I-81/HALFWAY BOULEVARD FREIGHT CONNECTION: MAKING WAY FOR ECONOMIC GROWTH AND SAFETY

BENEFIT-COST ANALYSIS REPORT

FY2019 INFRA DISCRETIONARY GRANT PROGRAM

Prepared for: WASHINGTON COUNTY, MD
FEBRUARY 28, 2019

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the ***Interstate 81/Halfway Boulevard Freight Connection: Making Way for Economic Growth and Safety Project*** for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the INFRA 2019 program. The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the 2019 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The period of analysis corresponds to 35 years and includes 5 years of construction and 30 years of benefits after operations begin in 2024.

The Interstate 81/Halfway Boulevard Freight Connection: Making Way for Economic Growth and Safety Project continues a multi-state effort to widen I-81, and provide a vital local highway connection between I-70 and I-81, which together will better serve the freight and personal transportation needs of western Maryland and the Appalachian Region.

The Project represents a critical investment in one of the most heavily utilized freight corridors in the United States. Only four lanes wide, the Maryland segment of I-81 carries freight volumes among the highest in the nation by lane mile, falling within the top one percent of all freight corridors. I-81 in the Project area today carries over 77,000 vehicles daily, more than 27% of which are trucks. Interstate travel (on I-81 and I-70) today accounts for 50 percent of the vehicle miles traveled (VMT) in Washington County. This traffic is expected to grow as well, with an estimated 70% increase in freight tonnage over the next two to three decades, and a 55% increase in overall traffic.

COSTS

The capital cost for this Project is expected to be $105.922 million in undiscounted 2019 dollars. To comply with the BCA guidance provided by US DOT, the costs are converted from their base year values in 2019 dollars to 2017 dollars to align with the standardized factors used to calculate the benefits and costs in the analysis. The discounted values are in 2017 dollars in the year 2019. At a 7 percent real discount rate, these costs are $84.6 million. Operations and maintenance costs are projected to average $0.01 million per year in the long term. Over the entire analysis period these costs accumulate to $6.9 million in undiscounted 2017 dollars, or $2.2 million when discounted at 7 percent. Finally, rehabilitation and replacement costs are expected to total $10.7 million in undiscounted 2017 dollars over this same period, or $8.4 million when discounted at 7 percent.

The Project is expected to be financed by Federal, State and Local funds according to the allocation shown in Table ES-1.

TABLE ES-1: Project Costs by Funding Source, in Undiscounted Millions of 2017 Dollars

	I-81 Improvements	Halfway Boulevard Extension	Total Amount	Total Percentage
INFRA Grant Request (Federal)	$55.0	--	$55.0	52%
Appalachian Regional Commission (Federal)	--	$3.8	$3.8	3.5 %
MDOT (State)	$42.6	--	$42.6	40%
Washington County	$1.0	$2.172	$3.172	3%
Private	--	$1.35	$1.35	1%
TOTAL	**$98.6**	**$7.322**	**$105.922**	**100%**

Source: Maryland Department of Transportation, 2019

BENEFITS

In 2017 dollars, the Project is expected to generate $113,875,359 in discounted benefits using a 7 percent discount rate. The addition of lanes and other improvements to I-81, and the extension of the highway connector will reduce the number of crashes within the I-81 Project segment, reduce congestion due to road closures and congestion (lack of capacity), and facilitate the movement of freight tonnage throughout the Halfway Boulevard economic development area within the I-81 corridor. The benefits lead to an overall Project Net Present Value of $29,234,796 and a Benefit Cost Ratio (BCR) of 1.34. The overall Project benefit matrix can be seen in Table ES-2.

Table ES-2: Project Impacts and Benefits Summary, Monetary Values in Millions of 2017 Dollars

Baseline & Problem to be Addressed	Change to Baseline	Type of Impact	Population Affected by Impact	Economic Benefit	Summary of Results (at 7% discount rate)	Page Reference in BCA
Economic Competitiveness	▼	Cost & Time Savings	Auto & Freight	Reduced travel time for persons	$36.0m	12
Safety	▼	# of Crashes	Auto & Freight	Avoided crashes	$66.8m	15
State of Good Repair	▼	Road Condition	Auto & Freight	Reduced damage to roads from reduced vehicle miles traveled (VMT)	$0.3m	16
Environmental Sustainability	▼	Air Quality	General Society	Lower emissions (reduced health risks)	$0.6m	16
Agency Cost Reductions	▲	O&M / R&R Costs	MDOT	Avoided rehabilitation costs	$2.9m	18

Source: WSP, 2019

The overall Project impacts can be seen in Table ES-3, which shows the magnitude of change and direction of the various impact categories.

Table ES-3: Project Impacts for the I-81/Halfway Boulevard Project, Cumulative 2019-2053

Category	Unit	Quantity	Direction
Vehicle-Miles Traveled	VMT	22,427,974	▼
Vehicle-Hours Traveled	VHT	4,449,730	▼
Fuel Consumed	gallons	2,363,916	▼
Fatalities	#	16	▼
Injury Accidents	#	583	▼
Property Damage Only (PDO)	#	642	▼
CO_2 Emissions	tons	49,042	▼
NO_X Emissions	tons	78.15	▼
PM^{10}	tons	1.56	▼
SO_X	tons	0.35	▼
VOC	Tons	14.25	▼

Source: WSP, 2019

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1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the ***Interstate 81/Halfway Boulevard Freight Connection: Making Way for Economic Growth and Safety Project*** for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the INFRA 2019 program. The following section describes the BCA framework, evaluation metrics, and report contents.

1.1 BCA FRAMEWORK

A BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of an investment alternative. Benefits and costs are quantified in monetary terms to the extent possible. The overall goal of a BCA is to assess whether the expected benefits of a project justify the costs from a national perspective. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off because of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the grant request is awarded and the project is built as proposed. The BCA assesses the incremental difference between the Base Case and the Build Case, which represents the net change in welfare, or benefit. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project life-cycle. The values of future welfare changes are determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

The analysis was conducted in accordance with the benefit-cost methodology as recommended by the U.S. DOT in the December 2018 *Benefit-Cost Analysis Guidance for Discretionary Grant Programs*.

The analysis methodology includes the following:

- Defining existing and future conditions under a No Build base case as well as under the Build Case;
- Estimating benefits and costs during project construction and operation, including 30 years of operations beyond the Project completion when benefits accrue;
- Using U.S. DOT recommended monetized values for reduced fatalities, injuries, property damage, travel time savings, and emissions, while relying on best practices for monetization of other benefits;
- Presenting dollar values in real 2017 dollars. In instances where cost estimates and benefits valuations are expressed in historical dollar years, using an appropriate Consumer Price Index (CPI) to adjust the values;
- Discounting future benefits and costs with real discount rates of 7 percent consistent with U.S. DOT guidance.

1.2 PRISM

This benefit cost analysis was done using PRISM™, a benefit cost analysis tool that uses a methodology consistent with the most recent guidelines developed by USDOT. The tool determines benefits according

to the following six categories: Economic Competitiveness; Safety; State of Good Repair; Environmental Sustainability; Agency Costs Reduction; and Residual Value.

1.3 REPORT CONTENTS

Section 2 contains an explanation of the benefit-cost analysis methodology and a description of the project

Section 3 contains a detailed explanation and calculation of the project costs

Section 4 contains a detailed explanation and calculation of the benefit categories

Section 5 contains the detailed results of the benefit-cost analysis

2 PROJECT OVERVIEW

2.1 DESCRIPTION

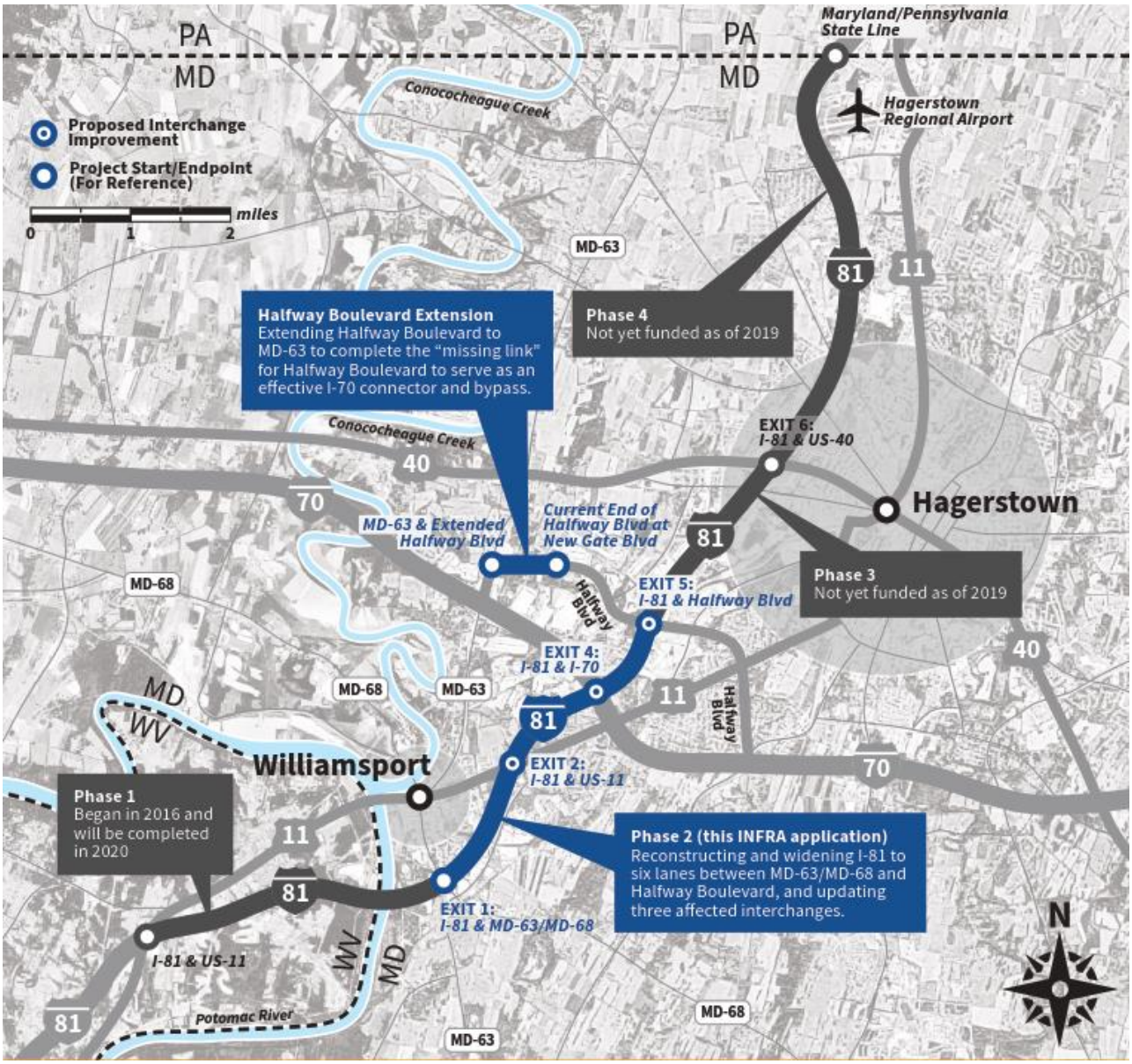
The ***Interstate 81/Halfway Boulevard Freight Connection: Making Way for Economic Growth and Safety Project (***the Project) includes two components: a much-needed widening and upgrade of a 3.5-mile section of I-81, and a 0.6-mile extension of Halfway Boulevard to create a new link between interstate interchanges on I-81 and I-70, opening land for development along this new road segment. Figure 1 below shows the project area limits and elements in blue.

The I-81 component of the Project, known as I-81 Phase 2, will convert an existing 4-lane to a 6-lane cross section on Interstate 81 in Washington County, Maryland. I-81 Phase 2 is one component of a four-phase, 12.1-mile, multi-year project with an estimated total project cost of $386.7 million. The four phases of this I-81 corridor expansion project are shown in Figure 1, which also shows the three interchanges that will be improved as part of the Phase 2 work (U.S. 11, I-70, and Halfway Boulevard).

The Halfway Boulevard extension is the other component of the Project. Halfway Boulevard is the location of a number of warehouse/distribution facilities and truck services (tires, repair, fuel, and rest areas). Currently it links only to I-81. This Project would extend it to reach MD 63, just a half mile north of its interchange with I-70, creating a much shorter trip to I-70 west for the many truck trips originating at (or destined to) businesses on Halfway Boulevard.

The Project lies wholly within Washington County, Maryland.

Figure 1. Project Context



2.2 GENERAL ASSUMPTIONS

2.2.1 *EVALUATION PERIOD*

For the project, the evaluation period includes the construction period during which capital expenditures are undertaken, plus 30 years of operations beyond the project completion within which to evaluate ongoing benefits and costs.

For the purposes of this study, it has been assumed that final design and construction of the project will begin in 2019, with construction completed by the end of 2023 and operations beginning in 2024. As such, the 30-year evaluation period concludes in 2053.

2.2.2 DISCOUNT RATES

For purposes of present value discounting, all benefits and costs are conservatively assumed to occur at the end of each year. Benefits accruing from the improvements are assumed to begin in the calendar year immediately following the final construction year.

For project costs and benefits, monetary values in this analysis are expressed in constant, year-end 2017 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values from other (historical) years, the U.S. Bureau of Labor Statistics' Consumer Price Index for All Urban Consumers (CPI-U) was used to adjust them to 2017 prices.[1]

The real discount rate used for this analysis is 7.0 percent, consistent with U.S. DOT guidance for Discretionary Grant Programs[2] and OMB Circular A-4.[3]

2.3 BASE CASE AND BUILD CASE

The analysis of the Project considered how the balance of costs and benefits resulting from the construction of the project improvements would result in long-term benefits to its users and general society, compared to a future without the Project.

In the "Build" Case, the Project includes the expansion of I-81 from 4 lanes to 6 lanes between the U.S 11 interchange and the Halfway Boulevard interchange, as well as interchange modernization of the three interchanges in this segment. It also includes the extension of Halfway Boulevard west to meet MD 63.

The "No Build" Case examines the societal costs of not building these two Project components, while traffic continues to increase, resulting in additional crashes, increased traffic delays, increased damage to the existing highway infrastructure, and increased costs for vehicles.

[1] U.S. Bureau of Labor Statistics. Consumer Price Index, All Urban Consumers, U.S. City Average, Series CUSR0000SA0. 1982-1984=100

[2] US DOT. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Updated December 2018; https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance

[3] White House Office of Management and Budget, Circular A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (October 29, 1992). (http://www.whitehouse.gov/omb/circulars_a094).

3 PROJECT COSTS

3.1 CAPITAL COSTS

Initial Project investment (capital) costs include engineering and design, construction, and contingency factors totalling $105.9 million in current dollars. In undiscounted 2017 dollars, the total Project cost is $102,761,677. Table 2 shows timing assumptions, with expenditures beginning in 2019 and ending in 2023. The improved facilities are expected to be open and operational at the beginning of 2024.

Table 1: Project Costs, Current Dollars

Project Activity	I-81 Phase 2	Halfway Boulevard Extension	Project Total
Land, Rights-of-Way, Appraisals	$1,900,000	*donated*	$1,900,000
Architectural, Engineering and Design	$12,849,050	$100,000	$12,949,050
Project Inspection Fees	$12,767,041	$250,000	$13,017,041
Construction	$61,454,636	$6,972,000	$68,426,636
Sub-Total	$88,970,727	$7,322,000	$96,292,727
Contingencies	$9,629,273	*(incl in above)*	$9,629,273
Total	**$98,600,000**	**$7,322,000**	**$105,922,000**

Source: Washington County & Maryland Department of Transportation, 2019

Table 2: Project Schedule and Cost in 2017$

Variable	Unit	Value
Construction/Design Start	year	2019
Construction End	year	2023
Construction Duration	years	5
Project Opening	year	2024
Capital Cost – Construction, Professional Services, and Right-of-Way	$2017 M	$102.8

Source: Maryland Department of Transportation, 2019

3.2 OPERATIONS AND MAINTENANCE COSTS

The annual costs of operating and maintaining the project are included in the analysis. Since the project segment includes an existing asset requiring continued maintenance, operating and maintenance costs are assumed to continue in 2019 and then increase in 2023 with the first year of Project operation.

In the “Build” Case, the operations and maintenance costs for the project include the patching and resurfacing of the four existing highway lanes, the two new highway lanes and the highway shoulders.

The "No Build" Case includes the operating and maintenance costs of only the four existing highway lanes and the highway shoulders. The O&M cost for the extension of Halfway Boulevard is also included.

The annual combined operations and maintenance costs for the "Build" and the "No Build" Case for the project segment are shown in Table 2.

3.3 REPAIR AND REHABILITATION (R&R) COSTS

The I-81 lanes will need to be replaced or rehabilitated during the evaluation period. Rehabilitation of the highway lanes will occur every 25 years, per the standard practices of the Maryland Department of Transportation. Because the Build will include resurfacing of existing lanes, the R&R cost will occur around 25 years after construction, in 2049. The No Build will require R&R work soon on the existing lanes (assumed to be in 2025) and again 25 years later (2050).

The results are shown in Tables 3 and 4 below.

Table 3: Schedule of Operations and Maintenance and Repair/Rehabilitation/Replacement Costs (in 2017 Dollars)

Year	Build		No Build	
	O&M	R&R	O&M	R&R
2019	$0	$0	$0	$0
2020	$0	$0	$0	$0
2021	$0	$0	$0	$0
2022	$0	$0	$0	$0
2023	$0	$0	$0	$0
2024	$228,959	$0	$161,047	$0
2025	$228,959	$0	$161,047	$6,306,064
2026-2048 (each year)	*$228,959*	*$0*	*$161,047*	*$0*
2049	$228,959	$10,671,800	$161,047	$0
2050	$228,959	$0	$161,047	$6,306,064
2051	$228,959	$0	$161,047	$0
2052	$228,959	$0	$161,047	$0
2053	$228,959	$0	$161,047	$0

Source: Maryland Department of Transportation, 2019

Table 4: Net Change in Operations and Maintenance and Repair/Rehabilitation/Replacement Costs (in 2017 Dollars)

Year	Change Between Build and No Build	
	O&M	R&R
2019	$0	$0
2020	$0	$0
2021	$0	$0
2022	$0	$0
2023	$0	$0
2024	$67,911	$0
2025	$67,911	($6,306,064)
2026-2048 (each year)	*$67,911*	*$0*
2049	$67,911	$10,671,800
2050	$67,911	($6,306,064)
2051	$67,911	$0
2052	$67,911	$0
2053	$67,911	$0

Source: Maryland Department of Transportation, 2019

4 PROJECT BENEFITS

The benefits of the project improvements can be described in two categories: user benefits, including travel time savings and vehicle operating costs; and social benefits, including emissions reductions and the reduction in damage to property and humans resulting from crash incidents. The analysis covers the following benefit categories:

- Travel Time Savings
- Safety Benefits
- Vehicle Operating Cost Savings
- Reduced Pavement Damage
- Reduced Emissions
- Reduced Agency O&M and R&R Costs
- Residual Value of the Project

The analysis uses standardized factors provided by USDOT Guidance and other government and industry sources to determine the monetized value of user and social benefits resulting from the Project improvements. These benefits include the reduction of existing costs or the prevention of future costs related to the operation and use of the existing road facilities. Table 5 summarizes the benefit categories.

Table 5: Project Benefits by Category

Type of Benefit	Description	Monetized (Discounted 2017$M)
Travel Time Savings	Elimination of bottlenecks in the freight supply chain; reduction in barriers separating workers from employment centers	$30.5
Safety	Reduction in crashes, including fatalities, injuries & property damage	$66.8
Vehicle Operating Cost Savings (including Fuel)	Reduction in vehicle miles travelled resulting in less fuel used and reduced wear and tear on trucks and other vehicles	$5.5
Reduced Pavement Damage	Reduced pavement damage as a result of lower VMT for some trips on Halfway Boulevard	$0.3
Reduced Emissions	Enhancement of the natural environment; reduced health risks	$0.6
Reduced Agency O&M/R&R Costs	Investment in infrastructure (specifically resurfacing of existing lanes on I-81) reducing near-term rehabilitation costs compared to No Build	$0.0
Residual Value	Promotion of good infrastructure condition, supporting commerce	$2.9

4.1 DEMAND PROJECTIONS

The analysis incorporates growth projections developed by the Maryland Department of Transportation using INRIX traffic demand modeling to project future growth in traffic and incidents. The analysis resulted in a projected annual growth rate in VMTs of approximately 1.14%.

Much of the benefits are derived from savings in vehicle miles traveled (VMT) and vehicle hours traveled (VHT). Assumptions used in calculating these two figures for each of the analysis' benefit years (2024-2053) are shown in Table 6.

Table 6: Demand Projection Assumptions and Sources

Variable	Unit	Value	Source
Traffic VMT Growth Rate	% increase / year	1.14%	MDOT Traffic Projection
Traffic Volume and Travel Speed Projections	Average MPH in 2040	Varies by year	MDOT SHA Phase 2 Traffic Operations Analysis
Crash Modification Factor	% crash reduction factor per addl. lane	40%	West Virginia Crash Reduction Data/USDOT
Crash Rate Projections	# of crashes from 2025 to 2040	Varies by year	I-81 Phase 2 Safety Analysis Study
Trip Generation for Industrial Park Uses	Trips per 1000 square feet of building	1.4-14.98 (average 3.37)	ITE Trip Generation Manual
Halfway Boulevard Truck Trips	% of total daily trips	40%	Local Business Operational Demands

Project effects that lead to changes in VMT and VHT are listed below.

VMT: Reductions in vehicle miles traveled (specifically truck miles traveled) are derived from the fact that trucks heading to I-70 west from locations along Halfway Boulevard will be able to travel a shorter route to access I-70. Factors for trips generated by "Industrial Park" and other land uses were applied to locations where the Halfway Boulevard would provide a benefit for drivers heading to (or from) I-70 west of the MD 63 interchange. Mileage saved per (round) trip varied from just under a mile to over 2.5 miles. Total daily trip generation was calculated, it was assumed that 40% of the trips were truck trips, and that 15% of these trips were headed to or from I-70 West. Auto trips were not examined in this category, as it was unknown how many visitors or commuters would be heading to or from this area from I-70. Commuters are more likely to come from the north or south, and visitors (e.g., I-70 drivers stopping for fuel or food), are unlikely to know about and utilize Halfway Boulevard (most will enter and exit I-70 at the same interchange).

VHT: Reductions in vehicle hours traveled or person hours traveled (PHT) were calculated from three different Project effects. Reduced hours of travel are often called travel time savings or avoided delay.

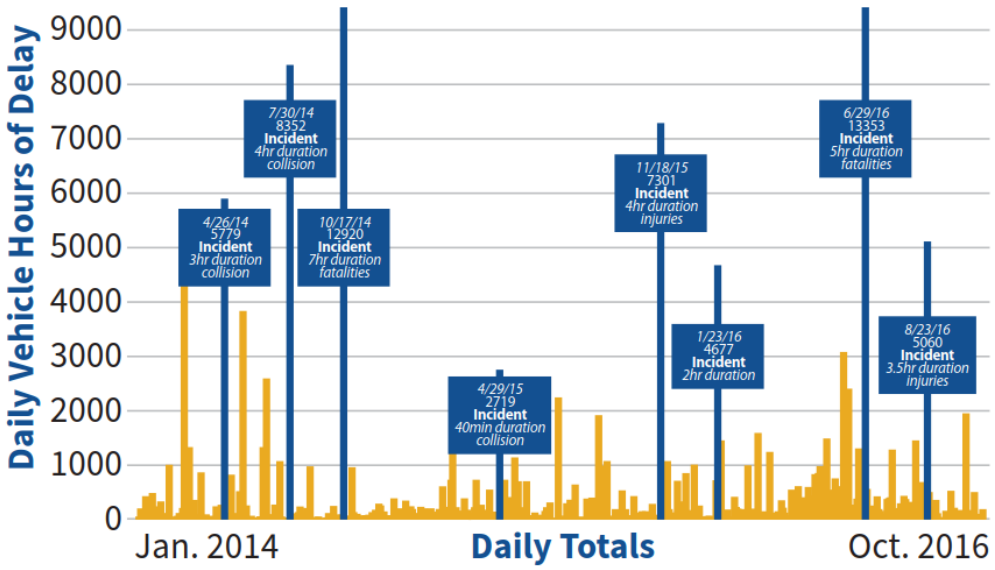
- Avoided crash-related delay –there are currently a high number of accidents on I-81 in the Project area. Approximately 20% involve trucks, and when an accident blocks one or both of the two

lanes (either northbound or southbound), the traffic backlog can literally last for hours, involving thousands of vehicles (Figure 2).

- Travel time savings on I-81 – resulting from increased capacity (one additional lane in each direction), as well as traffic operation benefits from interchange upgrades

- Reduced truck hours related to the VMT savings (shorter trips) for trucks traveling between Halfway Boulevard and I-70 west.

Figure 2. INRIX daily vehicle hours of delay and major crashes on Maryland I-81



The resulting demand projections are presented in Table 7.

Table 7: No Build and Build Demand Projections

Variable	Project Opening Year		Final Year of Analysis	
	No Build	Build	No Build	Build
Traffic Volume (VMT, Truck)	395,730	394,410	1,105,743	1,129,146
Traffic Volume (VMT, Auto)	2,062,100	2,055,226	5,761,897	5,883,845
Total Traffic Volume (VMT)	2,457,830	2,449,636	6,867,640	7,012,991
Crash Incidents	89.5	89.5	118.8	118.8
Travel Time Delays (PHT, Truck)	10,062	9,984	18,777	18,739
Travel Time Delays (PHT, Passenger Vehicle)	52,430	52,027	97,846	97,649

4.2 ECONOMIC COMPETITIVENESS

This Project would contribute to increasing the economic competitiveness of the Nation and the study area through improvements in the mobility of people and goods on two interstates (I-81 and, to a lesser extent, I-70) and on Halfway Boulevard. All of these roads are on the National Highway Freight Network. Two types of societal benefits are measured in the assessment of economic competitiveness: travel time savings and vehicle operating savings.

With the reduction of congestion and decrease in crash-related delay from the improvements to I-81, and the traffic efficiency resulting from the Halfway Boulevard extension, travel time savings and vehicle operating cost savings are significant direct benefits for users of the Project roads. The user benefits represent a reduction of future costs related to the personal and commercial use of the roadways. The reduction in time delays and vehicle distance traveled enables the freight truck industry to deliver goods across the country in a more cost- and time-efficient manner, impacting nearly all economic industries active regionally and nationally. As a central component of a major intercity transportation corridor on the Atlantic Coast, the Project segment facilitates travel for personal and other business-related activities, improving the reliability and costs of travel for regional users.

The reduction in travel time for passenger vehicles and trucks resulting from the three Project effects listed in the previous section is expected to total 4.5 million person-hours and truck-hours saved. The more efficient use of the roadway network enabled by the Halfway Boulevard extension is expected to reduce 22.4 million truck miles traveled over the 30-year benefit analysis period. The reduction in vehicle miles traveled will result in the conservation of approximately 2.4 million gallons of fuel for commercial truck users. The cost savings in operating costs and travel time savings from the reduction in vehicle miles traveled is calculated to be $35.96 million in discounted 2017 dollars.

Table 8: Economic Competitiveness Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Total Travel Time Savings	**$2.57m**	**$1.83m**	**$107.40m**	**$30.50m**
Total Operating Cost Savings	**$0.59m**	**$0.42m**	**$17.19m**	**$5.46m**

4.2.1 *VALUATION OF TRAVEL TIME SAVINGS*

Travel time savings includes in-vehicle travel time savings for auto drivers and passengers as well as truck drivers. Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities. The reduction in travel time for the project is calculated to be $30.50 million in 2017 dollars.

Table 9: Travel Time Savings Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Travel Time Savings - Auto	$1.76m	$1.25m	$76.66m	$21.49m
Travel Time Savings - Truck	$0.82m	$0.58m	$30.74m	$9.01m

The assumptions used in the valuation of travel time savings benefits are presented in the following table.

Table 10: Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Value of Travel Time Savings - Personal, Local	2017$ per person hour	$14.80	US DOT Guidance, December 2018
Value of Travel Time Savings - Business, Local	2017$ per person hour	$26.50	US DOT Guidance, December 2018
Value of Travel Time Savings - All Purposes, Local	2017$ per person hour	$16.10	US DOT Guidance, December 2018
Value of Travel Time Savings - Personal, Intercity	2017$ per person hour	$20.70	US DOT Guidance, December 2018
Value of Travel Time Savings - Business, Intercity	2017$ per person hour	$26.50	US DOT Guidance, December 2018
Value of Travel Time Savings - All Purposes, Intercity	2017$ per person hour	$21.94	US DOT Guidance, December 2018
Value of Travel Time - Real Growth Rate	Annual Rate	1.20%	US DOT Guidance, 2014
Average Vehicle Occupancy Rate, Passenger Vehicle	Persons per vehicle	1.68	US DOT Guidance, December 2018
Average Vehicle Occupancy Rate, Truck	Persons per vehicle	1	US DOT Guidance, December 2018

4.2.2 *OPERATING COST SAVINGS*

Vehicle operating cost savings includes the cost of fuel, as well as maintenance and repair, replacement of tires, and the depreciation of the vehicle over time. Consumption rates per vehicle mile travelled (VMT) are used to calculate the vehicle operating cost savings. Estimates of VMT and unit costs for each component of vehicle operating cost are applied to the consumption rates to calculate the total vehicle operating cost. The assumptions used in the estimation of vehicle operating costs are presented in the following table. This table also includes additional out-of-pocket operating costs such as user fees and parking fees. The operating cost savings associated with the reduction in vehicle miles traveled is calculated to be $5.46 million in discounted 2017 dollars.

Table 11: Operating Cost Savings Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year	Project Lifecycle

	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Fuel Savings – Truck	$0.27	$0.19	$7.65	$2.45
Vehicle O&M Costs – Truck	$0.32	$0.23	$9.54	$3.01
Total Operating Cost Savings	**$0.59**	**$0.42**	**$17.19**	**$5.46**

The assumptions used in the estimation of operating cost savings benefits are presented in the following table.

Table 12: Operating Cost Savings Assumptions and Sources

Variable	Unit	Value	Source
Auto Maintenance, Repair & Tires	2018$/VMT	$0.09	AAA "Your Driving Costs" 2018
Auto Depreciation	2018$/VMT	$0.24	AAA "Your Driving Costs" 2018
Truck Maintenance & Repair	2017$/VMT	$0.17	ATRI 2018 Update
Truck Tires	2017$/VMT	$0.04	ATRI 2018 Update
Truck Depreciation	2018$/VMT	$0.23	AAA "Your Driving Costs" 2018
Gasoline Costs	2017$/gal, incl. taxes	range from $2.53 (2019) to $3.67 (2050)	US EIA, "Annual Energy Outlook 2018," Table 12
Diesel Costs	2017$/gal, incl. taxes	range from $2.78 (2019) to $4.09 (2050)	US EIA, "Annual Energy Outlook 2018," Table 12
Fuel Growth post-2050	% Growth	1.2% for gasoline; 1.3% for diesel	Calculated based on CAGR from EIA forecast
Federal Fuel Taxes	2019$	$0.184 (gasoline); $0.244 (diesel)	API, "State Motor Fuel Taxes by State", January 2019
State of Maryland Fuel Taxes	2019$	$0.320 (gasoline); $0.388 (diesel)	API, "State Motor Fuel Taxes by State", January 2019
Auto Fuel Efficiency	Miles per Gallon	range from 23.67 (2019) to 38.18 (2050)	US EIA, "Annual Energy Outlook 2018," Table 7
Truck Fuel Efficiency	Miles per Gallon	range from 7.34 (2019) to 10.45 (2050)	US EIA, "Annual Energy Outlook 2018," Table 7
Fuel Efficiency Growth post-2050	% Growth	1.6% (gasoline); 1.2% (diesel)	Calculated based on CAGR from EIA forecast
Auto Fuel Efficiency Adjustment Factor	Factor	range from 1.00 (55 MPH) to 3.70 (5 MPH)	US EIA 2013
Truck Fuel Efficiency Adjustment Factor	Factor	range from 1.00 (55 MPH) to 2.57 (5 MPH)	US EIA 2013

4.3 SAFETY

The safety benefits assessed in this analysis include a reduction in fatalities and injuries, as well as a reduction in property damage crash costs resulting directly from the Project.

The relatively high volume of freight trucks as a percentage of the total traffic volume in the I-81 corridor and the high rates of crash incidents within the 3.5-mile Project segment result in significant interruptions to the delivery of goods, as well as damage to property and people. With the high traffic volumes limited to two lanes in each direction, incidents involving trucks and passenger vehicles occur regularly. From 2012 to 2017, 371 crashes occurred within the 3.5-mile project segment, including 141 injuries and two fatalities. The expansion of the highway allows for an improved segregation of truck and passenger vehicles and reduced collisions between drivers, resulting in a projected reduction in crashes and delay-causing incidents by an average of 40%, or 35 to 48 crashes annually. The prevention of these crash incidents is calculated to be $66.8 million in discounted 2017 dollars.

The projected decrease in accidents is from the MDOT I-81 Phase 2 Safety Analysis Study. It is based on a 40% reduction in crashes – a number approved by USDOT in a de-brief call regarding a previous grant application BCA for I-81 Phase 2. The previous analysis applied the full 80 percent reduction in crashes that was experienced on a recent widening of the West Virginia segment of I-81, which was improved just a mile to the south of I-81 Phase 2. That segment experienced an 80 percent drop in accidents when crashes during the four years prior to the 4-to-6 lane expansion were compared to the four years after the widening was opened to traffic. It was felt to be more conservative to assume a 40 percent reduction.

Table 13: Safety Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Fatality Reduction	$4.15	$2.96	$154.61	$45.81
Injury Reduction	$1.29	$0.92	$66.97	$20.16
Property Damage Reduction	$0.08	$0.06	$2.76	$0.83
Total Safety Benefits	**$5.52**	**$3.94**	**$224.34**	**$66.81**

The analysis assumes constant accident rates for the “Build” and “No Build” scenarios. As a result, any changes in the number of accidents between the opening year and out-years will be a result of growth in VMT, not of structural changes to the safety conditions on the roadway network. The assumptions used in the valuation of safety benefits are presented in the following table.

Table 14: Safety Benefits Assumptions and Sources

Variable	Unit	Value
Cost per Fatality	2017$	$9,600,000
Cost per MAIS 5 Injury	2017$	$5,692,800
Cost per MAIS 4 Injury	2017$	$2,553,600
Cost per MAIS 3 Injury	2017$	$1,008,000
Cost per MAIS 2 Injury	2017$	$451,200
Cost per MAIS 1 Injury	2017$	$28,800
Cost per Property-Damage Only Crash	2017$	$4,300

Source: US DOT Guidance, December 2018

4.4 STATE OF GOOD REPAIR

The state of good repair benefits assessed in this analysis include maintenance and repair savings, deferral of replacement cost savings, as well as reduced VMT which leads to less road and pavement damage.

As the traffic volumes in the I-81 corridor are projected to continue to rise, the reduction in crash-related delays and traffic congestion will result in a decline in damages to local road infrastructure affected by diverted traffic. The two-lane highway is prone to partial and full closure following an incident, diverting traffic to the local road network for an alternative route due to the lack of an adjacent highway or streets meant for large traffic volumes. The prevented damages to the local road infrastructure are calculated to be $0.34 million in discounted 2017 dollars.

Table 15: State of Good Repair Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Pavement Damage – Trucks	$0.03m	$0.02m	$0.96m	$0.34m

The assumptions used in the valuation of state of good repair benefits are presented in the following table.

Table 16: State of Good Repair Benefits Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Pavement Cost	2017$ / VMT	$0.0002	derived from FHWA, Cost Allocation Study, 2000
Truck Average Pavement Cost	2017$ / VMT	$0.0458	derived from FHWA, Cost Allocation Study, 2001

4.5 ENVIRONMENTAL SUSTAINABILITY

This Project will create environmental and sustainability benefits relating to reduction in air pollution associated with decreased automobile and commercial truck travel. The benefits of reducing air pollution include decreases in health complications. The reduction of emissions associated with automobile and truck travel as a result of project improvement are projected to be $0.46 million in discounted 2017 dollars.

Table 17: Environmental Sustainability Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Total Emissions Reduction	**$0.10**	**$0.07**	**$1.17**	**$0.46**

The assumptions used in the estimation of environmental sustainability benefits are presented in the following sub-sections.

4.5.1 *EMISSIONS REDUCTION*

Five forms of emissions were identified, measured and monetized, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide.

Related to decreases in vehicle miles traveled, the reduction of emissions represents a benefit enjoyed by persons who do not directly use the road facility. The reduction in gasoline consumption due to less miles traveled results in fewer emissions, including sulfur dioxide and fine particulate matter, being released into the local environment. As the emissions resulting from the combustion of fuels are known to cause health problems and property damage, their reduction is projected to result in avoided costs of $0.46 million in discounted 2017 dollars.

Table 18: Emissions Reduction Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
CO2 Emissions Reduction	$0.00	$0.00	$0.06	$0.02
NOx Emissions Reduction	$0.04	$0.03	$0.64	$0.23
SOx Emissions Reduction	$0.00	$0.00	$0.01	$0.00
PM Emissions Reduction	$0.06	$0.04	$0.50	$0.22
VOC Emissions Reduction	$0.00	$0.00	$0.02	$0.01

The assumptions used in the estimation of emissions reduction benefits are presented in the following table.

Table 19: Emissions Reduction Assumptions and Sources

Variable	Unit	Value	Source
Cost of CO2 emissions	2017$ per metric ton	$1 through 2035, $2 thereafter	US DOT Guidance, Dec. 2018 (converted from short tons)
Cost of NOx emissions	2017$ per metric ton	$9,142.45	US DOT Guidance, Dec. 2018 (converted from short tons)
Cost of PM10 emissions	2017$ per metric ton	$416,146.70	US DOT Guidance, Dec. 2018 (converted from short tons)
Cost of SOx emissions	2017$ per metric ton	$53,863.35	US DOT Guidance, Dec. 2018 (converted from short tons)
Cost of VOC emissions	2017$ per metric ton	$2,203.00	US DOT Guidance, Dec. 2018 (converted from short tons)
Emissions per VMT	Metric tons of emissions per VMT	Varies by year, fuel type, and emission type	California Air Resources Board EMFAC Database, 2017; Cal B/C, 2010; EPA MOVES, 2014
Emissions Speed Adjustment Factors	Factor	Varies by year, fuel type, emission type, and speed	California Air Resources Board EMFAC Database, 2014

4.6 AGENCY COST REDUCTIONS

Project improvements resulting in reductions in agency costs related to the operation, maintenance, repair or rehabilitation of an asset are derived from the fact that the I-81 Phase 2 component of the Project includes the resurfacing of existing lanes on I-81. In the No Build, these lanes would need to be repaired in the near future (assuming 2025), and again 25 years after that (2050). Over the analysis period, the addition of the highway lanes will result in an increase in annual operations & maintenance costs and a decrease in occasional repair & rehabilitation costs that nets to a savings of $2.93 million in discounted 2017 dollars.

Table 20: Agency Costs Reduction Estimation of Benefits, Millions of 2017 Dollars

Benefit	Project Opening Year*		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Change in O&M Costs	($0.07m)	($0.05m)	($2.04m)	($0.64m)
Change in R&R Costs	$6.31m	$4.20m	$1.94m	$3.57m
Total Agency Cost Reduction Benefits	**$6.24m**	**$4.15m**	**($0.10m)**	**$2.93m**

* The savings is high in the Opening Year (2025) because that is the scheduled year for rehabilitation and repair work in the No Build. In the Build, no rehabilitation would be required in 2025.

The assumptions used in the estimation of residual value benefits are presented in the following table.

Table 21: Agency Costs Reduction Assumptions and Sources

Variable	Unit	Frequency	Source
Operations & Maintenance Costs	2017$	Annual	MDOT SHA
Repair & Rehabilitation	2017$	Every 25 Years	MDOT SHA

4.7 RESIDUAL VALUE

The residual value is calculated by determining the percentage of useful life remaining beyond the analysis period, and multiplying that percentage by the construction cost for that component. Since we are using a 30-year analysis period and a 100-year design life, the residual value is 70% of the initial cost using the straight-line depreciation method. The remaining capital value is viewed as cost offset or "negative cost" and is applied to the last year of analysis period as a negative value. This residual value, already expressed in 2017 dollars, is discounted back to $7.07 million in the BCA calculations.

Table 22: Residual Value Estimation of Benefits, Millions of 2017 Dollars

Benefit	Final Analysis Year	
	Undiscounted	Discounted (7%)
I-81 Improvements Remaining Capital Value in Final Year	$66.46	$6.66
Halfway Blvd Remaining Capital Value in Final Year	$4.06	$0.41
Remaining Land Value in Final Year	$2.03	$0.00
Total Residual Value Benefits	**$72.54**	**$7.07**

The assumptions used in the estimation of residual value benefits are presented in the following table.

Table 23: Residual Value Assumptions

Asset Name	Expected Life Span (Years)	Capital Cost	Last Purchase Year
Interstate-81 Improvements	100	$94,940,218	2023
Halfway Boulevard	100	$5,793,817	2023
Right of Way & Land Acquisition Costs	100	$2,027,642	2021

5 SUMMARY OF RESULTS

5.1 EVALUATION MEASURES

The benefit-cost analysis converts potential gains (benefits) and losses (costs) from the Project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this BCA:

- Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.
- Benefit Cost Ratio (BCR): The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The BCR expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of the costs.
- Internal Rate of Return (IRR): The IRR is the discount rate which makes the NPV from the Project equal to zero. In other words, it is the discount rate at which the Project breaks even. Generally, the greater the IRR, the more desirable the Project.

5.2 BCA RESULTS

The table below presents the evaluation results for the project. Results are presented in undiscounted, discounted at 7 percent as prescribed by the U.S. DOT. All benefits and costs were estimated in constant 2017 dollars over an evaluation period extending 30 years beyond system completion in 2023.

The total benefits from the project improvements within the analysis period are calculated to be $111.7 million in discounted 2017 dollars. The total capital costs, including engineering, construction, and right-of-way and land acquisition, are calculated to be $84.6 million in discounted 2017 dollars. The difference of the discounted benefits and costs equal a net present value of $27.1 million in discounted 2017 dollars, resulting in a benefit-cost ratio (BCR) of 1.34. The internal rate of return for the project is 10%.

Table 24: Benefit Cost Analysis Results, Millions of 2017 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (7%)
Total Benefits	$423.9	$113.9
Total Costs	$102.8	$84.6
Net Present Value (NPV)	$321.1	$29.2
Benefit Cost Ratio (BCR)	4.13	1.3
Internal Rate of Return (IRR)	10%	N/A

The benefits over the project lifecycle are presented in the table below by U.S. DOT long-term outcome category. As the table shows, more than half (58.9 percent) of benefits are derived from reduced crashes, with an additional 31.6 percent of the benefits from reduced travel time and vehicle operating costs.

Table 25: Benefits by Long-Term Outcome, Millions of 2017 Dollars

Long-Term Outcome	Project Lifecycle		Percent of Benefit (using discounted 7%)
	Undiscounted	Discounted (7%)	
Economic Competitiveness	$124.6	$36.0	31.6%
Safety	$224.3	$66.8	58.7%
State of Good Repair	$1.0	$0.3	0.3%
Environmental Sustainability	$1.4	$0.6	0.5%
Agency Costs Reduction	($0.1)	$2.9	2.6%
Residual Value	$72.5	$7.1	6.4%

5.3 OTHER NON-QUANTIFIED BENEFITS

There are a number of other Project benefits that could not be reasonably quantified for the benefit-cost analysis. Among these are:

- The projected reduction in crashes might be underestimated for two reasons. First, the widening of I-81 just a mile south of the Project in West Virginia has led to an 80% drop in crashes (comparing the four years before the opening of 6 lanes to the four years before). Second, the growth in No Build accidents was increased at the same annual rate as traffic growth. In reality, as traffic and congestion grow, it is likely that accidents will grow faster than the increase in traffic volumes. This is due to lower Level of Service, which makes it more difficult for vehicles to change lanes and enter/exit a highway safely.
- Travel time savings and vehicle operating cost savings of commuters on Halfway Boulevard were not captured as part of the Project benefits due to the challenges in determining their arrival-destination trips, instead, only the benefits to truck traffic were captured;
- The benefits to new users, due to local induced demand, were not considered in the analysis. Only travel time savings for trips that would be made in the No Build.
- Benefits related to truck driver hours of service (HOS) requirements. Truck travel time savings is valued at $26.50 per hour for long-distance travel in this analysis. However, the Halfway Boulevard area provides services for truckers during mandated rest breaks, including a soon-to-open secure, reservable overnight truck parking facility. Truck drivers recently surveyed indicated that they spend an hour a day on average looking for safe truck parking for their rest breaks. For a truck driver nearing his or her limit for the day, knowing that there are faster, more reliable travel times, and (for I-70) shorter distances to drive, may enable them to drive a little further before having to stop for the day. This potential for increased truck driver productivity was not assessed in the BCA.