I-44 and US-75 Corridor Improvement Projects, Tulsa, Oklahoma
Appendix Report: Project Benefit Cost Analysis
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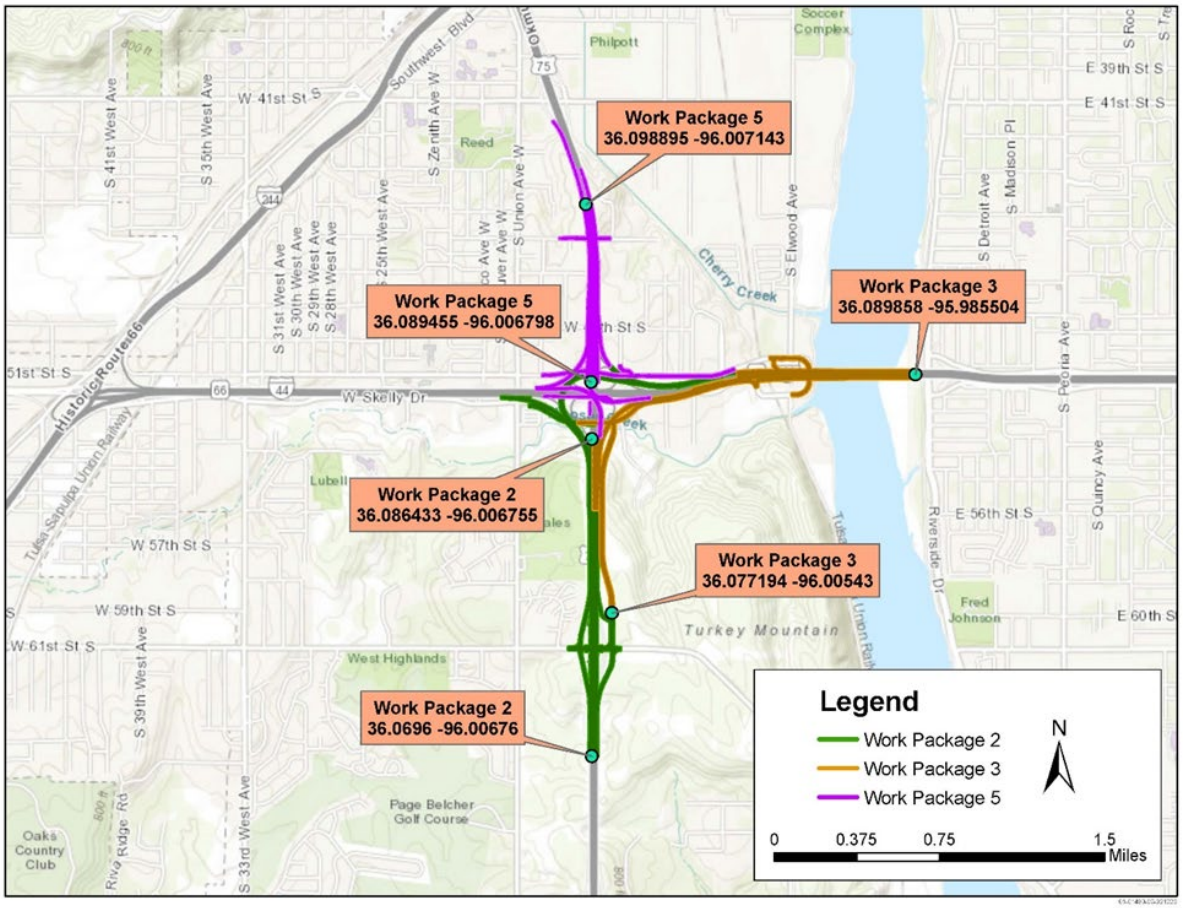

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Table of Contents

1 Overview of Approach

A Benefit Cost Analysis (BCA) has been conducted for WP 2, 3, and 5 of the I-44/US-75 Interchange, a major part of the overall I-44 and US-75 Corridor Improvement Projects in Tulsa County, Oklahoma. The BCA follows the most recent 2020 DOT guidance for BCAs, which provides both methodological guidance and specific values for monetizing various types of benefits, such as hourly values of travel time and the economic cost of vehicle crashes (including pedestrian-vehicle incidents). All values from that guidance are in 2018 dollars, which have been updated to 2019 real dollars using the 2018-2019 GDP Price Deflator published by the U.S. Bureau of Economic Analysis.

The following general parameters and assumptions have been used in carrying out the BCA:

- A real discount rate of 7 percent is applied to all costs and benefits, which are expressed in 2019 dollars.
- A project life cycle of 25 years is assumed, which represents a mid-point between a recommended 20-year horizon of analysis for rehab and replace projects, vs. 30 years for new right-of-way and facilities. The I-44 and US-75 Corridor Improvement Projects comprises multiple individual elements reflecting a mix of old and rehabbed infrastructure.
- No residual value is assumed at the close of the 25-year period of operation.
- The project construction is assumed to commence in 2024 and end in late 2026, with operation commencing in 2027. Some advance right-of-way acquisition for interchange construction will occur in years 2020 – 2024.
- All costs and benefits are in 2019 dollars.

2 Project Costs

2.1 Cost Summary by Year

Major capital, capital maintenance, and bridge rehab and repair costs are summarized in Table 1. These exclude routine maintenance for items such as patching, snow or ice clearance, or other non-capital items.

Table 1: Build and No Build Capital and Major Rehab Cost Summary by Year

Year	No-Build				BUILD		
	Maint & Rehab Costs for I-44/ US-75	Bridge Rehab Costs	Bridge Damage repair	TOTAL	Capital Costs	Maintenance	TOTAL
2016	4,900,000			4,900,000			-
2017		2,500,000		2,500,000			-
2018	1,700,000			1,700,000			-
2019				-			-
2020				-			-
2021		2,400,000		2,400,000			-
2022				-			-
2023				-			-
2024				-	54,666,666		54,666,666
2025					54,666,666		54,666,666
2026				0	54,666,666	1,000,000	55,666,666
2030	6,600,000	2,000,000	100,000	8,700,000			0
2035		3,300,000	100,000	3,400,000			-
2040	6,600,000	4,900,000	100,000	11,600,000			-
2045			100,000	100,000		5,000,000	5,000,000
2050	6,600,000	10,000,000	100,000	16,700,000		2,500,000	2,500,000
2055							-
2060							-
TOTAL	**$26,400,000.00**	**$25,100,000.00**	**$600,000.00**	**$52,000,000.00**	**$163,999,998.00**	**$8,500,000.00**	**$172,499,998.00**

Source: Oklahoma DOT design engineers

2.2 Capital Cost

The estimated capital cost of combined WP 2, 3, and 5 is $164.0 million in 2019 dollars (including contingency), and is broken down as follows:

- WP 2: $56.0 million
- WP 3: $48.9 million
- WP 5: $59.1 million

Further details of the capital costs are provided in the Table 2 funding table below, reproduced from the grant application.

Table 2: Build and No Build Capital and Major Rehab Cost Summary by Year

PROJECT COMPONENT	FUNDING TYPE	COST SHARE (%)	COST ($1000s)
Construction	INFRA	43.0%	61,317.4
	Other Federal	21.0%	29,946.0
	ODOT	36.0%	51,336.6
Contingency and Other	INFRA	43.0%	9,197.6
	Other Federal	21.0%	4,491.9
	ODOT	36.0%	7,700.5
Total	INFRA	43.0%	70,515.0
	Other Federal	21.0%	34,437.9
	ODOT	36.0%	59,037.1

2.3 Operations and Maintenance Costs

Because very little difference in lane mileage will be in place with the I-44 and US-75 Corridor Improvement Projects versus the No-Build, no incremental difference in routine lane-related maintenance costs have been assumed. However, as seen in the cost summary, there are significant differences in non-routine capital maintenance, bridge repair and rehab costs, and bridge damage costs. Under the No-Build, ODOT design engineers estimate $52 million have and will be spent for non-routine roadway and bridge maintenance through 2050, compared with $8.5 million for the Build (i.e., with I-44 and US-75 Corridor Improvement Projects). With the exception of the $9.1 million spent prior to now, the differences between No Build and Build maintenance and rehab costs represent significant life cycle cost savings, which are included as benefits for BCA purposes.

3 Project Benefits

3.1 Monetized Benefits Included in the BCA

Three primary categories of benefit have been captured by the BCA: reduced motor vehicle crashes, travel delay savings, and life cycle cost savings. Other categories of benefit which the I-44 and US-75 Corridor Improvement Projects is anticipated to deliver, such as reduced congestion at key bottlenecks and improved reliability for passengers and freight have not been included in the analysis due to time and data limitations.

Crash Reductions: Because much of the I-44 and US-75 Corridor Improvement Projects involve reconfiguring the complex network of US-75 and I-44 interchanges and approach lanes and roadways to the interchanges, a significant share of the benefits anticipated will be reduced vehicular collisions and improved pedestrian safety. To estimate these likely impacts, a detailed data list of all collisions that occurred throughout the I-44 and US-75 Corridor Improvement Projects limits between the years 2014 and 2018 were collected, by severity. Levels of severity were measured across a scale of 1 to 5, including fatal crashes, injury crashes of three degrees of severity, and property-damage-only crashes. These levels of severity are assumed to be roughly equivalent to KABCO scale measurements.

During the five-year period (covering full calendar years 2014 through 2018), the following count of crashes was obtained from ODOT:

- 408 PDO (property damage only)
- 201 Injury Severity 2 (least severe)
- 134 Injury Severity 3
- 25 Injury Severity 4
- 5 Fatal (including 1 pedestrian fatality

Table 3 summarizes the accident data, VMT data, and calculations leading to estimated accident reductions.

Table 3: Accident Reduction Calculations

Accident Reductions for Work Packages 2,3, and 5								
Avg. Annual Crashes (2014-2018)								
PDO	81.60							
Injury Severity 2	40.20							
Injury Severity 3	26.80							
Injury Severity 4	5.00							
Fatal	1.00							
2016 (mid period) VMT								
WP2	29,739,324							
WP3	28,454,999							
WP5	15,673,173							
Total	**73,867,496**							
2040 Projected VMT								
WP2	42,872,225							
WP3	38,123,064							
WP5	21,149,031							
Total	**102,144,319**							
Average Project-wide Crash Rates per million VMT								
PDO	1.10468075							
Injury Severity 2	0.54421772							
Injury Severity 3	0.36281181							
Injury Severity 4	0.06768877							
Fatal	0.01353775							
Projected No-Build Annual Crashes								
		2016 midpoint	2025	2030	2035	2040	2045	2050
PDO		81.60	94.67	101.28	108.36	112.84	120.72	129.15
Injury Severity 2		40.20	46.64	49.90	53.38	55.59	59.47	63.63
Injury Severity 3		26.80	31.09	33.26	35.59	37.06	39.65	42.42
Injury Severity 4		5.00	5.80	6.21	6.64	6.91	7.40	7.91
Fatal		1.00	1.16	1.24	1.33	1.38	1.48	1.58
VMT CAGT	1.0136							
Projected Crash Reductions by Type			2025	2030	2035	2040	2045	2050
Assumed Crash Reduction Factor*	45%	Total 25-year period						
PDO		**1259**	42.60	45.58	48.76	50.78	54.32	58.12
Injury Severity 2		**620**	20.99	22.45	24.02	25.01	26.76	28.63
Injury Severity 3		**413**	13.99	14.97	16.01	16.68	17.84	19.09
Injury Severity 4		**77**	2.61	2.79	2.99	3.11	3.33	3.56
Fatal		**15**	0.52	0.56	0.60	0.62	0.67	0.71

Sources of input data: Oklahoma DOT
Calculations: EBP

Based on these data, combined with annual vehicle miles traveled (VMT) measured across the project, accident rates were calculated (crashes per million VMT) and applied to ODOT's estimates of project-wide VMT in the future, and a baseline of total anticipated crashes without the I-44 and US-75 Corridor Improvement Projects was calculated for the entire project horizon of 25 years, through year 2051. Next, the FHWA's Crash Modification Factor database was consulted to obtain the most applicable Crash Reduction Factor.[1] This search yielded a most relevant CRF of 45 percent for the countermeasure **"**provide straight ramp instead of cloverleaf ramp." This CRF was then applied to the

[1] Elvik, R. and Erke, A., "Revision of the Hand-Book of Road Safety Measures: Grade-separated junctions." (3-27-2007) http://www.cmfclearinghouse.org/study_detail.cfm?stid=13

future stream of No-Build crashes (by category of severity) to obtain estimates of reduced annual crashes over the study period.

The I-44 and US-75 Corridor Improvement Projects will generate significant savings in human costs of crashes. Over the 25-year period, it is estimated that about 15 lives will be saved, and another 77 serious injury-crashes will also be avoided.

Travel Delay Savings: ODOT has provided an analysis of travel delay reductions based on application of the VISSIM traffic simulation model to a future 2045 build year. The model simulated the effects of the I-44 and US-75 Corridor Improvement Projects (WP 2, 3, and 5). Based on estimates provided by ODOT, the BCA analysis assumes that 75 percent of the total VISSIM delay reductions due to the entire I-44 and US-75 corridor improvements can be attributed to WPs 2, 3 and 5. Delay savings for years prior to 2045 were reduced based on the anticipated compound annual growth rates (CAGR) in VMT projected for the corridor of about 1.5 percent per year. For the years after 2045, delay was correspondingly increased by the same CAGR. In 2045, approximately 1,200 hours of delay would be saved by the I-44 and US-75 Corridor Improvement Projects each workday, covering am and pm peak periods combined.

Table 4 presents the outputs of the VISSIM run; Table 5 presents the computations to derive the annual travel delay for trucks (vehicle hours of delay) and passenger (passenger hours of delay). These savings were monetized utilizing the values of time prescribed in the USDOT BCA guidance, updated to 2019 real dollars.

Table 4: Outputs of VISSIM for Travel Delay

AM Period

	MPH				Seconds			
	SpeedAvg (All)	SpeedAvg (10)	SpeedAvg (20)	SpeedAvg (70)	DelayTot (All)	DelayTot (10)	DelayTot (20)	DelayTot (70)
Existing AM (2016)	45.91	45.91	43.71	47.34	937508.10	854992.06	35081.61	47434.43
2045 AM - No Action	30.89	30.98	30.06	30.07	4048058.07	3672981.50	136664.32	238412.25
Ult Build AM 2045	38.42	38.16	38.65	43.35	2458430.49	2295219.80	75520.53	87690.16
Ult Build 2045 AM - Added NB lane on US 75 beyond study area	48.57	48.61	46.63	49.12	801893.84	727557.95	30576.16	43759.72

PM Period

	MPH				Seconds			
	SpeedAvg (All)	SpeedAvg (10)	SpeedAvg (20)	SpeedAvg (70)	DelayTot (All)	DelayTot (10)	DelayTot (20)	DelayTot (70)
Existing PM (2016)	42.03	41.98	40.65	43.68	1487821.31	1356992.92	52772.68	78055.71
2045 PM - No Action	27.72	27.78	26.34	27.75	5247407.76	4756955.20	189138.21	301314.35
Ult Build PM 2045	46.53	46.62	44.14	46.52	1108530.75	999481.11	43956.01	65093.63
Ult Build 2045 PM - Added NB lane on US 75 beyond study area	46.63	46.73	44.25	46.54	1091935.53	983929.89	43359.67	64645.97

Source: Garver Engineering and ODOT

Table 5: Travel Delay Calculations

Total 2045 AM and PM Delay Savings, All Vehicles (for Work Packages 2,3, and 5)						
Daily Vehicel Hours						
Car	813.54	871.19	932.93	999.04	1,069.84	1144.60
Commercial Vehicles single axle	32.69	35.00	37.48	40.14	42.98	45.99
Commercial Vehicles multi-axle	47.11	50.45	54.02	57.85	61.95	66.28
Annual Vehicle Hours						
Car	203,385.71	217,798.62	233,232.89	249,760.92	267,460.20	286,148.96
Commercial Vehicles single axle	8,171.73	8,750.82	9,370.94	10,035.01	10,746.15	11,497.03
Commercial Vehicles multi-axle	11,777.39	12,612.00	13,505.75	14,462.83	15,487.74	16,569.94
Annual passenger hours saved	301,010.85	322,341.95	345,184.68	369,646.16	395,841.09	423,500.46

Source: EBP

Life Cycle Cost Savings: A**s** noted, there are significant differences in non-routine maintenance, bridge repair and rehab costs, and bridge damage costs. Under the No-Build, ODOT engineers estimate $52 million have been and will be spent for non-routine roadway and bridge maintenance, compared with $8.5 million for the Build (i.e., with the proposed Project). With the previously noted exception of the $9.1M in costs already spent, these represent significant life cycle cost savings which are included as benefits for BCA purposes. All costs are discounted at 7 percent based on when they are anticipated to be incurred.

3.2 Project Benefits Not Included in the BCA

Due to time and data limitations, the analysis does not include secondary benefits of reduced congestion, over and above the estimated reduction in travel delay itself. Severe bottlenecks and driving under highly congested conditions, which characterize several of the ramp and ramp approach roadways of the interchange, generally introduce significant unreliability into travel decision making, often necessitating that drivers build in added buffer time to their trips. It also involves inventory cost for truck shipping, due to that unreliability. In addition, delay for trucks as measured in the BCA does not include any inventory costs to the freight itself; truck delay is measured strictly in terms of average driver wages, utilizing the most current DOT guidance for BCAs.

No significant changes in VMT are anticipated as a result of the I-44 and US-75 Corridor Improvement Projects; accordingly, there are no changes in vehicle operating and maintenance costs and emissions measured for BCA purposes. In fact, since some significant bottlenecks will be alleviated, and average speeds through the system will increase during am and pm peak periods, it is probable that emissions and vehicle operating costs of fuel would both fall somewhat, but probably not by a significant amount.

Table 6: Input Values and Assumptions

Discount rate	7%
Period of Operation	25 years
GDP price deflator growth factor (2018-2019)	1.0173
Value of Accidents (KABCO) ($2018)	
No Injury (PDO equivalent)	$3,200
Possible Injury (=OK Severity 2)	$63,900
Non-capacitating Injury (=OK Severity 3)	$125,000
Incapacitating Injury (=OK Severity 4)	$459,000
Fatal	$9,600,000
Crash Reduction Factor (CRF)	.45
Value of Travel Time ($2018)	
Passengers all purposes	$16.60
Truck drivers	$29.50
Average passenger vehicle occupancy	1.48
Percent of travel time benefits attributable to WP 2, 3, 5	75%

4 BCA Results

Based on the assumptions, methodology, and other information presented above, the project yields a Benefit Cost Ratio of 1.33 and a Net Present Value of $36.1 million. The results are summarized in Table 7. About 40 percent of the total monetized benefits are travel delay savings. Accident reductions comprise 55 percent, and 5 percent are life cycle cost savings.

Table 7: BCA Results

Discounted Capital Costs (millions $2018)	$	109.45
Facilities Residual Value Undiscounterd	$	0.00
Discounted Present Value of Capital Costs incl. Residual	$	109.45
Total Discounted Costs	**$**	**109.45**
Total Discounted Benefits - Total (million $2018)	**$**	**145.56**
Travel delay cost savings	$	55.21
Accident reduction benefits	$	80.05
Life Cycle Benefits	$	10.30
Benefit Cost Ratio		1.33
Net Present Value	$	36.11

Source: EBP