Technical Memorandum: Benefit-Cost Analysis of the Youngstown SMAR^{2}T Network Project

Date:	October 15, 2017
Subject:	Benefit-Cost Analysis for the Youngstown SMAR^{2}T Network Project

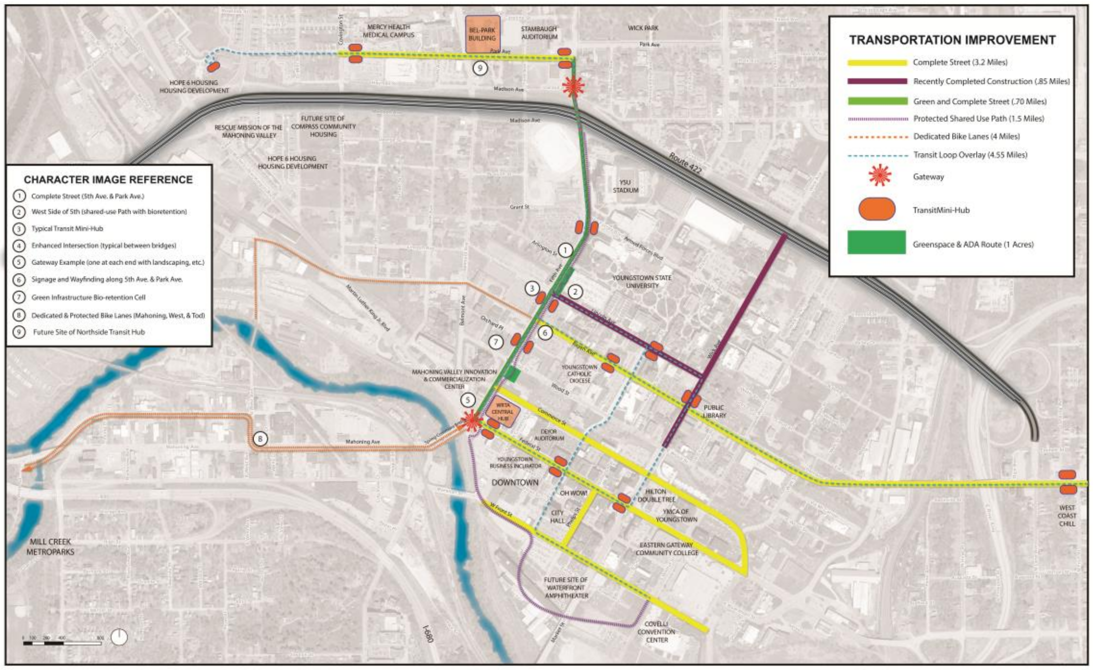
Project Description

The Youngstown SMAR^{2}T Network Project builds on over a decade of planning and coalition-building to transition Youngstown's economy to one reliant on high value-added services and advanced manufacturing. The Project is an integrated investment in transit, bike lanes and pedestrian improvements that collectively facilitate circulation between the economic anchors of Youngstown's new economy: Mercy Health Youngstown Medical Campus (Mercy Health), Youngstown State University (YSU) and the downtown core that includes the nation's first advanced manufacturing institute, America Makes, and globally recognized Youngstown Business Incubator. The City has incrementally been making investments in complete streets in its downtown core; the SMAR^{2}T Network project connects to transportation infrastructure investments in place and under construction by the federal, state and local governments to complete the citywide circuit.

Key elements of the Project, shown in Exhibit 1, include:

- **The reintroduction of a bus circulator** that runs from the Arlington Heights Recreation Center at the heart of a low income neighborhood, to a new transit hub at Mercy Health, to the YSU campus, to key destinations in the downtown including the manufacturing innovation institute, America Makes; the Youngstown Business Incubator, a nonprofit corporation formed to accelerate the formation, growth and success rates of scalable, technology based businesses; and key stops throughout the city's "eater-tainment" district along West Federal Street and much of the central business district, along with connections to an event route leading to the future Riverfront Amphitheatre Park.
- **Pedestrian improvements** throughout the network to fill gaps, make sidewalks ADA compliant, and complement transit and bike improvements to facilitate the "last mile" connection;
- **Separated bike lanes** and bikeshare to encourage use and improve safety and wellness; and
- **Public realm improvements** through the network that establish a high quality, vibrant city environment that welcomes continued redevelopment and civic life.

Exhibit 1: The Youngstown SMAR²T Network



Introduction

The Youngstown SMAR²T Network Project would provide new transportation opportunities with a bus circulator and pedestrian/bike paths, removing autos from the region's roads as well as providing a premium value on properties adjacent to the Project. The Project provides local and regional benefits for both public and private stakeholders and connects a segmented community to retail, commercial, and industrial jobs across Youngstown.

This technical memorandum estimates the benefits associated with the Project. The benefits presented relate to the five (5) Long-Term Outcomes identified in the TIGER 2017 Notice of Funding Availability (NOFO)[1]: State of Good Repair, Economic Competitiveness, Quality of Life, Environmental Sustainability, and Safety. The final section discounts the stream of anticipated benefits and costs and calculates the Benefit Cost Ratios for the Project at 7 percent and 3 percent.

The Project described in this application would support the region's economy over the long-term by providing the workforce and residents of the City of Youngstown with better safety by improving transit and providing new transportation options in the City. The improved streetscape would result in a safer and more walkable environment for pedestrians and bicyclists, yielding safety savings and property premiums. The balance of this discussion describes the assumptions and methods used to develop the benefit-cost analysis and estimates the value of the benefits generated by the investment. The benefits of the capital investment have been estimated over a 20-year analysis horizon.

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[1]See TIGER Notice of Funding Opportunity, https://www.transportation.gov/tiger/tiger-nofo

The Project would be completed by December of 2021, and a benefits period of 2022-2041 was used. The stream of benefits and costs over time are converted to the present value using the required 7 percent discount rate. The equivalent results also are shown at a 3 percent discount rate. All benefits are estimated in accordance with guidance provided by US Department of Transportation (USDOT) for benefit-cost analysis. If no USDOT guidance was available for the estimate, the Project team consulted industry research for the best practice and information on which to base the assumptions and methodology. The benefits quantified in the benefit-cost analysis are described in the following pages in 2017 dollars.

Analysis Assumptions and Methodology

A complete list of assumptions for the project is provided in the benefit-cost analysis (BCA) workbook (see Inputs tab in the file YoungstownTIGER2017_BCA) as well as in **Exhibit 2**.

Exhibit 2 - BCA Calculation Inputs

Input	Value	Source
General		
Discount Rate	7%	2017 TIGER BCA Resource Guide
Discount Rate	3%	2017 TIGER BCA Resource Guide
Deflator	See "Deflator" Sheet	https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/budget/fy2018/hist10z1.xls
Assumed Travel Speed (MPH)	28	http://www.epa.gov/otaq/consumer/420f08024.pdf
Commuting Days per Year (5 days a week, 52 weeks)	260	Assumption
Precipitation Days per Year	138	http://www.bestplaces.net/climate/city/ohio/youngstown
Bike / Pedestrian Commuting Days per Year (Commuting Days per Year less Rain Days)	226	Assumption
Bikeshare annual O&M costs	$40,000	Eastside, for 100 bikes
Auto Occupancy	1.39	2017 TIGER BCA Resource Guide, FHWA Statistics 2015, Table VM1
User Information		
New Bicycle Commuters (Residents 0-0.25 Miles from the Project), Multiplier of Existing Bicycle Commuters	2.93	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Existing Bicycle Users Multiplier of Adult Population - Low	0.000	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Existing Bicycle Users Multiplier of Adult Population - Mean	0.004	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Existing Bicycle Users Multiplier of Adult Population - High	0.006	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Existing Bicycle Users Multiplier of Existing Bicycle Commuters - Low	1.00	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Existing Bicycle Users Multiplier of Existing Bicycle Commuters - Mean	1.20	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Existing Bicycle Users Multiplier of Existing Bicycle Commuters - High	3.00	NCHRP - http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf
Reduced VMT		
Mean Travel Time to Work (Minutes)	17.94	2015 U.S. Census American Consumer Survey 5-year Estimates - For Census Tracts within 0.25 Mi of the project (assumption)
Speed of Commuters (MPH)	28	http://www.epa.gov/otaq/consumer/420f08024.pdf
Commuting Trips Per Day	2	Assumption
State of Good Repair		
Vehicle Maintenance Cost per Mile	$0.29	Source: AAA, Your Driving Costs, 2017

Input	Value	Source
(Gas, maintenance, and tires, + 1/2 of depreciation) (2017$/Mile)		
Maintenance (Gas, Oil, Tires) Cost per VMT (2017$)	$0.18	Source: AAA, Your Driving Costs, 2017
1/2 of Depreciation per VMT (2017$)	$0.11	Source: AAA, Your Driving Costs, 2017
Regular Adult Transit Fare	$1.25	Source: WRTA, http://www.wrtaonline.com/rider-info/fares-and-passes/
Alterative Roadway Maintenance Cost (1990$/mi)	$0.08	
Alterative Roadway Maintenance Cost (2017$/mi)	$0.14	Calculated from: http://www.its.ucdavis.edu/research/publications/publication-detail/?pub_id=19
Lane miles converted to bike lanes, Total Project	3.30	Eastgate
Quality of Life		
Property Premium	2.25%	Less than the median value of property premiums found in Literature Review. See Property Value Increases tab for Literature Review.
Environmental Sustainability		
VOC Value of Emissions (2016$) per metric ton	$1,872	2017 TIGER BCA Resource Guide
NOx Value of Emissions (2016$) per metric ton	$7,377	2017 TIGER BCA Resource Guide
PM Value of Emissions (2016$) per metric ton	$337,459	2017 TIGER BCA Resource Guide
SOx Value of Emissions (2016$) per metric ton	$43,600	2017 TIGER BCA Resource Guide
VOC Value of Emissions (2017$) per metric ton	$1,906	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
NOx Value of Emissions (2017$) per metric ton	$7,512	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
PM Value of Emissions (2017$) per metric ton	$343,654	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
SOx Value of Emissions (2017$) per metric ton	$44,400	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
Passenger Car Emission Rates per Mile, VOC, 2013-2024	0.6	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, Nox, 2013-2024	0.91	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, PM25, 2013-2024	0.01	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, CO2, 2013-2024	532	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, VOC, 2025-2034	0.27	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, Nox, 2025-2034	0.28	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, PM25, 2025-2034	0.01	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, CO2, 2025-2034	434	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, VOC, 2035-	0.21	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, Nox, 2035-	0.2	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf

Input	Value	Source
Passenger Car Emission Rates per Mile, PM25, 2035-	0.01	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Emission Rates per Mile, CO2, 2035-	397	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Passenger Car Gasoline Consumption Per mile	0.04149	http://www.epa.gov/otaq/consumer/420f08024.pdf
Bus Emission Rates per Mile, VOC, 2013-2024	0.73	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, Nox, 2013-2024	8.67	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, PM25, 2013-2024	0.48	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, CO2, 2013-2024	3319	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, VOC, 2025-2034	0.24	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, Nox, 2025-2034	2.08	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, PM25, 2025-2034	0.09	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, CO2, 2025-2034	2854	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, VOC, 2035-	0.16	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, Nox, 2035-	1.14	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, PM25, 2035-	0.03	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Bus Emission Rates per Mile, CO2, 2035-	2721	http://www.apta.com/gap/fedreg/Documents/NS-SS_Final_PolicyGuidance_August_2013.pdf
Safety		
AIS 0 (2016$) per vehicle	$4,252	2017 TIGER BCA Resource Guide
AIS 1 (2016$)	$28,800	2017 TIGER BCA Resource Guide
AIS 2(2016$)	$451,200	2017 TIGER BCA Resource Guide
AIS 3(2016$)	$1,008,000	2017 TIGER BCA Resource Guide
AIS 4(2016$)	$2,553,600	2017 TIGER BCA Resource Guide
AIS 5(2016$)	$5,692,800	2017 TIGER BCA Resource Guide
AIS 6(2016$)	$9,600,000	2017 TIGER BCA Resource Guide
AIS 0 (2017$) per vehicle	$4,330	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
AIS 1 (2017$)	$29,329	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
AIS 2 (2017$)	$459,483	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
AIS 3 (2017$)	$1,026,505	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
AIS 4 (2017$)	$2,600,480	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
AIS 5 (2017$)	$5,797,311	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator
AIS 6 (2017$)	$9,776,242	2017 TIGER BCA Resource Guide, Adjusted by GDP Deflator

Methodology for Bicycle and Pedestrian Benefits

The Project follows the National Cooperative Highway Research Program (NCHRP) Report 552[2] recommendations for estimating the existing and new users of a bicycle facility. New and Existing users have been calculated based upon the US Census-reported populations, adult populations, commuting populations, and percent of bicycle and pedestrian commuters for Census Tracts adjacent to and within the Project boundaries. The Census Tracts included in the analysis are shown in **Exhibit 3**.

Exhibit 3 – Census Tracts

Census Tract 8005, Mahoning County, Ohio	Census Tract 8010, Mahoning County, Ohio
Census Tract 8040, Mahoning County, Ohio	Census Tract 8139, Mahoning County, Ohio
Census Tract 8140, Mahoning County, Ohio	Census Tract 8141, Mahoning County, Ohio
Census Tract 8006, Mahoning County, Ohio	Census Tract 8017, Mahoning County, Ohio
Census Tract 8041, Mahoning County, Ohio	Census Tract 8025, Mahoning County, Ohio
Census Tract 8137, Mahoning County, Ohio	Census Tract 8026, Mahoning County, Ohio

Demographics

The BCA considers population groups for pedestrian bicycle users. Population information is gathered for the US Census Tracts listed in **Exhibit 3**. Populations within these areas were quantified and forecasted linearly based on historic population growth from 2000 to 2014.

I. Bicycle Users

Bicycle user populations were calculated using methodologies recommended by the NCHRP 552 Guidelines. "Existing" refers to 2022 without the Project, while "new" refers to 2022 with the Project.

Existing Bicycle Commuters

The methodology for estimating existing bicycle commuters involves multiplying the existing adult population (U.S. Census) by the existing share of bicycle commuters (U.S. Census ACS Journeys to Work). Considering the Census Tracts for the Project, in 2014, there were 19,705 adults within the project area. Of these, 6,597 were commuters. Approximately 0.07 percent of workers within the project area commuted to work via bicycle. From this data, we can estimate that there were 4 existing bicycle commuters within the project area in 2014. The 2014 U.S. Census total, adult, commuter, and existing bicycle commuter populations were forecasted for future years using the historic growth rates from 2000 to 2014. Based on historic growth, the existing bicycle commuters in 2022 are expected to be 5.

Existing Bicycle Recreation Users

Existing bicycle recreation users are calculated by subtracting the existing bicycle commuters from the existing bicycle total users, as recommended by NCRHP guidelines. Based on historic population growth rates and this methodology, 75 bicycle recreation users are predicted in 2022.

Existing Bicycle Total Users

Total existing bicycle total users are calculated from NCHRP multipliers based on the National Household Travel Survey and the existing bicycle commuters. NCHRP forecasts low, median, and high total bicycle users. The low existing bicycle total users were calculated as the existing bicycle commuters. The average existing bicycle total users were calculated as 0.4 percent of the adult population plus 1.2 times the existing bicycle commuters. The high existing bicycle total

[2] National Cooperative Highway Research Program Report 552, Guidelines for Analysis of Investments in Bicycle Facilities, 2006

users were calculated as 0.6 percent of the adult population plus 3.0 times the existing bicycle commuters. This BCA has assumed a median total bicycle user population. Once populations are forecasted using the 2000 to 2014 historic growth rates, it can be estimated that there will be 80 total existing bicycle total users in the project area in 2022.

New Bicycle Commuters

The methodology for estimating new bicycle commuters involves multiplying the existing bicycle commuters by NCHRP multipliers. To calculate the new bicycle commuters, the following formula is applied:

*New Bicycle Commuters = Existing Bicycle Commuters * (Z – 1)*

Where:

Z = 2.93

After applying historic population growth rates and the above formula, we can estimate that there will be 9 new total bicycle commuters within the project area in 2022.

New Bicycle Recreation Users

New bicycle recreation users are calculated by subtracting the new bicycle commuters from the new bicycle total users, as recommended by NCRHP guidelines. Based on historic population growth rates and this methodology, there will be 145 new bicycle recreational users in 2022.

New Bicycle Total Users

The methodology for estimating new bicycle total users involves multiplying the existing total bicycle users by NCHRP multipliers. To calculate the new bicycle total users, the following formula is applied:

*New Total Bicycle Users = Existing Total Bicycle Users * (Z – 1)*

Where:

Z = 2.93

After applying historic population growth rates and the above formula, we can estimate that there will be 154 new bicycle commuters within the project area in 2022.

II. Pedestrian Users

NCHRP recommends that pedestrian users do not consider the same multipliers as bicycle users. The 2014 U.S. Census ACS 5-year estimate for those tracts have a median travel time to work at 17.9 minutes. Assuming a conservative walking pace of 2.0 miles per hour, the average pedestrian would walk approximately 0.60 miles to work.

Existing Pedestrian Commuters

The methodology for estimating existing pedestrian commuters involves multiplying the existing adult population (U.S. Census) by the existing share of pedestrian commuters, including those who walk to transit. Considering historic population growth rates and the 2014 U.S. Census ACS 5-year Journey to Work estimates, the existing pedestrian commuters in 2022 will be 563.

Existing Pedestrian Recreation Users

NCHRP estimates that walking is 10 times as common as bicycling. Existing pedestrian recreational users are calculated by multiplying the existing bicycle recreation users by 10. Once populations are forecasted using the historic growth rates, it can be estimated that there will be 750 existing pedestrian recreation users in the project area in 2022.

Existing Pedestrian Total Users
Existing pedestrian total users are calculated by adding the existing pedestrian commuters and existing pedestrian recreational users. Once populations are forecasted using the historic growth rates, it can be estimated that there will be 1,313 total existing pedestrian total users in the project area in 2022.

New Pedestrian Commuters
Because pedestrian facilities already commonly exist, new pedestrian commuters are not expected to be extensive. New pedestrian commuters are conservatively estimated to be equal to the new bicycle commuters. After applying historic population growth rates and the above formula, we can estimate that there will be 9 new pedestrian commuters within the project area in 2022.

New Pedestrian Recreation Users
NCHRP estimates that walking is 10 times as common as bicycling. New pedestrian recreational users are calculated by multiplying the new bicycle recreation users in the project area by 10. Once populations are forecasted using the historic growth rates, it can be estimated that there will be 1,447 new recreation pedestrian users in the project area in 2022.

New Pedestrian Total Users
New pedestrian total users are calculated by adding the new pedestrian commuters and new pedestrian recreational users. Once populations are forecasted using the historic growth rates, it can be estimated that there will be 1,456 total new pedestrian total users in the project area in 2022.

Reduced Vehicle Miles Traveled
The forecasted modal shift to bicycle and pedestrian commuting, which is based upon demographic data and NCHRP Guidelines, was used to determine the estimated reduction in vehicle trips and VMT associated with the Project. The replacement of transit, carpool, and other modal trips were weighted based upon the existing percentage of vehicle, carpool, and transit users. The reduction in car users was calculated as:

*Annual Reduction in VMT = Daily Reduction in Vehicles * Mean Travel Time to Work * Speed * Trips per Day * Commuting Days per Year*

*Where: Daily Reduction in Vehicles = ∑ [New Commuters * (Percent of Commuters by Previous Modal Share * Cars required for Previous Modal]*

Where: New Commuters = New Bicycle Commuters + New Pedestrian Commuters AND

Previous Modal Shares = 2014 U.S. Census Journey to Work Modal Shares

In addition to the modal shift by bicyclists and pedestrians, the new transit riders will also contribute to reduced VMT. Based on ridership estimates from Western Reserve Transit Authority (WRTA), the local transit operator, a total of 77,360 annual miles would be taken on the circulator. Ridership is estimated at 255,096 in 2022 and is assumed to grow by a conservative 1 percent per year. It is assumed that three quarters (75 percent) of those riders would divert from autos, and the remaining quarter from other modes such as walking, biking, or other transit modes; 2.5 percent are assumed to be induced riders. This results in 1.12 million auto VMT avoided in 2022. In total, 23.3 million VMT would be avoided over the analysis period by circulator riders.

The reduction in VMT associated with an increase in the number of bicycle and pedestrian users and circulator riders were used to monetize the benefits of the forecasted modal shift by year.

Benefits

Safety

Safety benefits are quantified in two ways for this analysis:

- Reduction of VMT due to bicyclists, pedestrians, and circulator users diverting from autos, and
- The reduction of risk for pedestrian and bicyclist crashes due to separation of bike lanes from auto traffic.

Reduced Highway Fatalities and Crashes

The rates of crashes that result in fatalities, injuries, and property damage only are applied to the VMT diverted to derive the estimated crashes avoided from drivers switching from autos to transit service, biking, or walking. To ensure consistency between the types of crashes, the crash rates for fatalities, injuries, and property damage only are the national average crash rates. These crash rates are shown in **Exhibit 4**.

Exhibit 4: Crashes by Type per 100,000,000 VMT

	Rate	
Fatalities	1.133692236	per 100,000,000 VMT
Injured persons	78.92426005	per 100,000,000 VMT
Crashes	203.4003853	per 100,000,000 VMT

Source: 2015 BTS Motor Vehicle Safety Data Table 2-17, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_02_17.html

These crash reduction factors were then converted to the Maximum Abbreviated Injury Score (MAIS) crash types in order to apply US DOT Guidance on the value of avoiding a crash. The conversion is based on the National Highway Safety and Traffic Administration (NHTSA) KABCO-AIS Conversion Table (July 2011) provided on page 13 of the TIGER Benefit-Cost Analysis Resource Guide (USDOT 2016)[3], for Injury (severity unknown), and No Injury crashes. KABCO refers to the letters used to designate five levels of crash severity used by police at a crash scene; AIS refers to the Abbreviated Injury Scale used by hospitals. These factors provide the probability that an injury will range from critical to minor to more accurately capture the total number of different types of injuries associated with the diverted VMT. Estimating the distribution of expected injury types is important because each type of injury has a different associated economic cost.

The total annual value for crash severity is based on USDOT guidance and the National Highway Safety Council estimates for the value of avoiding a crash. These estimates are applied to the number of crashes avoided to estimate the total value of crashes avoided from auto VMT diverted. **Exhibit 2** provides the estimated cost of different types of crashes.

[3] TIGER Benefit-Cost Analysis Resource Guide (updated March 1, 2016), https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202016.pdf

Based on the value of accidents avoided, the value of safety incidents avoided due to the reduction in VMT is estimated for the Project. ***The total reduction in highway fatalities and crashes results in $2.58 million discounted at 7 percent.***

Reduced Bike and Pedestrian Crashes

According to City of Youngstown Police records for 2015 and 2016,[4] there were 34 property damage crashes, 11 injury crashes, 13 hit/skip incidents, 1 pedestrian incident, and zero fatal accidents resulting in zero fatalities along the project network in 2015. In 2016, there were 38 property damage crashes, 11 injury crashes, 19 hit/skip incidents, 3 pedestrian incidents, and zero fatal accidents resulting in zero fatalities along the project network. Based on AECOM traffic engineer's estimates, separating bike and pedestrian paths from roads will result in a 63 percent reduction in bike/vehicle crashes. The annual average reduction in incidents was estimated based on 2015 and 2016 crashes and held constant throughout the analysis period. Because no records on bicycle injuries were kept, it is assumed that 20 percent of the hit/skip and 20 percent of the injury crashes involved bicycles.

Reduced Bike and Pedestrian Crash Savings are monetized using the BCA Guidance recommended Value of Injuries and Lives. It is assumed that a hit/skip incident would avoid an injury of AIS 1, an injury crash would avoid injuries of AIS 3, and pedestrian incidents would avoid injuries of AIS 2. ***The total safety savings to pedestrians and bicyclists totals $8.93 million discounted at 7 percent.***

State of Good Repair

State of Good Repair benefits can reduce long-term maintenance and repair costs for the project.

Roadway Maintenance Savings

A reduction in VMT incurs long-term maintenance benefits in the form of roadway maintenance savings, such as painting and paving. The BCA estimates the roadway maintenance cost per VMT at $0.14[5]. ***Roadway Maintenance Savings amount to $1.33 million, discounted at 7 percent.***

Residual Value

Construction of the new roads and pavement, sewer systems, buses, bridges, and right of way would have residual value after the end of the 20-year analysis period, because the useful life of these elements is longer than 20 years. Roads and highways have a useful life of 60 years[6], and as a result the remaining value was estimated for after the analysis period and discounted at 7 percent and 3 percent. Sewer systems also have a useful life of 60 years,[7] and bridges have a useful life of 75 years.[8] The new buses are 30' and assumed to be small-size, heavy-duty transit

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[4] See supplemental materials for files 2015 and 2016 traffic maps.

[5] Kitamura, Ryuichi, Huichun Zhao, A. R. Gibby (1989) Development of a Pavement Maintenance Cost Allocation Model. Institute of Transportation Studies, University of California, Davis, Research Report UCD-ITS-RR-89-03, http://www.its.ucdavis.edu/research/publications/publication-detail/?pub_id=19

[6] BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

[7] Ibid.

[8] Source: USDOT Bridge Preservation guide, Maintaining a State of Good Repair Using Cost Effective Investment Strategies, August 2011, page 2, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiv-

buses with seven years of useful life.[9] Because buses will be replaced periodically and sold for salvage value, the residual value of buses includes the remaining value at the end of the useful life and the discounted salvage value of buses sold and replaced during the benefits period. Right of way does not depreciate, so the undiscounted value of the right of way acquired for the Project was also included in the residual analysis. The remaining discounted value of the road was summed with the undiscounted value of the right of way acquired. ***The value of the remaining useful life for the Project discounted at 7 percent is $2.38 million.***

Environmental Sustainability

Vehicle Emission Reduction Savings

The reduction in auto vehicle miles traveled will result in a reduction in emissions, but the increase in mileage from the new circulator will result in new emissions. The two are netted in this analysis. The emissions reductions for auto and additions for diesel buses were estimated using emissions rates from USDOT guidance[10] for volatile organic compounds (VOC), nitrogen oxides (NOx), and particulate matter (PM2.5). The rates are shown in **Exhibit 2** and vary over time as vehicle efficiencies improve. The tons of emissions reduced were monetized using the recommended value of emissions from TIGER 2017 guidance[11], also shown in **Exhibit 2**. ***In total, the Project results in net emissions savings (auto emissions reduced less additional bus emissions) of $0.01 million discounted at 7 percent.***

In addition to VOC, NOx, and PM2.5, reductions, carbon dioxide (CO2) or greenhouse gas would also be reduced. Because there is no official guidance on the value of CO2 emissions reductions, this benefit is not quantified in the analysis.

Economic Competitiveness

Economic Competitiveness benefits occur in the form of travel cost savings.

Travel Cost Savings

Travel cost savings can include reduced operating costs for passengers by providing lower-cost alternatives to the use of private vehicles. The BCA uses a cost savings per reduced auto VMT of $0.29, which is based on the vehicle maintenance cost per mile provided by AAA.[12] The conservative estimate of $0.29 per VMT includes marginal savings such as a reduction in gas, oil, tires and half of depreciation.

8XR8cLLAhVV5WMKHYZ6Ap8QFggcMAA&url=http%3A%2F%2Fwww.fhwa.dot.gov%2Fbridge%2Fpreservation%2Fguide%2Fguide.pdf&usg=AFQjCNEf26d_7T9a9n7jxVGGtwyGvq2zQg&sig2=Z8jY2-M9fT0zre_vXvSplg&bvm=bv.116954456,d.cGc

[9] Federal Transit Administration Circulator 5010.1D Grant Management Requirements 2008, https://cms.fta.dot.gov/funding/grant-programs/capital-investments/fta-circular-50101d-november-2008

[10] USDOT, Federal Transit Administration, New and Small Starts Evaluation and Rating Process Final Policy Guidance, August 2013

[11] 2017 TIGER and INFRA BCA Resource Guide, see https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2017.pdf

[12] Source: AAA, Your Driving Costs, 2017

Induced riders, assumed to be 2.5 percent of the total ridership of 255,096 in 2022, would also save on operating costs. Induced riders, or those that would not otherwise take the trip, would be attracted to use the circulator service. An induced trip is valued at half of the auto variable costs per mile, or $0.14.

Offsetting the total vehicle operating cost savings is the transit fare paid by new riders. Based on WRTA information, a regular adult transit fare is $1.25 per trip. Assuming that 20 percent of ridership is transfers, the remaining 80 percent of riders will pay a new transit fare. Subtracting the transit fares from the vehicle operating cost savings yields the travel cost savings. ***Travel cost savings amount to $0.61 million discounted at 7 percent.***

Quality of Life

Quality of Life benefits increase accessibility and result in property value increases.

Property Value Increases

The Center for Urban Policy and the Environment at Indiana University-Purdue University Indianapolis estimates that people will be willing to pay more to live near greenway facilities. It is assumed that the increased willingness-to-pay will lead to increased property values within the project area. There have been several studies on the changes in property values associated with multiuse trails; some of these studies are summarized in **Exhibit 5**. The Project is highly modelled after the Cultural Trail in Indianapolis, Indiana, which produced property value increases of approximately 48 percent for those properties within 500 feet or 0.1 miles of the project. Alternatively, the Project is very similar to projects studied in Boulder, Colorado and San Antonio, Texas, which produced property value increases of 32.0 percent and 5.0 percent, respectively. To be conservative, the BCA uses a premium of 2.25 percent, which is well below the median property value increase of the studies listed in **Exhibit 5** (4.7 percent). This is far less than those increases observed in Boulder and Indianapolis.

In total, the Project has over $552 million in property values within ¼ mile buffer of the project alignment. The 2.25 percent premium is applied over the years 2020-2022 in anticipation of and opening of the Project. ***The pedestrian and bicycle trails and lanes will result in a property premium benefit of $8.87 million discounted at 7 percent.***

Exhibit 5 – Property Value Literature Summary

Study	Year	Setting	City	City Population*	City Average Population Density (people per square mile)*	Radius of Trail	Percent Increase
Cultural Trail Assessment	2015	Urban	Indianapolis	1,759,791	457	500 feet	48.0%
Understanding the Impact of Trails on Residential Property Values	2011	Suburban/Rural	Little Miami Scenic Trail, Ohio	1,508,338	718	10,000 feet	8.72%
The Relative Impacts of Trails and Greenbelts on Home Price (Trail alone)	2007	Urban/Suburban	San Antonio, Bexar County, Texas	308,745,538	87	Unspecified	2.00%
The Relative Impacts of Trails and Greenbelts on Home Price (Trail/Greenbelt Combination)	2007	Urban/Suburban	San Antonio, Bexar County, Texas	308,745,538	87	Unspecified	5.00%
Two Approaches to Valuing Some of Bicycle Facilities' Presumed Benefits(Off-street, Urban)	2006	Urban	Minneapolis-St. Paul	667,646	6,301	400 meters	0.34%
Minutemen Bikeway and Nashua River Rail Trail Run	2006	Various	7 towns in Massachusetts	Various	Various	Unspecified	1.22%
Property Value/Desirability Effects of Bike Paths Adjacent to Residential Areas	2006	Various	Delaware	Various	Various	50 meters	4.46%
Property values, recreation values, and urban greenways	2004	Various	Marion County	65,738	163	0.5 mile	11.00%
The Effect of Environmental Zoning and Amenities on Property Values: Portland, Oregon	2003	Various	Portland, Oregon	539,546	3,721	200 feet	-6.80%
City of Vancouver, Bicycle Plan	1999	Urban/Suburban	Vancouver, Washington	146,574	3,177	Unspecified	0.00%
Evaluation Of The Burke-Gilman Trail's Effect on Property Values and Crime	1987	Urban/Suburban	Seattle, Washington	515,761	6,144	Unspecified	6.00%
The effects of greenbelts on residential property values: some findings on the political economy of open space.	1978	Urban/Suburban	Boulder, Colorado	189,625	252	3,200 feet	32.00%

* US Census data was compiled based on year of study publication. When data for the year of publication was not available, the nearest decentennial Census population/density was used.

Costs

Capital Costs

The capital costs for the Project total $20.46 million in 2017 dollars. Costs include the new circulator operations, sitework and utilities, pedestrian/bicyclist access and accommodations, bikeshare, bus lanes and parking lots, and right of way. The capital costs are applied over the two year construction period, beginning in 2020 and ending in 2021. Forty percent of the project costs are expended in 2020 and the remaining 60 percent in 2021, with the project opening in 2022. ***The capital costs for the project discounted at 7 percent total to $16.04 million.***

The project's construction will result in temporary job years and earnings over the two-year construction period in the construction and professional services sectors. Employment is expressed in job years which represent one job for one person for the duration of one year. Three job years would be equal to one job for three people over one year, or one job for one person over three years. **Exhibit 6** shows the direct and total employment and earnings for construction, while **Exhibit 7** shows the direct and total employment and earnings for professional services. In total, the Project will result in 172 total job years, of which 104 are direct job years, and earnings will total over $21.8 million.

Exhibit 6: Construction Impacts by Year

Year	Direct Employment	Total Employment	Total Earnings
2020	36	64	$3,991,567
2021	54	96	$5,987,351

Source: BEA RIMS II Multipliers for Youngstown MSA

Exhibit 7: Professional Services Impacts by Year

Year	Direct Employment	Total Employment	Total Earnings
2020	5	5	$4,727,200
2021	8	7	$7,090,801

Source: BEA RIMS II Multipliers for Youngstown MSA

Operating and Maintenance Costs

The project requires annual and periodic operating and maintenance (O&M) costs to keep the roads, bus circulator, bikeshare, and bike paths up to a state of good repair. Maintenance of the system begins in 2022, as the first full year of operation, and the costs total $16.5 million over the analysis period. Periodic bus replacements are valued at $325,000, bikeshare maintenance costs $40,000 per year, and O&M also includes $554,480 per year for the new circulator operations. ***The total O&M costs over the analysis period and discounting at 7 percent is $6.57 million.***

The project's operation will result in job years and earnings over the 20-year analysis period in the Transit and Ground Passenger Transportation and Other Transportation and Support Activities sectors. Employment is expressed in job years. **Exhibit 8** shows the direct and total employment and earnings for the Project. In total, the Project will result in 232 total job years, and earnings will total nearly $7.2 million. These jobs and earnings are long-term; they occur for the duration of the project's operation, resulting in net new jobs to the City of Youngstown.

Exhibit 8: Total O&M Impacts (2022-2041)

Total Employment	Total Earnings
232	$7,192,654

Source: BEA RIMS II Multipliers for Youngstown MSA

Reduced Pavement O&M (O&M Cost Offset)

Due to the project converting a total of 3.3 lane miles from auto traffic to bike paths, the City of Youngstown will avoid maintaining those lane miles. Consistent with the O&M costs, this results in a savings of $2,500 per lane mile. This reduced pavement maintenance is applied as an offset to the O&M costs in the analysis. ***The total savings from reduced pavement O&M over the analysis period and discounting at 7 percent is $0.07 million.***

Summary

Exhibit 9 summarizes the discounted value of the benefits discussed in this memorandum for the Project. Taken in total and using a 7 percent discount rate, the benefits—reduced highway fatalities and crashes, reduced bike and pedestrian crashes, roadway maintenance savings, residual value, emissions savings, travel cost savings, and property premium less O&M costs provide $18.19 million dollars of benefits over the analysis period. Compared to a similarly discounted cost estimate, the Benefit Cost Ratio for the Project is 1.13, a solid return on this critical investment for the region. The net benefits at 7 percent total $2.15 million.

Exhibit 9: Benefit-Cost Analysis

	20 Year Analysis Period (2022-2041)	
	Values stated in 2017 $M	
	Discounted at 7%	Discounted at 3%
Costs		
Capital Costs	$16.04	$18.39
Total Costs	***$16.04***	***$18.39***

Benefits		
Safety Benefits		
Reduced Highway Fatalities and Crashes	$2.58	$4.27
Reduced Bike and Pedestrian Crashes	$8.93	$14.60
Sub-Total Safety Benefits	***$11.51***	***$18.87***
State of Good Repair		
Roadway Maintenance Savings	$1.33	$2.19
Residual Value	$2.38	$3.97
Sub-Total State of Good Repair	***$3.70***	***$6.16***
Environmental Sustainability		
Emissions Savings (auto less bus)	$0.01	$0.03
Sub-Total Environmental Sustainability	***$0.01***	***$0.03***
Economic Competitiveness		
Travel Cost Savings	$0.61	$1.01
Sub-Total Economic Competitiveness	***$0.61***	***$1.01***
Quality of Life		
Property Premium	$8.87	$10.72
Sub-Total Quality of Life	***$8.87***	***$10.72***

O&M Costs	$6.57	$10.84
Reduced Pavement O&M (Cost Offset)	*$0.07*	*$0.11*
Net O&M	***-$6.51***	***-$10.73***

Total Benefits	***$18.19***	***$26.05***

BC Ratio	**1.13**	**1.42**
Net Benefits	**$2.15**	**$7.66**

List of Supporting Information

2017 TIGER and INFRA BCA Resource Guide, see https://www.transportation.gov/sites/dot.gov/files/docs/mission/office-policy/transportation-policy/284031/benefit-cost-analysis-guidance-2017.pdf

AAA, Your Driving Costs, 2017

AECOM, YoungstownTIGER2017_BCA.xls (Excel spreadsheet with BCA calculations by benefit type and summary)

BEA Rate of Depreciation, Service Lives, Declining-Balance Rates, and Hulten-Wykoff Categories, http://www.bea.gov/scb/account_articles/national/wlth2594/tableC.htm

Federal Transit Administration Circulator 5010.1D Grant Management Requirements 2008, https://cms.fta.dot.gov/funding/grant-programs/capital-investments/fta-circular-50101d-november-2008

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National Cooperative Highway Research Program Report 552, Guidelines for Analysis of Investments in Bicycle Facilities, 2006

TIGER Benefit-Cost Analysis Resource Guide (updated March 1, 2016), https://www.transportation.gov/sites/dot.gov/files/docs/BCA%20Resource%20Guide%202016.pdf

TIGER Notice of Funding Opportunity, https://www.transportation.gov/tiger/tiger-nofo

USDOT Bridge Preservation guide, Maintaining a State of Good Repair Using Cost Effective Investment Strategies, August 2011, page 2, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiv-8XR8cLLAhVV5WMKHYZ6Ap8QFggcMAA&url=http%3A%2F%2Fwww.fhwa.dot.gov%2Fbridge%2Fpreservation%2Fguide%2Fguide.pdf&usg=AFQjCNEf26d_7T9a9n7jxVGGtwyGvq2zQg&sig2=Z8jY2-M9fT0zre_vXvSplg&bvm=bv.116954456,d.cGc

USDOT, Federal Transit Administration, New and Small Starts Evaluation and Rating Process Final Policy Guidance, August 2013

USDOT. Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in U.S. Department of Transportation Analyses – 2014 Adjustment, https://www.transportation.gov/sites/dot.gov/files/docs/VSL_Guidance_2014.pdf

WRTA Fares, http://www.wrtaonline.com/rider-info/fares-and-passes/

Youngstown Police Department crash data

2015 traffic map.pdf

2016 traffic map.pdf