I-81/HALFWAY BOULEVARD FREIGHT CONNECTIONS: PROVIDING OPPORTUNITIES FOR ECONOMIC GROWTH, EQUITABLE JOB ACCESS, AND IMPROVED SAFETY

BENEFIT-COST ANALYSIS REPORT

FY2021 INFRA DISCRETIONARY GRANT PROGRAM

Prepared for: Maryland Department of Transportation State Highway Administration & Washington County, Maryland

March 19, 2021

MARYLAND DEPARTMENT OF TRANSPORTATION

Washington County MARYLAND

EXECUTIVE SUMMARY

A benefit-cost analysis (BCA) was conducted for the **Interstate 81/Halfway Boulevard Freight Connections: Providing Opportunities for Economic Growth, Equitable Job Access and Improved Safety** Project ("the Project") for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the INFRA 2021 program. The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the 2021 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The period of analysis corresponds to 26 years and includes 6 years of construction and 20 years of benefits after operations begin in 2027.

The 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 costs of the Project include costs related to right-of-way acquisition, engineering and design, and construction total $91.4 million in year-of-expenditure dollars. Adjusted for inflation, capital costs for this Project are expected to be $82.6 million in undiscounted 2019 dollars, as shown by type of expense and year in Table ES-1.[1] At a 7 percent real discount rate, these costs are $60.3 million.

Table ES-1: Project Costs by Year, in Undiscounted Millions of of 2019 Dollars

Project Activity	2021	2022	2023	2024	2025	2026	Project Total
Architectural, Engineering and Design	$2.3	$4.9	$2.8	-	-	-	**$10.0**
Rights-of-Way Acquisition	-	-	-	-	-	-	**-**
Construction	-	-	$2.8	$16.7	$24.5	$28.5	**$72.5**
Total	**$2.3**	**$4.9**	**$5.6**	**$16.7**	**$24.5**	**$28.5**	**$82.5**

Source: Maryland Department of Transportation, 2021

Annual operations and maintenance costs in the Build scenario are projected to average $236,000 in undiscounted 2019 dollars, compared to $164,000 in the No Build scenario. Over the entire analysis period, the net operations and maintenance costs accumulate to $0.5 million in undiscounted 2019 dollars, or cost savings of $0.3 million when discounted at 7 percent. Finally, savings in rehabilitation and replacement costs are expected to total $17.0 million in undiscounted 2019 dollars over this same period, or $13.2 million when discounted at 7 percent.

BENEFITS

In 2019 dollars, the Project is expected to generate $82.9 million 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 $22.7 million and a Benefit Cost Ratio (BCR) of 1.38**. 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 2019 Dollars

Baseline & Problem to be Addressed	Change to Baseline	Type of Impact	Population Affected by Impact	Summary of Results (at 7% discount rate)	Page Reference in BCA
Traffic congestion in the Project area results in slower average speeds and reduced vehicle throughput for business, personal and freight travel	Infrastructure changes reduce bottlenecks, improving speeds	Travel Time Savings	Auto & Freight	$26.7	11
Congestion and merging traffic results in frequent sideswipe and rear-end collisions	The additional lane in the I-81 Highway mainline reduces dangerous weaving conditions	Crash Reduction	Auto & Freight	$31.4	13
Road damage due to detouring traffic on local infrastructure	Reduced damage to roads from reduced vehicle miles traveled (VMT)	Road Condition	Auto & Freight	$0.6	15
Congestion in the project area suppresses vehicle throughput and traffic volumes	Infrastructure changes reduce bottlenecks and detours amidst increasing volumes	Vehicle Operating Cost Savings	Auto & Freight	$9.3	13
		Emissions Reductions	General Society	$1.4	15

Source: WSP, 2021

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 2021-2046

Category	Unit	Quantity	Direction
Vehicle-Miles Traveled	VMT	42,773,747	▼
Person-Hours Traveled	PHT	3,970,285	▼
Fatalities	#	3	▼
Injury Accidents	#	205	▼
Property Damage Only (PDO)	#	507	▼
CO_2 Emissions	tons	24,677	▼
NO_X Emissions	tons	22.46	▼
PM^{10}	tons	0.61	▼
SO_X	tons	0.25	▼

Source: WSP, 2021

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1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the **Interstate 81/Halfway Boulevard Freight Connections: Providing Opportunities for Economic Growth, Equitable Job Access and Improved Safety** Project ("the Project") for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the INFRA 2021 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 lifecycle. 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 February 2021 *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 20 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 2019 dollars. In instances where cost estimates and benefits valuations are expressed in historical or future dollar years, using an appropriate inflation factor to adjust the values;
- Discounting future benefits and costs with real discount rates of 7 percent consistent with U.S. DOT guidance.

1.2 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

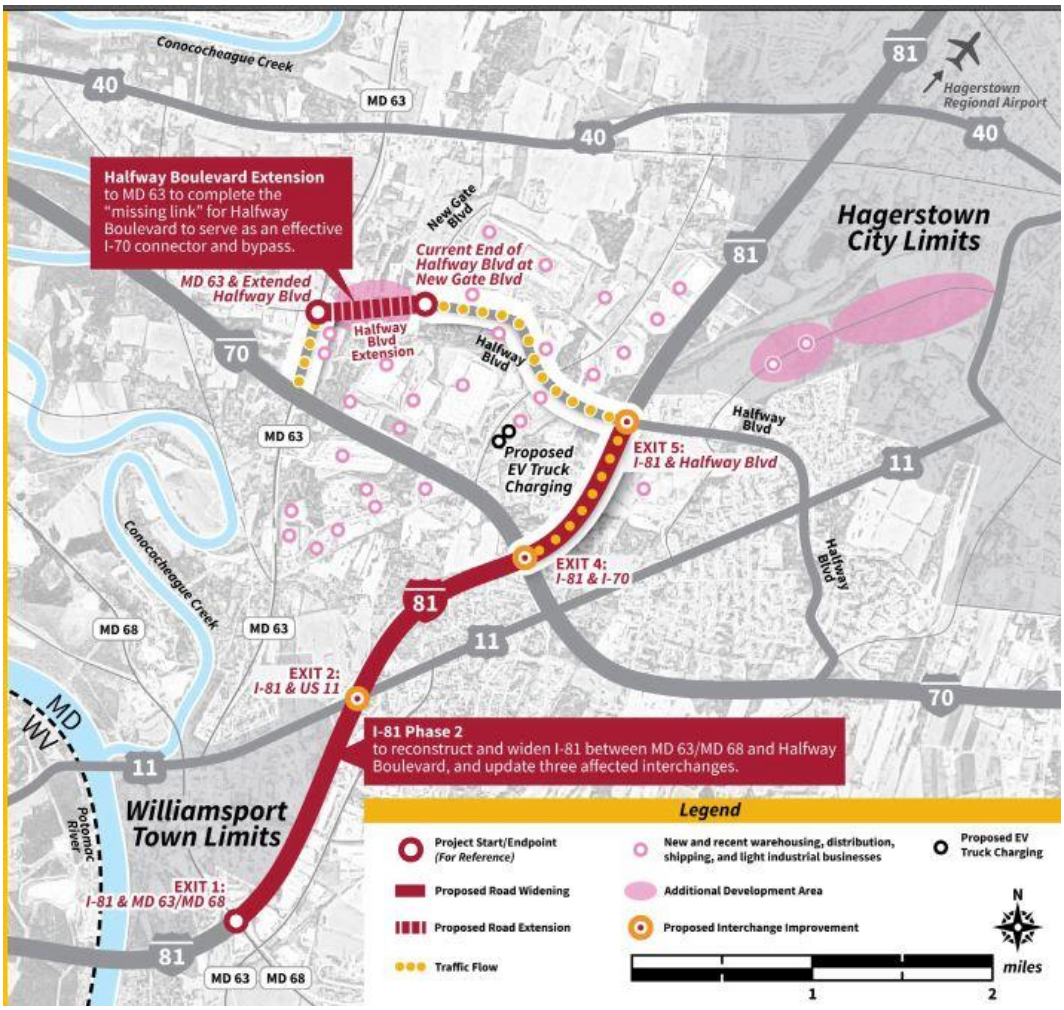
The **Interstate 81/Halfway Boulevard Freight Connections: Providing Opportunities for Economic Growth, Equitable Job Access and Improved Safety** Project (the "Project") includes two components: a much-needed widening and upgrade of a 3.5-mile section of I 81, and a 0.6-mile extension of Halfway Boulevard 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: Interstate 81/Halfway Boulevard Freight Connections Phases



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 20 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 the environmental services and engineering work of the project began in 2020, with construction to be completed by 2026 and operations beginning in 2027. As such, the 20-year evaluation period concludes in 2046.

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 year immediately following the final construction year in 2026.

For project costs and benefits, monetary values in this analysis are expressed in constant, year-end 2019 dollars. In instances where certain cost estimates or benefit valuations were expressed in dollar values from other (historical) years, the U.S. Bureau of Economic Analysis' Implicit Price Deflator for Gross Domestic Product was used to adjust them to 2019 prices.[2]

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

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 Interstate 81 from four lanes to six lanes between the U.S 11 interchange and the Halfway Boulevard interchange, as well as interchange modernization of the three interchanges in this segment. The expansion of the highway will include and additional lane in each direction of travel. In addition to the expansion of the highway, a westward extension of Halfway Boulevard will be constructed to connect with Maryland Route 63 and an electric vehicle charging station will be installed.

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.

[2] U.S. Department of Transportation. *Benefit-Cost Analysis Guidance for Discretionary Grant Applications*. February 2021. Citing Bureau of Economic Analysis, National Income and Product Accounts, Table 1.1.9, "Implicit Price Deflators for Gross Domestic Product".

[3] US DOT. Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Updated February 2021; https://www.transportation.gov/office-policy/transportation-policy/benefit-cost-analysis-guidance

[4] 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

The capital costs of the Project include costs related to right-of-way acquisition, engineering and design, and construction totaling $91.4 million in year-of-expenditure dollars. Adjusted for inflation, the total capital cost of the Project is $82.6 million in undiscounted 2019 dollars.

Table 1 shows the schedule of construction and operations for the Project with capital activities starting in 2021 and ending in 2026.

Table 1: Project Schedule and Cost in Millions of Undiscounted 2019 Dollars

Project Activity	2021	2022	2023	2024	2025	2026	Project Total
Architectural, Engineering and Design	$2.3	$4.9	$2.8	-	-	-	**$10.0**
Rights-of-Way Acquisition	-	-	-	-	-	-	**-**
Construction	-	-	$2.8	$16.7	$24.5	$28.5	**$72.5**
Total	**$2.3**	**$4.9**	**$5.6**	**$16.7**	**$24.5**	**$28.5**	**$82.5**

Source: Maryland Department of Transportation, 2021

3.2 OPERATIONS AND MAINTENANCE COSTS

The annual costs of operating and maintaining the project improvements are included in the analysis, calculated as the net costs between the "Build" and "No Build" scenarios. As the project segment includes an existing asset requiring continued maintenance, the incremental operations and maintenance costs required for the "Build" condition are included, beginning when the project opens in 2026 and continuing throughout the analysis period. In the "No Build" case, the annual operations and maintenance costs to be incurred during the proposed construction period and the operations period are included.

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, the highway shoulders and the extension of Halfway Boulevard. The "No Build" Case includes the operating and maintenance costs of only the four existing highway lanes and the highway shoulders. The annual combined operations and maintenance costs for the "Build" and the "No Build" Case for the project segment are shown in Table 2.

Per USDOT guidance, these net O&M costs are included as a benefit in the numerator of the benefit-cost equation.

Table 2: Schedule of Operations and Maintenance Costs (in Undiscounted 2019 Dollars)

Year	O&M		
	Build	No Build	Net Change
2021 – 2026 (each year)	$0	$164,000	($164,000)
2027 - 2046 (each year)	$236,000	$164,000	$72,000

Source: Maryland Department of Transportation, 2021

As shown in Table 3, net O&M cost savings throughout the analysis period are $0.3 million in 2019 dollars, discounted using a 7 percent rate.

Table 3: Operations and Maintenance Cost Savings, Millions of 2019 Dollars

Benefit	Project Full Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Net O&M Costs	$0.16	$0.15	($0.46)	$0.27

The assumptions for calculating the operations and maintenance costs are described below in Table 4.

Table 4: Operations and Maintenance Cost Savings Assumptions

Variable	Unit	Value	Source
I-81 Highway Annual Maintenance Cost – No Build	2019$	$164,000	Maryland DOT SHA
I-81 Highway Annual Maintenance Cost - Build	2019$	$234,000	Maryland DOT SHA
Halfway Boulevard Annual Maintenance Cost - Build	2019$	$2,000	Maryland DOT SHA

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 10 years, per the standard practices of the Maryland Department of Transportation. Because the "Build" Case will include resurfacing of existing lanes, the R&R cost will occur every 10 years after construction, in 2033 and 2043. The "No Build" Case will require R&R work soon on the existing lanes, assumed to be in 2022, and then in 10-year increments thereafter in 2032 and 2042. The schedule of annual and periodic maintenance and repair costs are shown in Table 5 below.

Table 5: Schedule of Operations and Maintenance and Repair/Rehabilitation/Replacement Costs (in Undiscounted 2019 Dollars)

Year	Build		No Build		Change	
	O&M	R&R	O&M	R&R	O&M	R&R
2021	$0	$0	$164,000	$0	($164,000)	$0
2022	$0	$0	$164,000	$13,000,000	$164,000)	($13,000,000)
2023	$0	$0	$164,000	$0	($164,000)	$0
2024	$0	$0	$164,000	$0	($164,000)	$0
2025 - 2031 (each year)	*$236,000*	*$0*	*$164,000*	*$0*	*$72,000*	*$0*
2032	$236,000	$0	$164,000	$13,000,000	$72,000	($13,000,000)
2033	$236,000	$11,000,000	$164,000	$0	$72,000	$11,000,000
2034 - 2041 (each year)	*$236,000*	*$0*	*$164,000*	*$0*	*$72,000*	*$0*
2042	$236,000	$0	$164,000	$13,000,000	$72,000	($12,803,700)
2043	$236,000	$11,000,000	$164,000	$0	$72,000	$11,000,000
2044 - 2046 (each year)	*$236,000*	*$0*	*$164,000*	*$0*	*$72,000*	*$0*

Source: Maryland Department of Transportation, 2021

As shown in Table 6, net R&R cost savings throughout the analysis period are $13.2 million in 2019 dollars, discounted using a 7 percent rate.

Table 6: Operations and Maintenance Costs, Millions of 2019 Dollars

Benefit	Project Full Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Net R&R Cost Savings	$13.00	$11.35	$17.00	$13.18

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. As this project is anticipated to increase VMT, some of the benefit categories in fact include disbenefits, though these are far outweighed by the project benefits.

The analysis covers the following benefit categories:

- Travel Time Savings
- Safety Benefits
- Vehicle Operating Cost Savings
- Avoided Pavement Damage
- Emissions Reductions

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 7 summarizes the benefit categories.

Table 7: Project Benefits by Category in Millions of Discounted 2019 Dollars

Type of Benefit	Description	Monetized
Travel Time Savings	Elimination of bottlenecks in the freight supply chain; time savings in commute and business travel in the Mid-Atlantic region	$26.7
Safety	Reduction in crashes, including fatalities, injuries & property damage, in the Interstate 81 corridor	$31.4
Vehicle Operating Cost Savings (including Fuel)	Change in the fuel used and wear and tear on trucks and other vehicles based on improved vehicle throughput in the Interstate 81 corridor	$0.3
Reduced Pavement Damage	Reduced pavement damage as a result of lower VMT from shorter trips on Halfway Boulevard and Interstate 81	$0.6
Reduced Emissions	Reduced emissions due to higher average travel speeds and shorter trips on Halfway Boulevard and Interstate 81	$1.4

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 traffic analysis used growth in traffic volumes and travel time from the existing conditions to develop a projection in the years 2020 and 2040 for the “Build” and “No Build” Cases. The traffic analysis primarily provides travel delay and traffic volumes on the ramps and mainline of the Interstate 81 within the limits of the Project area. For Halfway Boulevard, the projections of traffic mix and volumes are

based on reports from the lessors on the Halfway Boulevard industrial development area. The analysis resulted in a projected annual growth rate in VMTs of approximately 1.14%.

The majority of benefits are calculated from savings in vehicle miles traveled (VMT) and vehicle hours traveled (VHT) and reductions in annual crashes. Assumptions used in calculating these values from the analysis period of 2027 to 2046 are shown in Table 8 below.

Table 8: 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	26%	"Install an Additional Lane", CMF ID: 8336
Crash Rate Projections	# of crashes from 2025 to 2040	Varies by year	I-81 Phase 2 Safety Analysis Study
Crash Rate Annual Growth Rate	Annual growth in crashes	1.14 %	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
Electric Vehicles as Percentage of Total Auto Trips with Charging Stations	% of total daily trips	2.5%	MDOT Traffic Projection

Project effects that lead to changes in vehicle-miles traveled (VMT) and vehicle-hours traveled (VHT) are listed below.

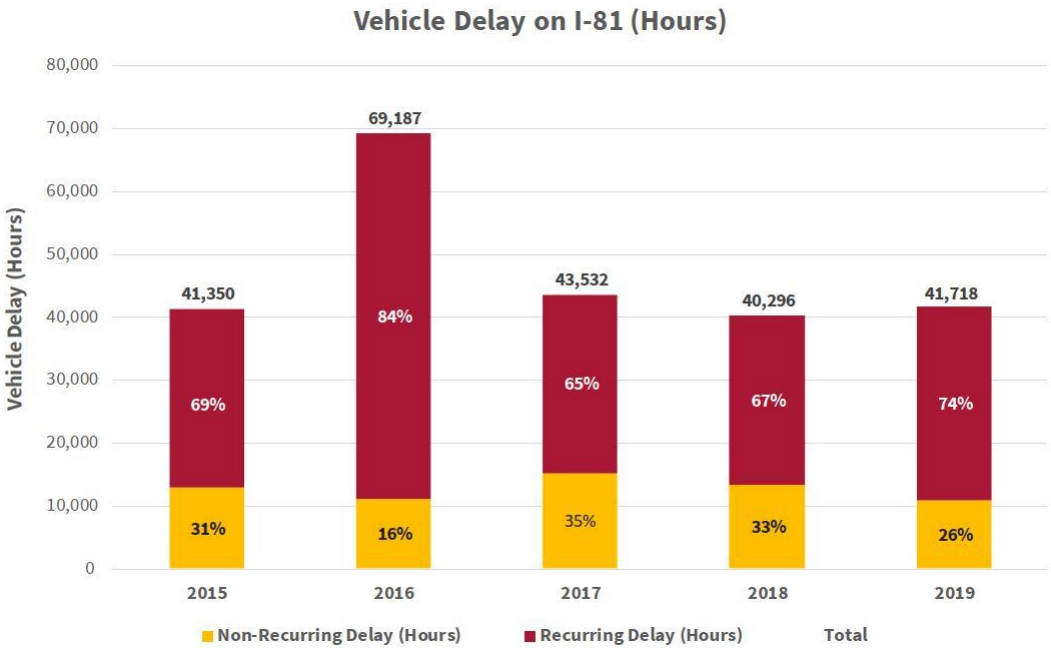
Vehicle-Miles Traveled: Reductions in vehicle miles traveled (specifically truck miles traveled) are derived from the fact that trucks heading to I-70 west from locations along Halfway Boulevard will be able to travel a shorter route to access I-70. Factors for trips generated by "Industrial Park" and 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. The percentage of traffic diverting to I-70 West over Halfway Boulevard was applied to auto trips starting or ending at the industrial park complex, which include customers, commuters and commercial traffic. The installation of

electric vehicle charging stations around the project area is expected to replace an equivalent number of gas-powered vehicles related to commuter and commercial traffic with electric vehicles.

Vehicle-Hours Traveled: 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 Interstate 81



The resulting demand projections for vehicle-miles traveled by vehicle type are detailed in Table 9 below.

Table 9: Annual No-Build and Build Demand Projections

Variable	Project Opening Year		Final Year of Analysis	
	No Build	Build	No Build	Build
Traffic Volume (VMT, Truck)	1,137,600	638,400	1,444,000	788,000
Traffic Volume (VMT, Auto)	2,825,000	1,702,800	3,323,900	1,916,500
Total Traffic Volume (VMT)	3,962,600	2,341,200	4,767,800	2,704,600
Crash Incidents	123	91	153	113
Travel Time Delays (PHT, Truck)	28,000	-	38,500	-
Travel Time Delays (PHT, Auto)	131,700	-	211,100	-

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 4.1 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 18.4 million truck-miles traveled over the 20-year benefit analysis period. The cost savings in operating costs and travel time savings from the reduction in vehicle-miles traveled is calculated to be $9.9 million in discounted 2019 dollars.

Table 10: Economic Competitiveness Estimation of Benefits, Millions of 2019 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Travel Time Savings	**$3.2**	**$2.0**	**$79.6**	**$26.7**
Net Vehicle Operating Cost Savings	**$1.2**	**$0.7**	**$27.2**	**$9.3**

4.2.1 *VALUATION OF TRAVEL TIME SAVINGS*

Reductions in vehicle hours traveled or person hours traveled (PHT) were calculated from the changes in the project area as a result of the project improvements. Reduced hours of travel are often called travel time savings or avoided delay. Travel time savings on Interstate 81 and Halfway Boulevard are due to the

increased highway capacity, as well as reductions in crash-related delays, reductions in trip duration over Halfway Boulevard and reductions in time truck drivers spend looking for parking.

Travel time savings were calculated in much the same way as changes in VMT, relying on the INRIX traffic analysis of Interstate 81, which also estimated vehicle hours traveled (VHT). The daily VHT estimates are shown in Table 11.

Table 11: Estimated Annual VHT on Interstate 81 under No-Build and Build Conditions

Year	No-Build	Build
2016	36,098	
2020	38,339	38,052
2040	49,543	49,502

Source: INRIX Traffic Analysis, Maryland Department of Transportation

Like with VMT, annual VHT were projected for each year using compound annual growth rates derived from these base years, and these were adjusted to account for a start of operations in 2025.

Annual VHT were then allocated across automobile and truck categories and annualized, based on the assumptions shown above in Table 10. In addition, the VHT were multiplied by vehicle occupancy factors to derive total passenger hours traveled (PHT). To convert these PHT to dollar values, USDOT recommended values of travel time and estimates of business and personal travel shares. These assumptions are detailed in Table 12.

Table 12: Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Value of Travel Time Savings - Personal, Local	2019$ per person hour	$16.50	US DOT Guidance, February 2021
Value of Travel Time Savings - Business, Local	2019$ per person hour	$27.90	US DOT Guidance, February 2021
Value of Travel Time Savings - All Purposes, Local	2019$ per person hour	$17.90	US DOT Guidance, February 2021
Value of Travel Time Savings – Truck Drivers	2019$ per person hour	$30.80	US DOT Guidance, February 2021
Average Vehicle Occupancy Rate, Passenger Vehicle	Persons per vehicle	1.67	US DOT Guidance, February 2021
Average Vehicle Occupancy Rate, Truck	Persons per vehicle	1	US DOT Guidance, February 2021

Based on these assumptions, the total reduction in travel time for the project is calculated to be $26.7 million in discounted 2019 dollars, divided between savings for automobile users and trucks as shown in Table 13.

Table 13: Travel Time Savings Estimation of Benefits, Millions of 2019 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Travel Time Savings - Auto	$2.4	$1.5	$59.3	$19.8
Travel Time Savings - Truck	$0.9	$0.5	$20.3	$6.9
Total Travel Time Savings	**$3.2**	**$2.0**	**$79.6**	**$26.7**

4.2.2 CHANGE IN VEHICLE OPERATING COSTS

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 Table 14 below.

Table 14: Vehicle Operating Cost Assumptions and Sources

Variable	Unit	Value	Source
Vehicle Operating Costs – Light Duty Vehicles	2019$/VMT	$0.43	US DOT Guidance, February 2021
Vehicle Operating Costs – Commercial Trucks	2019$/VMT	$0.93	US DOT Guidance, February 2021

The operating cost savings associated with the reduction in vehicle miles traveled is calculated to be $9.3 million in discounted 2019 dollars, as detailed in Table 15 below.

Table 15: Change in Vehicle Operating Costs, Millions of 2019 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Change in Vehicle O&M Costs – Auto	$0.5	$0.3	$10.8	$3.7
Change in Vehicle O&M Costs – Truck	$0.7	$0.4	$16.4	$5.6
Total Change in Vehicle Operating Costs	**$1.2**	**$0.7**	**$27.2**	**$9.3**

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 2015 to 2019, 562 crashes occurred within the 3.5-mile project segment, including 161 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 26%, or 32 to 39 crashes annually.

The projected decrease in accidents is based on 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 26 percent reduction with an annual growth rate of 1.14%, based on data of crashes in the Project area from 2015 to 2019 and the crash modification factor related to constructing an additional highway lane.

Table 16: Project Area Crashes by Type, 2015-2019

Crash Type	2015	2016	2017	2018	2019	Total	Annual Average
Fatalities	0	1	1	0	0	**2**	**0.4**
Injuries	58	58	45	55	23	**239**	**32.2**
Property Damage Only	61	78	113	111	36	**399**	**79.8**
Total Crashes	**96**	**112**	**150**	**148**	**56**	**562**	**112.4**

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 crashes in recent years.

The prevention of these crash incidents is calculated to be $31.4 million in discounted 2019 dollars, as shown in Table 17, based on the unit costs per crash included in Table 18.

Table 17: Safety Estimation of Benefits, Millions of 2019 Dollars

Benefit	Project Opening Year			Project Lifecycle		
	Number	Undiscounted	Discounted (7%)	Number	Undiscounted	Discounted (7%)
Fatalities	0.1	$1.4	$0.9	2.5	$30.7	$10.6
Injuries	9.2	$2.6	$1.6	202.3	$58.1	$20.0
Property Damage Only	22.7	$0.1	$0.1	501.4	$2.3	$0.8
Total Safety Benefits	**31.9**	**$4.1**	**$2.5**	**706.1**	**$91.1**	**$31.4**

The assumptions used in the valuation of safety benefits are presented in Table 18 below.

Table 18: Safety Benefits Assumptions and Sources

Variable	Unit	Value	Source
Cost per Property-Only Damage Crash	2019$	$4,500	US DOT Guidance, February 2021
Cost per Injury	2019$	$284,100	US DOT Guidance, February 2021
Cost per Fatality	2019$	$12,071,000	US DOT Guidance, February 2021
Annual Growth Rate in Crashes	% CAGR	1.0%	MDOT I-81 Phase 2 Safety Analysis Study
Crash Modification Factor	factor	0.74	"Install an Additional Lane", CMF ID: 8336

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 $0.6 million in discounted 2019 dollars.

Table 19: State of Good Repair Estimation of Benefits, Millions of 2019 Dollars

Benefit	Project Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Pavement Damage	$0.1	$0.1	$1.8	$0.6

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

Table 20: State of Good Repair Benefits Assumptions and Sources

Variable	Unit	Value	Source
Auto Average Pavement Cost	2019$ / VMT	$0.001	derived from FHWA, Cost Allocation Study, 2000
Truck Average Pavement Cost	2019$ / VMT	$0.098	derived from FHWA, Cost Allocation Study, 2001

4.5 EMISSIONS REDUCTION

As described above, this project will improve traffic conditions in the project area, creating 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. Five forms of emissions are measured and monetized in this analysis, including: nitrous oxide, particulate matter, sulfur dioxide, volatile organic compounds, and carbon dioxide. The emissions associated with the change in VMT are calculated based on emissions per VMT factors. The reduction of emissions associated with automobile and truck travel as a result of project improvement are projected to be $1.4 million in discounted 2019 dollars.

Table 21: Emissions Reduction Estimation of Benefits, Millions of 2019 Dollars

Benefit	Project Full Opening Year		Project Lifecycle	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
CO2 Emissions Reduction	$71,500	$58,100	$1,690,500	$1,033,400
NOx Emissions Reduction	$26,900	$16,800	$402,200	$147,000
SOx Emissions Reduction	$500	$300	$12,100	$4,200
PM Emissions Reduction	$44,600	$27,800	$513,400	$197,400
Total Emissions Reduction	**$143,600**	**$103,000**	**$2,618,200**	**$1,382,000**

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

Table 22: Emissions Reduction Assumptions and Sources

Variable	Unit	Value	Source
Cost of CO2 emissions	2019$ per metric ton	$50 (in 2020) - $84 (in 2050)	US DOT Guidance, February 2021
Cost of NOx emissions	2019$ per metric ton	$15,700 (in 2020) - $18,000 (in 2050)	US DOT Guidance, February 2021
Cost of PM2.5 emissions	2019$ per metric ton	$729,300 (in 2020) - $852,700 (in 2050)	US DOT Guidance, February 2021
Cost of SOx emissions	2019$ per metric ton	$40,400 (in 2020) - $48,200 (in 2050)	US DOT Guidance, February 2021
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

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 2019 dollars over an evaluation period extending 20 years beyond system completion in 2026.

The total benefits from the project improvements within the analysis period are calculated to be $82.9 million in discounted 2019 dollars. The total capital costs, including engineering, construction, and right-of-way and land acquisition, are calculated to be $60.3 million in discounted 2019 dollars. The difference of the discounted benefits and costs equal a net present value of $22.7 million in discounted 2019 dollars, resulting in a **benefit-cost ratio (BCR) of 1.38**. The internal rate of return for the project is 12%.

Table 23: Benefit Cost Analysis Results, Millions of 2019 Dollars

BCA Metric	Project Lifecycle	
	Undiscounted	Discounted (7%)
Total Benefits	**$219.1**	**$82.9**
Travel Time Savings	$79.6	$26.7
Safety	$91.1	$31.4
Vehicle Operating Cost Savings (including Fuel)	$27.2	$9.3
Reduced Pavement Damage	$1.8	$0.6
Reduced Emissions	$2.6	$1.4
Agency O&M Cost Savings	$16.5	$13.4
Total Costs	**$82.6**	**$60.3**
Net Present Value (NPV)	**$136.5**	**$22.7**
Benefit Cost Ratio (BCR)	**2.65**	**1.38**
Internal Rate of Return (IRR)	**12%**	