Estimating Delay Impact of Operational Projects

Parameter	Value
No-Build Level-of-Service	Varied by component (D-F)
Delay per Vehicle (Sec)	80
K-Factor	Varied by component (10%-10.5%)
Number of congested hours/day	4

Source: Interchange Justification Reports and AHTD Input

The delay reduction calculation is based on the type of improvement. Each improvement is considered to be either a minor, moderate, or major improvement based on their potential impact on reducing delay. A list of improvements and their default level of impact in terms of travel time reduction is presented in Table 6. The percentage reduction in travel time is associated with project type and is based on general engineering rule of thumb metrics used for planning level analysis. This percentage is applied to the total daily delay to estimate the total travel-time savings for all vehicles.

Table 6 Operational Project Type and Impact Level Assumptions

Project Type	Operational	
	Impact Level	Time Reduction
Signal Timing/Phasing Changes	Minor	15%
Adding Turn Lanes	Moderate	30%
Adding a Through Lane	Moderate	30%
Add a Traffic Signal	Moderate	30%
Interchange Reconstruction	Moderate	30%

Source: Estimation based on ITE guidelines

Using the specified value of truck percentage and the annualization factor for autos and trucks, the daily annual travel-time savings are estimated for both the modes. The daily VOT savings are converted to the annual VOT savings using the following equation:

$$VOT\ Savings_{mode} = Travel\ time\ saved_{mode}(hr) \times VOT_{mode}\left(\frac{\$}{hr}\right)$$

Where: *mode = Auto, Truck*

The auto VOT is available for each of the three purposes- leisure, commute, and business- and for truck. The values used are displayed in Table 7. The resulting VOT benefits are presented in Table 8.

Table 7 Project Value of Time Impact Assumptions

Parameter	Category	$ per person hour ($2015)
Truck VOT	Truck Driver	$26.68
Weighted Auto VOT	Local Travel – All Purposes	$13.45

Source: USDOT TIGER grant guidelines and AHTD travel demand model.

Table 8. Travel Time Cost Savings Due to Increased Interchange Capacity

Year	Calendar Year	Travel Time Savings [C*Avg Veh OpEx/mile*2 miles* (1+ 24% Poor Roadway Effects)*260 work days]	NPV of Travel Time Savings (3%) [D/(1+3%)^A]	NPV of Travel Time Savings (7%) [D/(1+7%)^A]
1	2016	$55,197.00	$55,197.00	$55,197.00
2	2017	$58,318.00	$56,619.42	$54,502.80
3	2018	$61,439.00	$57,912.15	$53,663.20
4	2019	$64,562.00	$59,083.38	$52,701.82
5	2020	$67,683.00	$60,135.47	$51,635.04
6	2021	$70,804.00	$61,076.15	$50,482.27
7	2022	$73,925.00	$61,911.02	$49,259.35
8	2023	$77,048.00	$62,647.07	$47,981.62
9	2024	$80,169.00	$63,286.15	$46,659.09
10	2025	$83,289.00	$63,834.08	$45,303.70
11	2026	$86,413.00	$64,299.39	$43,927.99
12	2027	$89,535.00	$64,681.99	$42,537.43
13	2028	$92,657.00	$64,987.76	$41,140.82
14	2029	$95,777.00	$65,219.48	$39,744.05
15	2030	$98,899.00	$65,383.89	$38,354.74
16	2031	$102,024.00	$65,485.32	$36,978.19
17	2032	$105,143.00	$65,521.64	$35,615.57
18	2033	$108,263.00	$65,500.90	$34,273.29
19	2034	$111,385.00	$65,426.95	$32,954.80
20	2035	$114,508.00	$65,302.31	$31,662.42
21	2036	$117,631.00	$65,129.43	$30,398.09
22	2037	$120,749.00	$64,908.54	$29,162.46
23	2038	$123,871.00	$64,647.35	$27,959.32
24	2039	$126,994.00	$64,346.81	$26,788.99
25	2040	$130,116.00	$64,008.45	$25,651.93
Total			**$1,576,552.09**	**$1,024,535.98**

Safety and Crash Reduction Benefits

Crash data provided by AHTD identified crashes that occurred on the I-49 corridor in Washington and Benton counties during 2014. Crash data were summarized into property damages and personal injuries and used the USDOT TIGER Grant guidelines to quantify the crash costs. Table 9 summarizes the crash costs assumptions.

Table 9. Summary of I-49 Corridor Crash Cost Assumptions

Type of Incident	Cost per Incident ($2015)	Rate	Source
Property Damage	$4,198	47.5	USDOT TIGER grant guidelines and AHTD data
Personal Injury	$195,330.11	78.7	USDOT TIGER grant guidelines, based on average of all crash severity types throughout corridor and AHTD data and AHTD data
Fatality	$9,600,000	1.5	USDOT TIGER grant guidelines

Benchmark crash reduction rates developed using ITE guidelines are used to estimate the change in the number of crashes after the improvement. For intersection improvements, including turn lanes, signal improvements and reconstruction, it is estimated that crashes will be reduced on average by about 10 percent. Using the crash costs for 2015, assumed AADT growth rates from the AHTD travel demand model and benchmark crash reduction rates, safety savings were estimated between 2020 and 2040. The NPV of reduction in crash costs is then calculated by discounting at 3% and 7% rates as recommended by USDOT TIGER Grant recommendations. Table 10 presents the summary of crash reduction benefits.

Table 10. Crash Reduction Cost Savings

Year	Savings $2015	Savings NPV @ 7%	Savings NPV @ 3%
2020	$ 6,199,798	$ 4,729,797	$ 5,508,441
2021	$ 6,265,484	$ 4,467,203	$ 5,404,661
2022	$ 6,331,168	$ 4,218,725	$ 5,302,254
2023	$ 6,396,853	$ 3,983,639	$ 5,201,227
2024	$ 6,462,538	$ 3,761,256	$ 5,101,587
2025	$ 6,528,223	$ 3,550,921	$ 5,003,340
2026	$ 6,593,909	$ 3,352,009	$ 4,906,488
2027	$ 6,659,594	$ 3,163,925	$ 4,811,032
2028	$ 6,725,279	$ 2,986,104	$ 4,716,975
2029	$ 6,790,963	$ 2,818,008	$ 4,624,316
2030	$ 6,856,649	$ 2,659,127	$ 4,533,053
2031	$ 6,922,334	$ 2,508,972	$ 4,443,183
2032	$ 6,988,018	$ 2,367,084	$ 4,354,702
2033	$ 7,053,703	$ 2,233,022	$ 4,267,606
2034	$ 7,119,388	$ 2,106,370	$ 4,181,890
2035	$ 7,185,073	$ 1,986,733	$ 4,097,547
2036	$ 7,250,758	$ 1,873,734	$ 4,014,569
2037	$ 7,316,443	$ 1,767,017	$ 3,932,949
2038	$ 7,382,129	$ 1,666,244	$ 3,852,678
2039	$ 7,447,813	$ 1,571,093	$ 3,773,746
2040	$ 7,513,498	$ 1,481,261	$ 3,696,143
Total	**$ 143,989,617**	**$ 59,252,241**	**$ 95,728,385**

Mainline Widening Benefits

This section describes the method used for estimating benefits and life cycle costs of the mainline widening component of the I-49 Corridor Project. This analysis emphasizes the importance and full benefits of the project. In conducting the benefit-cost analysis, CS followed Federal guidance regarding evaluation criteria, discount and monetization rates, and evaluation methods prescribed in the 2016 TIGER and FASTLANE Guidance and supporting documents.

Travel Patterns

The estimation of the benefits involved establishing the Baseline and Build Scenario and calculating the differences between the Build and the Baseline in the benchmark years. The project team prepared and analyzed the following four model scenarios using the Arkansas travel demand model (TDM):

- 2020 No Build Baseline

- 2040 No Build Baseline
- 2020 Build –I-49 Corridor Project
- 2040 Build –I-49 Corridor Project
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The model outputs for each of the study scenarios used in the estimation of the benefits included the following:

- Daily vehicle-miles traveled (VMT) by vehicle type (passenger cars and trucks), trip purpose (commute, business and leisure trips), and time period (a.m. peak period, mid-day, p.m. peak period, and night) in 2020 and 2040.
- Daily vehicle-hours traveled (VHT) by vehicle type (passenger cars and trucks), trip purpose (commute, business and leisure trips), and time period (a.m. peak period, mid-day, p.m. peak period, and night) in 2020 and 2040.

Since the project completion date is scheduled for 2020, a straight-line growth pattern was assumed for VMT and VHT from 2020 to 2040 for the No-Build scenario and Build scenario. In this way the intermittent years during the 20-year study period (2020 to 2040) have been estimated. The focus of the travel efficiency portion of the benefit-cost analysis is the difference between the build and no-build scenarios in terms of a reduction in VMT and/or VHT.

Daily VMT and VHT accruing to commute and business trips were annualized by assuming 260 working days a year (i.e., 52 weeks). Daily VMT and VHT for leisure and truck trips were annualized by multiplying daily VMT and VHT by 365 days.

Travel demand benefits for the proposed improvements along I-49 are summarized below (Table 11). Benefits reflect corridor-level impacts compared to a future 2040 No-Build scenario. The project's proposed opening to traffic is in year 2020. A future/horizon year for the No Build and Build project scenarios is set at 2040 to provide a 20-year benefit stream for the impact analysis. Impacts are isolated to the I-49 project only; they do not reflect any additional planned improvements in the region.

It is estimated that in the base year, the proposed project will reduce truck delay by around 30% percent during (AM and PM) peak periods of travel and about 16% for autos.

Table 11. Daily Project-Level Impacts for the Mainline Widening

	Base Year No Build	Base Year Build	% Change
Delay/Auto (hours)	64,320	54,256	-16%
Delay/Truck (hours)	2,479	1,752	-30%

Table 12 provides traffic forecasts for the four model scenarios.

Table 12 Daily Traffic in 2010 and 2040

	2010 No-Build	2010 Build	2040 No-Build	2040 Build
AM VHT	33,640	32,507	77,162	75,648
MD VHT	85,271	82,100	173,157	169,603
PM VHT	99,843	94,084	232,353	225,734
NT VHT	39,454	39,397	64,780	64,738
Total VHT	**218,754**	**208,691**	**482,672**	**470,984**
AM Delay	8,536	7,403	35,710	34,196
MD Delay	17,744	14,572	61,490	57,935
PM Delay	38,040	32,281	130,437	123,818
NT Delay	477	419	1,562	1,519
Total Delay	**64,320**	**54,256**	**227,637**	**215,949**

Source: Output of the model scenarios using the Arkansas TDM

Travel Time Cost Benefits/Disbenefits

Annual changes in VHT by trip purpose over the 20-year analysis period are multiplied by the corresponding Average Vehicle Occupancy (AVO) and Value of Time (VOT). Travel time cost benefits/disbenefits resulting from the project are summarized in Table 13. The cost of time for leisure trips is assumed to only be opportunity cost and is therefor given no economic value. Time commuting is given 50% of the full value of time.

Table 13. Average Vehicle Occupancy and Value of Time by Vehicle Type/Trip Purpose

Trip Purpose	Average Vehicle Occupancy (AVO)	Value of Time (VOT) in 2015$
Auto - Leisure	2.0	$0
Auto -Commute	1.2	$9.75
Auto - Business	1.5	$19.49
Truck	1	$26.63

Source of AVO: Estimated based on the occupancy rates provided by the Arkansas Travel Demand Model
Source of VOT: The *2016 TIGER Benefit-Cost Analysis (BCA) Resource Guide*. Available at https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202516.pdf

Table 14 reflects changes in VOT over the 20-year analysis period. Overall, the improvements are expected to have a substantial positive impact on corridor users.

Table 14 Value of Time Benefits from Mainline Widening of I-49 over the 20-year Analysis Period

Calendar Year	Value of Time Savings	PV of Value of Time Savings (3%) [C/(1+3%)^A]	PV of Value of Time Savings (7%) [C/(1+7%)^A]
2020	$30,053,465	$26,702,115	$22,927,645
2021	$30,166,625	$26,021,996	$21,508,387
2022	$30,279,785	$25,358,843	$20,176,699
2023	$30,392,945	$24,712,245	$18,927,199
2024	$30,506,105	$24,081,801	$17,754,831
2025	$30,619,265	$23,467,117	$16,654,851
2026	$30,732,424	$22,867,810	$15,622,806
2027	$30,845,584	$22,283,506	$14,654,515
2028	$30,958,744	$21,713,840	$13,746,053
2029	$31,071,904	$21,158,455	$12,893,736
2030	$31,185,064	$20,617,001	$12,094,105
2031	$31,298,224	$20,089,139	$11,343,917
2032	$31,411,384	$19,574,536	$10,640,122
2033	$31,524,544	$19,072,867	$9,979,863
2034	$31,637,703	$18,583,816	$9,360,455
2035	$31,750,863	$18,107,074	$8,779,378
2036	$31,864,023	$17,642,337	$8,234,269
2037	$31,977,183	$17,189,312	$7,722,908
2038	$32,090,343	$16,747,709	$7,243,213
2039	$32,203,503	$16,317,249	$6,793,229
2040	$32,316,663	$15,897,657	$6,371,121
Total Value of Time Savings	**$654,886,342**	**$438,206,425**	**$273,429,301**

Source: Output of the model scenarios using the Arkansas TDM

Note: Positive values represent VOT savings

Emission Cost Benefits/Disbenefits

This category of project benefits (disbenefits) captures the savings (or additional expenditures) in emission damage costs resulting from reduced (increased) VMT under the Build Scenario (compared to the No Build).

This analysis applies the running emission rates pertain to Carbon Dioxide (CO_2), Volatile Organic Compound (VOC), Nitrogen Oxides (NOx), Particular Matter (PM) and Sulfur Dioxide (SOx) for passenger cars and trucks on urban restricted access roads estimated by Cambridge Systematics (CS) using data from the Environmental Protection Agency, and The Department of Energy.

The emissions rates (in grams per mile) of non-carbon emissions (VOC, NOx, PM and SOx) are multiplied by the annual changes in VMT resulting from the implementation of the I-49 Corridor Project, converted to metric tons and then, multiplied by the emission cost metric ton depicted in Table 15. The CO_2 emissions rates (in grams per mile) are multiplied by the annual changes in

VMT resulting from the implementation of the Project, converted to metric tons and then, multiplied by the emission cost per metric ton depicted in Table 16. It should be noted that the social cost of carbon (SCC) dioxide emissions increases annually and values for these emissions are to be discounted at a value of 3 percent rather than the 7 percent recommendation for all other non-carbon benefits or costs. The expected emission cost benefits/disbenefits are shown in Table 17.

Table 25. Emission Damage Costs

Emission Type	Emission Damage Cost ($/metric ton) in 2015$
	gram/mile
VOCs	$2,032
NOx	$8,010
PM	$366,414
SOx	$47,341

Source: 2016 TIGER Benefit-Cost Analysis (BCA) Resource Guide; Corporate Average Fuel Economy for MY2017-MY2025 Passenger Cars and Light Trucks (August 2012), page 922, Table VIII-16, "Economic Values Used for Benefits Computations (2010 dollars)."

Note: The 2016 Benefit-Cost Analysis (BCA) Resource Guide converts the emission damage cost value into 2015 dollars.

Table 16. Social Cost of Carbon (3%)

Year	3% SCC ($/metric tons) in 2015$
2025	$47
2021	$47
2022	$48
2023	$50
2024	$51
2025	$52
2026	$53
2027	$54
2028	$55
2029	$55
2030	$56
2031	$58
2032	$59
2033	$60
2034	$61
2035	$62
2036	$63
2037	$64
2038	$65
2039	$67
2045	$68

Source: 2016 TIGER Benefit-Cost Analysis (BCA) Resource Guide; Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis under Executive Order 12866 (May 2013; revised July 2015), page 17, Table A1 "Annual SCC Values: 2010-2050 (2007$/metric ton CO_2).
Note: The 2016 Benefit-Cost Analysis (BCA) Resource Guide converts the social cost of carbon (SCC) into 2015 dollars.

Table 17. Emissions Cost Benefits/Disbenefits

Calendar Year	Emissions Reduction Savings	PV of Emissions Reduction Savings (3%) [C/(1+3%)^A]	PV of Emissions Reduction Savings (7%) [C/(1+7%)^A]
2020	$2,046,680	$1,818,448	$1,561,402
2021	$1,968,587	$1,698,121	$1,403,576
2022	$1,895,756	$1,587,666	$1,263,222
2023	$1,827,538	$1,485,956	$1,138,099
2024	$1,753,629	$1,384,331	$1,020,628
2025	$1,679,288	$1,287,035	$913,422
2026	$1,604,516	$1,193,911	$815,655
2027	$1,529,314	$1,104,809	$726,566
2028	$1,453,679	$1,019,582	$645,451
2029	$1,373,863	$935,534	$570,104
2030	$1,297,582	$857,854	$503,225
2031	$1,224,190	$785,761	$443,703
2032	$1,146,831	$714,667	$388,471
2033	$1,069,042	$646,788	$338,431
2034	$990,820	$582,003	$293,148
2035	$912,168	$520,197	$252,222
2036	$833,085	$461,259	$215,285
2037	$753,570	$405,081	$181,997
2038	$673,624	$351,560	$152,046
2039	$594,843	$301,402	$125,480
2040	$513,820	$252,765	$101,298
Total Emissions Reduction Savings	**$27,142,426**	**$19,394,728**	**$13,053,430**

Vehicle Operating Costs Benefits/Disbenefits

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

The method to assess VOC benefits/disbenefits involves estimation of the VOC per vehicle type. Average per-mile VOC for passenger vehicles is estimated based on the VOC for three size categories of sedans (i.e., small, medium and large sedans), four wheel-drive sport utility vehicles (SUV) and minivans provided by the American Automobile Association (AAA) (see Table 18). This analysis uses the average auto VOC resulting from 15,000 miles traveled per year. Average per-mile VOC for trucks is estimated using published analyses of the operational costs for trucking based on information provided directly by motor carriers to the American Transportation Research Institute (ATRI) (see Table 19). The VOC for autos and trucks are inflated from 2014 to 2015 dollars using the Consumer Price Index (CPI).

Table 38. Average Marginal Vehicle Operating Cost for Passenger Vehicles

Auto Type	**VOC (in cents/mile) in 2014**		
	Miles per Year		
	10,000	**15,000**	**20,000**
Small Sedan	58.2	44.9	38.0
Medium Sedan	75.9	58.1	49.0
Large Sedan	93.3	71.0	59.5
Sedan (Composite Average)	75.8	58.0	48.8
4WD Sport Utility Vehicle	92.6	70.8	59.7
Minivan	81.2	62.5	52.9
Average =	**83.2**	**63.8**	53.8

Source: Your Driving Costs, 2015 Edition (AAA)
Notes: (1) VOC per mile derived from a popular model of each type listed assuming ownership of more than 5 years or 75,000 miles before replacement. (2) VOC per mile includes costs for fuel, maintenance, tires, full-coverage insurance, fees (license, registration and taxes), depreciation, and financing.

Table 49. Average Marginal Vehicle Operating Cost for Trucks for the Southeast Region ($/mile)

Operating Cost	VOC (in $/mile) in 2015 Dollars
Truck/Trailer Lease or Purchase Payments	$0.21
Repair & Maintenance	$0.19
Truck Insurance Premiums	$0.06
Permits and Licenses	$0.009
Tires	$0.04
Total =	**$0.51**

Source: An Analysis of the Operational Costs of Trucking: 2015 Update (ATRI, September 2015), Table 15, p. 27.

Fuel operating cost are calculated by multiplying the price of fuel per gallon by the average fuel efficiency, to come up with a fuel cost per mile. This is then applied to the change in vehicle miles traveled to produce the change in fuel cost. Fuel prices ($2.26 per gallon for gasoline, all grades and $2.58 for diesel, all types) were taken from the US Energy Information Administration, using the 2015 annual average for the Gulf Coast. Fuel efficiency numbers (autos: 0.05 gallons per mile and trucks: 0.159 gallons per mile)are taken from the Environmental Protection Agency, and The Department of Energy.

VOC benefits/disbenefits are estimated by multiplying the average marginal VOC by vehicle type by its corresponding annual changes in VMT over the 20-year analysis period. The results from this estimation are shown in Table 20.

Table 20. Vehicle Operating Cost Benefits/Disbenefits

Calendar Year	Non-Fuel VOC Savings	Fuel VOC Savings	Total Vehicle Operating Cost Savings	PV of VOC Savings (3%) [C/(1+3%)^A]	PV of VOC Savings (7%) [C/(1+7%)^A]
2020	$1,205,164	$1,443,509	$2,648,673	$2,353,312	$2,020,660
2021	$1,159,244	$1,388,837	$2,548,080	$2,197,996	$1,816,746
2022	$1,113,323	$1,334,164	$2,447,487	$2,049,732	$1,630,864
2023	$1,067,403	$1,279,491	$2,346,894	$1,908,240	$1,461,528
2024	$1,021,483	$1,224,818	$2,246,301	$1,773,251	$1,307,368
2025	$975,563	$1,170,145	$2,145,708	$1,644,507	$1,167,123
2026	$929,643	$1,115,472	$2,045,115	$1,521,758	$1,039,633
2027	$883,722	$1,060,800	$1,944,522	$1,404,764	$923,828
2028	$837,802	$1,006,127	$1,843,929	$1,293,295	$818,726
2029	$791,882	$951,454	$1,743,336	$1,187,127	$723,422
2030	$745,962	$896,781	$1,642,743	$1,086,046	$637,084
2031	$700,041	$842,108	$1,542,150	$989,847	$558,946
2032	$654,121	$787,435	$1,441,557	$898,330	$488,305
2033	$608,201	$732,763	$1,340,964	$811,305	$424,515
2034	$562,281	$678,090	$1,240,371	$728,587	$366,981
2035	$516,360	$623,417	$1,139,777	$649,999	$315,158
2036	$470,440	$568,744	$1,039,184	$575,371	$268,545
2037	$424,520	$514,071	$938,591	$504,539	$226,682
2038	$378,600	$459,399	$837,998	$437,345	$189,147
2039	$332,680	$404,726	$737,405	$373,637	$155,553
2040	$286,759	$350,053	$636,812	$313,269	$125,545
Total Value of VOC	**$15,665,194**	**$18,832,404**	**$34,497,598**	**$24,702,258**	**$16,666,360**

State of Good Repair

The expected reduction in VMT will lead to a reduction in pavement wear and tear over the 20-year analysis period.

The method to assess highway system state of good repair (SOGR) benefits involves estimation of the marginal external cost associated with pavement maintenance by vehicle type and highway functional class. This analysis uses the average external marginal costs for urban highways provided by the Federal Highway Administration (FHWA) (see Table 21) which represent the additional spending (or saving) in all costs of maintaining pavements, including resurfacing and reconstruction, resulting from a unit increase/decrease in VMT borne by public agencies responsible for highway maintenance. The marginal pavement cost is multiplied by the annual changes in VMT over the 20-year analysis period. . Table 22 summarizes the SOGR benefits/disbenefits.

Table 21 Marginal External Pavement Cost for Urban Highways

Vehicle Class	Urban Highways (Average)	Urban Highways (Average)
	in 2000$	in 2015$
Passenger Cars	0.001	0.0014
Trucks	0.257	0.354

Addendum to the 1997 Federal Highway Cost Allocation Study Final Report, 2000. Table 13
Notes:
1. Marginal pavement cost was inflated from 2000 to 2015 dollars based on the Consumer Price Index (CPI)
2. Truck costs were calculated as an average of 60 kip 5-axle combo/urban interstate and 80 kip 5-axle combo/urban interstate.

Table 22 Summary of State of Good Repair Benefits/Disbenefits through 2040

Calendar Year	State of Good Repair Savings	PV of SOGR Savings (3%) [C/(1+3%)^A]	PV of SOGR Savings (7%) [C/(1+7%)^A]
2020	$512,587	$455,427	$391,050
2021	$492,831	$425,120	$351,382
2022	$473,074	$396,192	$315,230
2023	$453,318	$368,589	$282,304
2024	$433,562	$342,258	$252,337
2025	$413,805	$317,147	$225,083
2026	$394,049	$293,209	$200,315
2027	$374,293	$270,397	$177,824
2028	$354,536	$248,665	$157,418
2029	$334,780	$227,969	$138,922
2030	$315,023	$208,268	$122,172
2031	$295,267	$189,521	$107,018
2032	$275,511	$171,689	$93,325
2033	$255,754	$154,736	$80,965
2034	$235,998	$138,624	$69,823
2035	$216,242	$123,320	$59,793
2036	$196,485	$108,789	$50,775
2037	$176,729	$95,000	$42,682
2038	$156,972	$81,923	$35,431
2039	$137,216	$69,526	$28,945
2040	$117,460	$57,782	$23,157
Total State of Good Repair Savings	**$6,615,492**	**$4,744,151**	**$3,205,950**

Total Monetized Benefits

Table 23 summarizes the monetized benefits (undiscounted and discounted) for each benefit category for both the intersection and the mainline capacity analyses.

Table 23. Total Monetized Benefits by Benefit Category

Benefits	2015$	7%	3%
Reduction in Value of Time Costs (Widening)	$654,886,342	$273,429,301	$438,206,425
Reduction in Value of Time Costs (Interchange)	$3,858,656	$1,502,083	$2,503,989
Reduction in Non-Fuel Vehicle Operating Costs (Widening)	$15,665,194	$7,573,241	$11,220,844
Reduction in Fuel Vehicle Operating Costs (Widening)	$18,832,404	$9,093,119	$13,481,413
Reduction in Safety Costs (Widening)	$26,766,322	$12,904,071	$19,146,776
Reduction in Safety Costs (Interchange)	$143,989,617	$59,252,241	$95,728,385
Reduction in Emissions Costs	$27,142,426	$13,053,430	$19,394,728
Reduction in Logistics Costs	$3,359	$1,421	$2,261
Reduction in Repair Costs	$6,615,492	$3,205,950	$4,744,151
Total Benefits	**$897,753,094**	**$380,012,016**	**$604,424,450**

Project Life Cycle Cost Analysis

The cost of the I-49 Project consist of capital expenditures, including design, land acquisition and construction, as well as operation and maintenance (O&M). The Arkansas State Highway and Transportation Department (AHTD) provided capital cost estimates (in 2015 dollars). The project is expected to require $650 million (in 2015 dollars) in capital expenditures, over four years with expected completion in 2021.

The cost of average cost maintenance for Arkansas (based on FHWA Highway Statistics) is around $3,614 per lane-mile annually. This analysis uses this value to estimate the annual O&M cost of net increase of 89 lane miles. Annual O&M expenditures are estimated assuming O&M costs start in 2022.

Table 24 presents the life cycle cost of the project.

Table 24. I-49 Corridor Project - Life Cycle Cost Analysis

Year	Initial Capital Cost	Operations & Maintenance Costs	Total Life Cycle Costs	PV of Life Cycle Costs (3%) [E/(1+3%)^A]	PV of Life Cycle Costs (7%) [E/(1+7%)^A]
2016	$0	$0	$0	$0	$0
2017	$64,800,000	$0	$64,800,000	$62,912,621	$60,560,748
2018	$64,800,000	$0	$64,800,000	$61,080,215	$56,598,830
2019	$64,800,000	$0	$64,800,000	$59,301,180	$52,896,102
2020	$0	$292,757	$292,757	$260,111	$223,343
2021	$0	$292,757	$292,757	$252,535	$208,732
2022	$0	$292,757	$292,757	$245,180	$195,077
2023	$0	$292,757	$292,757	$238,038	$182,314
2024	$0	$292,757	$292,757	$231,105	$170,387
2025	$0	$292,757	$292,757	$224,374	$159,241
2026	$0	$292,757	$292,757	$217,839	$148,823
2027	$0	$292,757	$292,757	$211,494	$139,087
2028	$0	$292,757	$292,757	$205,334	$129,988
2029	$0	$292,757	$292,757	$199,353	$121,484
2030	$0	$292,757	$292,757	$193,547	$113,536
2031	$0	$292,757	$292,757	$187,910	$106,109
2032	$0	$292,757	$292,757	$182,437	$99,167
2033	$0	$292,757	$292,757	$177,123	$92,679
2034	$0	$292,757	$292,757	$171,964	$86,616
2035	$0	$292,757	$292,757	$166,955	$80,950
2036	$0	$292,757	$292,757	$162,093	$75,654
2037	$0	$292,757	$292,757	$157,371	$70,705
2038	$0	$292,757	$292,757	$152,788	$66,079
2039	$0	$292,757	$292,757	$148,338	$61,756
2040	$0	$292,757	$292,757	$144,017	$57,716
Total Life cycle Costs	**$194,400,000**	**$6,147,902**	**$200,547,902**	**$187,423,922**	**$172,645,123**

Summary of Benefit-Cost Results

This memorandum describes the methodology used for conducting benefit-costs analysis (BCA) for the proposed I-49 Corridor. The analysis quantifies the economic benefits of the project in terms of reduced pavement maintenance costs, savings in travel time costs and vehicle operating costs, and avoided noise pollution, emission damages and traffic accident costs.

Table 25 summaries the BCA findings. Annual costs and benefits are computed over the lifecycle of the project (20 years). As stated earlier, construction is expected to be completed by the end of 2021 and benefits to be accrued during the full operation of the project. The project has a benefit-cost ratio of 3.2 at a real discount rate of 3 percent and 2.2 at a real discount rate of 7 percent. The Net Present Value (NPV) of the project is $417.0 million at 3 percent and $207.4 million at 7 percent over the assumed 20-year project life, from 2020 to 2040. These findings demonstrate that there are significant long-term economic benefits associated with the Project, and is regionally an important project.

Table 25. Summary of Benefit-Cost Analysis of I-49 Corridor Project

Cost Benefit Analysis (Discounted)	Discount Rate:	
Change in Travel Efficiency (Build - No-Build)	**7%**	**3%**
Vehicle Miles Traveled	-193,169,484	-193,169,484
Vehicle Hours Traveled	-76,208,381	-76,208,381
Hours of Delay	-76,208,381	-76,208,381
Benefits		
Reduction in Value of Time Costs (Widening)	$273,429,301	$438,206,425
Reduction in Value of Time Costs (Interchange)	$1,502,083	$2,503,989
Reduction in Non-Fuel Vehicle Operating Costs (Widening)	$7,573,241	$11,220,844
Reduction in Fuel Vehicle Operating Costs (Widening)	$9,093,119	$13,481,413
Reduction in Safety Costs (Widening)	$12,904,071	$19,146,776
Reduction in Safety Costs (Interchange)	$59,252,241	$95,728,385
Reduction in Emissions Costs	$13,053,430	$19,394,728
Reduction in Repair Costs	$3,205,950	$4,744,151
Total Benefits	**$380,012,016**	**$604,424,450**
Costs		
Construction Costs	$170,055,680	$183,294,016
Maintenance and Operations Costs	$2,589,443	$4,129,906
Total Costs	**$172,645,123**	**$187,423,922**
Benefits vs. Costs (7% Discount Rate)		
Net Benefits	**$207,366,893**	**$417,000,528**
Benefit-Cost Ratio	**2.2**	**3.2**

Economic Impact Analysis

The transportation costs savings and increased public expenditures are expected to have a positive impact on the regional and state economies in terms of increases in the number of jobs, income and overall gross state product.

The expenditure of public sector dollars is expected to create short-term jobs in the development and construction phases and maintenance of the I-49 Corridor Project (see Table 26). The benefit of increase in the job-years, estimated to be 2,037, as a result of the Project during development and construction was computed as a product of the undiscounted project cost and the value on government dollars spent to create a single job-year (i.e., $76,900 in 2015$).

In terms of long-term impacts, the "out-of-pocket" travel time changes for business trips and truck trips and the vehicle operating costs changes for all trips were entered in a regional IMPLAN economic model. The model estimates the direct, indirect and induced impacts arising from changes in regional transportation costs. The results of this analysis are displayed in Table 27. It is estimated that the improvements in the I-49 corridor will support significant long-term economic impacts, averaging 145 jobs, $6.7 million in income and $20.1 million in GSP annually. These benefits are not counted in the B/C calculation.

Table 56. Construction Spending Job Creation Benefits

Job Creation	Value
Increase in Short-Term Job-Years due to Project during Development and Construction	2,527 Job-Years

Table 27. Long-term Economic Impact, Average Annual Impacts

Impact Type	Employment	Labor Income	GSP
Total Effect	**145**	**$6.7 million**	**$20.1 million**

Source: CS calculations using IMPLAN