2020 BUILD GRANT – BENEFIT COST ANALYSIS
MARYLAND DEPARTMENT OF TRANSPORTATION MARYLAND TRANSIT ADMINISTRATION (MDOT MTA)
BUILDING BALTIMORE PENN STATION CONNECTIONS

A benefit-cost analysis (BCA) was conducted for the **Building Baltimore Penn Station Connections** by the Maryland Department of Transportation Maryland Transit Administration (MDOT MTA) for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the BUILD 2020 program. The analysis was conducted in accordance with the benefit-cost methodology as outlined by U.S. DOT in the 2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs. The period of analysis corresponds to 30 years after operations begin in 2024.

The project includes dedicated bus lanes and curb extensions on Charles Street and St. Paul Street, and improved curbside management for more efficient intermodal connections. Improved bicycle and pedestrian connectivity are expected to improve travel time for users of the Baltimore Penn Station. Reduced delays are also expected to reduce operating costs for the MDOT MTA. In addition, there are several benefits such as improved safety, signage, and convenience features that are not quantified in this BCA but discussed qualitatively in the main narrative.

COSTS

The capital cost for this Project is expected to be $10 Million in undiscounted 2018 dollars. Discounted at 7%, the present value of capital costs is $8.1 Million. The cost is summarized below in table ES-1.

Table ES-1: Project Impacts and Benefits Summary, Monetary Values in Millions of 2018 Dollars

Expenditure Type	Total Expenditure	Expenditure Start Date (Month/Year)	Expenditure End Date (Month/Year)
Preliminary Engineering and Planning, Inspection	$2,100,000	Feb-21	Nov-21
Construction	$7,900,000	Mar-23	Sept-24
TOTAL	**$10,000,000**	**n/a**	**n/a**

BENEFITS

The Project is expected to generate $11.6 Million discounted benefits using a 7 percent discount rate. The primary benefits are about $8.5 Million in travel time savings, and about $2.7 Million due reduced MDOT MTA operating costs. This leads to an overall project Net Present Value of $3.5 Million and a Benefit Cost Ratio (BCR) of 1.43[1]. The overall project benefit matrix can be seen in Table ES-2.

[1] Per USDOT guidance, operations and maintenance costs are included in the numerator along with other project benefits when calculating the benefit-cost ratio.

Table ES-2: Project Impacts and Benefits Summary, Monetary Values in Millions of 2018 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)
Economic Competitiveness	Dedicated bus lanes; improved curbside management	Cost & Time Savings	Station users; MDOT MTA	Reduced travel time; Reduced operating costs	$11.2
Safety	Crossing improvements and security cameras	# of Accidents	Station users	Avoided injuries and accidents	Qualitative
Residual Value		Residual Value of Assets	MDOT MTA	Residual Value of Assets	$0.4

Source: WSP, 2020

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, Cumulative 2025-2054

Category	Unit	Quantity	Direction
Passenger-Hours Traveled	PHT	1,619,294	▼
Transit O&M Cost	$PV (7%)	$2.7M	▼

Source: Compiled by WSP based on several datasets provided by the MDOT MTA, 2020

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1 INTRODUCTION

A benefit-cost analysis (BCA) was conducted for the **Building Baltimore Penn Station Connections Project** for submission to the U.S. Department of Transportation (U.S. DOT) as a requirement of a discretionary grant application for the BUILD 2020 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 broadly defined and 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 benefit change created by a project, including cost savings and increases in benefits, as well as disbenefits where costs can be identified (e.g., project capital costs), and benefit reductions where some groups are expected to be made worse off as a result 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 benefits. BCAs are forward-looking exercises which seek to assess the incremental change in benefits over a project life-cycle. The importance of future benefit changes is 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 2020 Benefit-Cost Analysis Guidance for Discretionary Grant Programs.[2] This methodology includes the following analytical assumptions:

- Assessing benefits with respect to each of the five long-term outcomes defined by the U.S. DOT;
- Defining existing and future conditions under a No Build base case as well as under the Build Case;
- Assessing the independent utility of each project if the overall application contains multiple separate projects linked together in a common objective;
- 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;

[2] U.S. Department of Transportation. Benefit-Cost Analysis Guidance for Discretionary Grant Programs. 2020.

- Presenting dollar values in real 2018 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 **Building Baltimore Penn Station Connections Project** (the Project) adds dedicated bus lanes and several curbside improvements that are expected to reduce travel time for Baltimore Penn Station users and reduce operating costs for the MDOT MTA. The following sections discuss how these benefits have been quantified.

2.1.1 *EVALUATION PERIOD*

For the project, the evaluation period 30 years of operations starting 2024. As such, the evaluation period ends in 2054.

2.1.2 *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 2018 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 2018 prices.[3]The real discount rates used for this analysis was 7.0 percent, consistent with U.S. DOT guidance for Discretionary Grant Programs[4] and OMB Circular A-4.[5]

2.2 BASE CASE AND BUILD CASE

The analysis of the project segment 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. In the "Build" Case assumes that the project is built with the proposed scope of work. The "No-Build" case assumes the status quo.

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

[4]Benefit-Cost Analysis Guidance for Discretionary Grant Programs, Updated January, 2020; https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf

[5] 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

Total capital costs of $10.0 Million (2018$) were included in the project budget as shown in Table 1.

Table 1: Project Schedule and Costs, Millions of 2018 Dollars

Variable	Unit	Value
Design Start	Year	2021
Construction Start	Year	2023
Construction End	Year	2024
Construction Duration	Years	2
Project Opening	Year	2025
Construction Cost	$M	$10.0

Source: MDOT MTA, 2020

4 PROJECT BENEFITS

The primary benefits of this project are reduced travel time and operating costs. Per USDOT BCA guideline, total benefits also include the residual value of the project. Table 2 shows how the benefit categories align with the merit criteria of the BUILD Grants program. The total benefits amount to $45.1 Million in undiscounted 2018 dollars, or $11.6 Million when discounted at 7%.

Table 2: Project Benefits by BUILD Merit Criteria (through 2053)

Type of Benefit	Relationship to BUILD Merit Criteria	Monetized (Discounted 2018$M)
Travel Time Savings	Dedicated bus lane and improved curbside management leads to lower travel time	$8.5
Reduced Transit Operating Costs	Reduced delays saves transit operating costs	$2.7
Residual Value of Assets		$0.4

4.1 TRAFFIC PROJECTIONS

A forecast of MDOT MTA transit ridership and travel time was provided by MDOT MTA, while the forecast of other users of the station such as Amtrak and curbside pick-up and drop-off using ride share and taxis was developed by WSP. While the Project Narrative presents projected growth in ridership across the modes (e.g., Amtrak, regional rail, etc.), for the purposes of the BCA a conservative approach has been taken to growth. Therefore, the travel time savings presented in this analysis and report are presumed to be on the low end of what will ultimately be realized through the Project's full implementation.

For the transit forecast, the selected bus lane improvement included 1.63 miles on Charles Street from Conway St. to North Ave., which has an average daily ridership of 23,934 including service by MDOT MTA, Johns Hopkins Shuttle, and Charm City Circulator buses. Based on observed delays, it was assumed that delays amount to about 1 minute per mile of bus operations, which when combined with the total daily ridership, leads to a total daily delay of 7,162 minutes of avoided delays. This is converted to annual passenger hours of delays of 31,034 by dividing by 60 to convert to hours, and then multiplying by a conservative annualization factor of 260. This calculation is summarized below in Table 3.

Table 3: Summary of Travel Time Savings Forecast

	Conway to Pratt	**Pratt to Fayette**	**Fayette to Mulberry**	**Mulberry to Centre**	**Madison to Oliver**	**Oliver to North**
Length (mi.)	0.13	0.26	0.25	0.14	0.55	0.30
Total Ridership	2,894	1,845	3,979	4,030	5,528	5,659
Daily Delays (mins)	389	479	1,002	572	3,015	1,704
Daily Delays (hrs)	6.49	7.98	16.70	9.54	50.25	28.40

Annual Delays (hrs)	1,686	2,075	4,343	2,480	13,066	7,384

Additional travel time savings are expected due to curb extensions at four bus stops from Mt Royal to Madison Street. Peak weekday ridership at these stops is estimated at about 11,381. It is assumed that curb extensions can reduce travel times by about 4 seconds per stop. The total annual passenger hours reduced from the curb extensions are calculated as (11,381 * 4)/3600 * 260 to give 3,288 passenger hours.

Combining the bus lane extension and curb extension, the total reduction in annual passenger hours traveled is calculated at about 34,322 passenger hours.

Next, WSP developed a forecast of passenger hours traveled for curbside pick-up and drop-offs including taxis and rideshare services. The methodology for this forecast is discussed below.

1. The first step is to estimate the growth in ridership by 2025 using the existing ridership at BPS for MARC and Amtrak. The estimated growth is based on projections provided by Amtrak, population increase, and planned service and infrastructure improvements at BPS.

2. The projected mode share in 2025 is applied to the passenger volumes. The result is total number of passengers using taxis, TNCs, or private vehicle pick-up/drop-off to access the station.

3. The bulk of the delay is associated with vehicle congestion, expected to happen during peak hours and peak shoulder hours. No congestion during off-peak hours is assumed.

4. Existing dwell and clearing times are projected to the 2025 growth, with the additional 1-2 minutes of delay per vehicle during peak hours and peak shoulder hours. This provides the delay in the 2025 No-Build scenario. Subtracting the 2025 Build scenario dwell and clearing time provides total delay savings per vehicle in minutes.

5. To calculate daily time savings in person-minutes and person-hours, volumes by mode are multiplied with respective mode's savings per vehicle. For annual delay savings, a Daily to Annual Factor of 303 was used in this analysis.

6. To calculate the delay savings, it was assumed that:

    a. Taxi passengers are essentially unaffected.

    b. Drop-offs are less affected than pick-ups, since some TNC and car drop-offs can occur without having to circulate through the curb roadways. Therefore, average time savings for drop-offs are reduced by 50%.

    c. Only some of the passengers in the peak periods experience delays (since demand is peaked, and there are times in the peaks when the curbside functions relatively smoothly). Therefore, it is assumed that 75% of peak hour passengers and 33% of peak shoulder hour passengers experience the delays.

Based on this methodology, the total reduction in passenger hours traveled (PHT) for pick-up/drop-offs was estimated at 19,654 PHT per year. These calculations are included in the attached spreadsheet model in the "Additional Ridership" tab for USDOT review.

Table 4: Traffic Projections Summary (2024-2053)

Variable	2024	2024-2053
Reduction in PHT from Bus ridership	34,322	1,029,660
Reduction in PHT from curb-side pick-up/drop-off	19,654	589,634

4.2 ECONOMIC COMPETITIVENESS

This project would contribute to increasing the economic competitiveness of the Nation through improvements in the mobility of transit riders at the Baltimore Penn Station and reduced travel time. Based on the traffic projections discussed above, the total PHT saved by this project over 30 years is estimated at about 1.6 Million PHT, of which 1.0 million PHT is due to bus ridership, while 0.6 million is due to curb-side pick-up/drop-offs. The travel time savings is calculated to be $8.5 million in discounted 2018 dollars. Travel Time Savings and assumptions are summarized below.

Table 5: Travel Time Savings Assumptions and Sources

Variable	Unit	Value	Source
Value of Travel Time Savings – Auto	2018$ per person hour	$16.60	US DOT Guidance, 2020
Value of Travel Time - Real Growth Rate	Annual Rate	0%	US DOT Guidance, 2020

Table 6: Travel Time Savings Estimation of Benefits, Millions of 2018 Dollars

Benefit	Project Opening Year (2024)		Project Lifecycle (2024-2053)	
	Undiscounted	Discounted (7%)	Undiscounted	Discounted (7%)
Travel Time Savings – Bus Ridership	$0.6	$0.4	$16.5	$3.1
Travel Time Savings – Curbside Users	$0.3	$0.2	$9.7	$5.4

4.3 SAFETY

The project scope includes several pedestrian and bike safety improvements such as crossing improvements and safety cameras. Even though these benefits are not quantified directly, they contribute to the overall importance of this project in improving the quality of life and safety in the project area. The Project Narrative further details these qualitative benefits for those who travel to, from, and through the Station and surrounding project area.

4.4 STATE OF GOOD REPAIR

No State of Good Repair benefits have been quantified for this project.

4.5 OPERATING COST SAVINGS

This section quantifies the operating cost savings to MDOT MTA due to improved travel times caused by the dedicated bus lanes. These costs include the additional cost of operating transit vehicles, and staff costs, and are estimated at about $163 per hour.

Earlier it was estimated that the project would reduce travel time by about 34,322 PHT per year for bus operations. Every bus trip on average has a ridership of 19.6. The average hours of delay reduced per trip is therefore 1,749 per year. Multiplying this by the average operating cost per hour gives a total cost saving of about $285,000 per year in 2018 dollars. The present value of these cost savings amount to about $2.7 Million when discounted at seven percent.

Table 7: Operating Cost Reduction Benefits Summary

Benefit	**Project Opening Year (2024)**		**Project Lifecycle (2024-2053)**	
	Undiscounted	**Discounted (7%)**	**Undiscounted**	**Discounted (7%)**
Transit Operating Cost Reduction	$0.29	$0.20	$8.6	$2.7

4.6 ENVIRONMENTAL SUSTAINABILITY

No environmental benefits have been quantified for this project.

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. The project improvements are assumed to have a useful life of 50 years and are depreciated on a straight line.

Table 8: Residual Value Estimation of Benefits, Millions of 2018 Dollars

Benefit	**Final Analysis Year (**2054**)**	
	Undiscounted	**Discounted (7%)**
Total Residual Value	**$4.0**	**$0.4**

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.
- Payback Period: The payback period refers to the period of time required to recover the funds expended on a 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 2018 dollars over an evaluation period extending 30 years starting in 2024.

The total discounted benefits from the project improvements within the analysis period are calculated to be $11.6 million in 2018 dollars. The total capital costs are $8.1 million in discounted 2018 dollars. The difference of the discounted benefits and costs equal a net present value of $3.5 Million in discounted 2018 dollars, resulting in a benefit-cost ratio (BCR) of 1.43.

Table 9: Benefit Cost Analysis Results, Millions of 2018 Dollars

BCA Metric	Project Lifecycle (30 years)	
	Undiscounted	Discounted (7%)
Total Benefits	$39.4	$11.6
Total Costs	$10.0	$8.1
Net Present Value (NPV)	$29.4	$3.5
Benefit Cost Ratio (BCR)	3.94	1.43
Internal Rate of Return (IRR)	N/A	10.5%

Payback Period (Year)	2032	2038

The benefits over the project lifecycle are presented in the table below by U.S. DOT long-term outcome category.

Table 10: Benefits by Long-Term Outcome, Millions of 2018 Dollars

Long-Term Outcome	**Project Lifecycle (2024-2053)**	
	Undiscounted	**Discounted (7%)**
Economic Competitiveness	$35.4	$11.2
Safety	Not quantified	Not quantified
State of Good Repair	Not quantified	Not quantified
Environmental Sustainability	Not quantified	Not quantified
Residual Value	$4.0	$1.2

The BCA results are summarized in the Appendix in

Table 11 and

Figure 1.

APPENDIX

Table 11: Summary of BCA Results

	Costs		*Benefits*					
Year	**CapEx (Undiscounted)**	**CapEx (Discounted @ 7%)**	**Travel Time Savings**	**Reduced Transit Operating Costs**	**Residual Value**	**Total Benefits (Undiscounted)**	**Total Benefits Discounted @ 7%**	**Net Benefits (Discounted @ 7%)**
2019	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-
2021	1,900,000	1,659,534	-	-	-	-	-	(1,659,534)
2022	4,900,000	3,999,860	-	-	-	-	-	(3,999,860)
2023	3,200,000	2,441,265	-	-	-	-	-	(2,441,265)
2024	-	-	896,009	203,274	-	1,099,284	842,117	842,117
2025	-	-	896,009	189,976	-	1,085,986	787,025	787,025
2026	-	-	896,009	177,548	-	1,073,557	735,537	735,537
2027	-	-	896,009	165,933	-	1,061,942	687,418	687,418
2028	-	-	896,009	155,077	-	1,051,087	642,447	642,447
2029	-	-	896,009	144,932	-	1,040,941	600,418	600,418
2030	-	-	896,009	135,450	-	1,031,460	561,138	561,138
2031	-	-	896,009	126,589	-	1,022,599	524,428	524,428
2032	-	-	896,009	118,308	-	1,014,317	490,120	490,120
2033	-	-	896,009	110,568	-	1,006,577	458,056	458,056
2034	-	-	896,009	103,334	-	999,344	428,089	428,089
2035	-	-	896,009	96,574	-	992,584	400,084	400,084
2036	-	-	896,009	90,256	-	986,266	373,910	373,910
2037	-	-	896,009	84,352	-	980,361	349,449	349,449
2038	-	-	896,009	78,833	-	974,843	326,587	326,587
2039	-	-	896,009	73,676	-	969,685	305,222	305,222
2040	-	-	896,009	68,856	-	964,866	285,254	285,254
2041	-	-	896,009	64,352	-	960,361	266,593	266,593
2042	-	-	896,009	60,142	-	956,151	249,152	249,152
2043	-	-	896,009	56,207	-	952,217	232,852	232,852
2044	-	-	896,009	52,530	-	948,539	217,619	217,619
2045	-	-	896,009	49,093	-	945,103	203,382	203,382
2046	-	-	896,009	45,882	-	941,891	190,077	190,077
2047	-	-	896,009	42,880	-	938,890	177,642	177,642
2048	-	-	896,009	40,075	-	936,084	166,020	166,020
2049	-	-	896,009	37,453	-	933,463	155,159	155,159
2050	-	-	896,009	35,003	-	931,012	145,009	145,009
2051	-	-	896,009	32,713	-	928,722	135,522	135,522
2052	-	-	896,009	30,573	-	926,582	126,656	126,656
2053	-	-	896,009	28,573	400,877	1,325,460	519,248	519,248
Total	*10,000,000*	*8,100,658*	*26,880,282*	*2,699,013*	*400,877*	*29,980,172*	*11,582,230*	*3,481,572*

APPENDIX

Figure 1: Cumulative Discounted Costs and Benefits