



VIII. BENEFIT COST NARRATIVE

INTRODUCTION

This technical memorandum estimates the long-term benefits associated with the 321 Calibrating Our National Network to Encourage Commerce and Tourism (321 CONNECT) Project. This evaluation discusses all the Performance Outcome Criteria mentioned in the Notice of Funding Opportunity. For some measures, an additional qualitative discussion is included. The assumptions and methods used to develop the Benefits-Cost Analysis (BCA) are detailed for each topic and are supported by supplementary material where appropriate.

The long-term quantifiable benefits are presented for the Project Outcome Criteria, including safety benefits, state of good repair, travel time savings (economic benefits), bicyclist and pedestrian benefits (equity, multi-modal and quality of life) and innovation (travel time reliability savings from fiber/broadband improvements). Adding ITS allows riders to know about dangerous conditions/road closures/etc. before stumbling upon them. That should allow a reduction of idling, reduced impacts from accidents, etc. These quantitative benefits are included as a component of the economic and innovation benefits.

The final section summarizes the anticipated benefits and costs of 321 CONNECT and calculates the overall Benefit-Cost Ratio.

YEARS OF ANALYSIS

The analysis is based on an estimated construction completion date of December 2028. A benefits period of 2029-2058 was used. This 30-year benefits period is consistent with the 2023 BCA Guidance for Discretionary Grant Programs (BCA Guidance) for projects involving the full reconstruction of highways or similar facilities.

METHODOLOGY

Benefits are estimated in accordance with the January 2023 BCA Guidance. Where no specific approach was

provided in the Guidance, NCDOT used best practices and research data as specified in the assumptions and methodology for each measure. As advised by USDOT, the benefits quantified in the BCA use 2021 dollars. Benefits for each project element are described within the benefit categories.

ANALYSIS ASSUMPTIONS

A list of assumptions for the project is provided in the Benefit-Cost Analysis (BCA) workbook and summarized in Tables 1 and 2. Table 1 consists of the generalized BCA input values provided by USDOT for a variety of categories including auto occupancy rates, vehicle values of time, safety crash rate values, emissions damage costs and pedestrian and bicyclist values.

TABLE 1 - INPUT VALUES FROM BCA GUIDANCE

INPUT	VALUE
GENERAL ASSUMPTIONS	
Analysis Period (Years) - Projects Involving Full Reconstruction of Highways	30
Discount Rate	7%
Discount Rate for Reductions in CO2 Emissions	3%
Dollar Year	2021
Auto Occupancy (Passenger Vehicles, All Travel)	1.67
Auto Occupancy (Trucks) ¹	1.00
Truck Value of Time (Hourly Value)	\$32.40
Passenger Vehicle Value of Time (Hourly Value)	\$18.80
Operating Costs per Mile (Light Duty Vehicles)	\$0.46
Operating Costs per Mile (Commercial Trucks)	\$1.01



TABLE 1 - INPUT VALUES FROM BCA GUIDANCE	
SAFETY - CRASH DATA ASSUMPTIONS	
O - No Injury	\$4,000
C - Possible Injury	\$78,500
B - Non-incapacitating	\$153,700
A - Incapacitating	\$564,300
K - Killed	\$11,800,000
U - Injured (Severity Unknown)	\$213,900
# of Accidents Reported (Unknown if Injured)	\$162,600
Property Damage Only Crashes	\$4,800
EMISSIONS - ASSUMPTIONS FOR DAMAGE COSTS PER METRIC TON	
NO _x - 2029	\$18,600
NO _x - 2030 and beyond	\$18,900
PM _{2.5} - 2021 to 2029	\$748,600 to \$854,000
PM _{2.5} - 2029; 2030 and beyond	\$893,400; \$907,600
CO ₂ - 2021 to 2050	\$63 to \$88
PEDESTRIAN AND BICYCLING BENEFITS ASSUMPTIONS	
Expanded Sidewalk (per foot of added width)	\$0.11
Dedicated Cycling Lane (per cycling mile)	\$1.77
Value per Induced Walking Trip (Ages 20 - 74) ■ Assumed 68% of trips within age range.	\$7.20
Value per Induced Walking Trip (Ages 20 - 64) ■ Assumed 59% of trips within age range.	\$6.42

Table 2 lists project-specific assumptions. Most of these project-specific assumptions come from the Greater Hickory Travel Demand Model and the crash strip analysis conducted by NCDOT for US 321 from US 70 to US 64 in Lenoir for the period between June 1, 2018 and May 31, 2022.

TABLE 2 - BCA CALCULATION INPUTS - PROJECT-SPECIFIC

INPUT	VALUE	SOURCE
GENERAL		
Annual Average Daily Traffic Volumes (AADT)	Varies by Scenario	NCDOT Traffic Survey; Greater Hickory Travel Demand Model
Compound Annual Growth Rate (Weighted average rate of all forecast roadway segments)	1.35%	
VHT/VMT values in vicinity of 321 CONNECT	Varies by Scenario	Greater Hickory Travel Demand Model
Crashes (categorized by type) from 6/1/2018 to 5/31/2022	Varies by Crash Type	NCDOT Traffic Engineering Accident Analysis System Strip Analysis Report
Crash Reduction Factor (CRF) ID 4.15.6 (Increase shoulder widths by 6')	0.81	NCDOT Traffic Safety Group



BENEFITS

Criterion 1 - Safety

An in-depth crash strip analysis report was completed for State Transportation Improvement Program (STIP) Project U-4700 based on the five-year period from June 1, 2018 to May 31, 2022. The crash analysis assessed all 1,966 crashes that occurred during this time, including a breakdown by crash type—fatal, non-fatal injuries and property damage only crashes (types A, B and C). The analysis found that the section of US 321 from US 70 to River Bend Drive, the U-4700A portion of U-4700, exceeded the statewide urban arterial average crash rates for total crashes, non-fatal injury crashes, night crashes and wet weather crashes. Future Year No-Build and Build crash estimates were projected by applying study-specific crash ratios to forecasted vehicle miles traveled (VMT) to produce estimates of different crash types in the future. Benefit values were estimated by using a combination of monetized values per injury level.

U-4700A, as part of 321 CONNECT, will greatly enhance the safety of drivers on the facility through multiple roadway improvements including providing a wider shoulder. After a review of multiple Crash Reduction Factors (CRFs) from the NCDOT Traffic Safety Group (refer to Table 3), a 19 percent reduction in crashes for U-4700A is considered a reasonable estimate based on CRF ID 4.15.6 for widening and the multiple substandard features being revised to meet current standards. Using the factors previously listed, the total safety benefit savings was found to be \$161.2 million, with a net present value in 2021 dollars of \$38.9 million.

TABLE 3 - PROJECT CRASH REDUCTION FACTOR

ID	4.15.6
Counter Measure Description	Increase shoulder width by 6 feet
CMF	0.81
Expected Crash Reduction	19%
Application	CRF applied to Build scenario

Source: [North Carolina Project Development CRF Information](#)

In addition to the safety benefits quantified above, there are qualitative benefits to safety associated with 321 CONNECT. The installation of ITS infrastructure will improve the safety of the entire 321 CONNECT corridor. ITS will allow the use of interactive signing to inform travelers on US 321 to be aware of crashes, flooding or other conditions that could mandate emergency stops.

The reduced conflict intersections (RCIs) will improve safety for bicyclists and pedestrians as well as motor vehicles. A study of seven RCIs by the Indiana Department of Transportation found that this intersection type:

- Reduced fatal and injury crashes by an average of 81 percent.
- Reduced property-damage crashes by an average of 58 percent.
- Reduced crashes of any severity by an average of 68 percent.

The replacement of the at-grade Caldwell County Railroad with a grade-separated crossing eliminates the possibility of rail/vehicle collisions on US 321.

Criterion 2 - State of Good Repair

Currently, the structures that are part of U-4700A are contributing to an aging, deteriorating facility with frequent and expensive maintenance costs. U-4700A will provide a greatly improved facility that will have less frequent and less costly maintenance. This includes pavement preservation, bridge maintenance and general maintenance.

Altogether, state of good repair benefits will total \$29.3 million, with a net present value in 2021 dollars of \$8.8 million.

In addition to the quantified state of good repair elements discussed above, there are qualitative benefits associated with 321 CONNECT. The ITS and broadband installation will also help prepare the 321 CONNECT corridor for the coming generation of automated/connected vehicles. Installation of these improvements now will eliminate the need to install them in the future when installation and materials



costs will likely increase.

Criterion 3 - Economic Impacts, Freight Movement, and Job Creation

TRAVEL TIME

321 CONNECT will result in travel time savings for cars and freight vehicles in the Hickory area. Vehicle hours of travel (VHT), defined as total travel time in hours for passenger cars and trucks, was estimated for the No-Build and Build scenarios in the design year (2045). The difference between these two scenarios provides the foundation to quantify the hours saved for passenger cars and trucks. Travel time savings benefits were estimated using total travel time saved by passenger cars and trucks at a value of \$18.80 per hour for passenger vehicles and \$32.40 per hour for trucks. The combination of passenger and freight vehicle time-savings will result in a total savings of \$7.7 million in the opening year and increasing to \$11.5 million at the end of the analysis period. The total travel time savings benefit is \$284.5 million, with a net present value in 2021 dollars of \$68.6 million.

Note that these benefit values incorporate the disbenefits of increased VMT and increased emissions damages. Refer to Table 4 for a full breakdown of travel time benefits and disbenefits.

TABLE 4 - VHT SAVINGS BENEFITS AND INDUCED VMT DISBENEFITS

INPUT	VALUE
BENEFITS	
VHT Benefits - Value of Time Savings	\$284.5 million
DISBENEFITS	
VMT Increase - Operating Cost	(\$193.4) million
VMT Increase - Emissions ¹	(\$57.1) million
NET BENEFITS	
Net Benefits	\$34.0 million
Net Benefits (NPV)	\$7.5 million

In addition to the economic impacts quantified above, counties in the 321 CONNECT corridor have provided extensive training opportunities for area residents that will benefit from the proposed broadband installation. The Catawba Apprenticeship Program (CAN) through Catawba Valley Community College (CVCC) has worked to develop apprenticeship opportunities. Participating companies work predominantly with high school students and offer opportunities for complete scholarships for a two-year Associate's degree.

Other programs include:

- Manufacturing Solutions Center (CVCC) - covers hosiery, textiles, engineering and testing
- US 321 Workforce Innovation Center (CVCC) - with Hickory Aviation Museum, robotics, maritime technology and avionics
- Catawba Valley Furniture Academy
- Alexander County Furniture Academy

These programs are critical in the 321 CONNECT Broadband corridor, where much of the population lacks a high school education (see Criterion 6). Of the 24 census tracts proposed for broadband installation through 321 CONNECT, 25 have 10 percent or more of the population that have less than a high school education. Overall, 17 percent of the residents living in 321 CONNECT broadband census tracts lack a high school education.

Criterion 4 - Climate Change, Resiliency, and the Environment

Highway widening projects generally induce travel, as detailed in Criterion 3. 321 CONNECT is anticipated to increase emissions with a subsequent cost of \$57.1 million. Having an improved US 321 would allow the facility to be a more reliable corridor that could better serve the National Freight Network.

However, the project was designed to provide specific environmental improvements. The replacement bridges over the Catawba River are higher, replacing the at-grade Caldwell County Railroad with a grade separated crossing, eliminating idling emissions when US 321 is closed for train crossings. In addition, the



higher bridge provides greater resiliency in the case of flooding events. Care was taken during project design to ensure the new structures would mimic the pier spacing of the current northbound bridge on US 321. This measure was suggested by resource agencies and allows for safer boating on the Catawba River as well as a more consistent channel for aquatic life.

321 CONNECT will provide increased ability to adapt to climate change. Drainage along the U-4700A corridor will be upgraded, allowing for greater storage during flood events. Recent years have seen an increase in heavy rainfall events in North Carolina. This trend is expected to continue. 321 CONNECT includes the installation of a flood gauge on Frye Creek, which will be connected to North Carolina’s Flood Inundation Mapping and Alert Network for Transportation (FIMAN-T). FIMAN-T was developed as a partnership between NCDOT and NC Emergency Management (NCEM) to provide NCDOT officials and emergency management stakeholders with real-time and forecasted flood inundation depths along roads, bridges and other NCDOT assets in support of risk-based decision-making during flooding events. The application features an interactive dashboard allowing users to navigate between current conditions, modeled scenarios and forecasted conditions where available. The system reports critical emergency response information such as bridge freeboard (the distance between the water surface and the bridge’s low chord elevation) allowing for a more informed response by NCDOT, NCEM and other stakeholders. This application allows for a timely response to increased precipitation events caused by climate change.

Criterion 5 - Equity, Multimodal Options and Quality of Life

BICYCLIST/PEDESTRIAN BENEFITS

U-4700A will include new active transportation infrastructure on nearly all of the roadway structures from US 70 to River Bend Drive. These new pedestrian and bicycling facilities will provide improved connections and may begin to restore communities that were divided by the construction of US 321. There are 11 census tracts immediately adjacent to the

U-4700A corridor that include 14,930 occupied housing units (per the 2020 Census). It is assumed that 75 percent of these housing units are within the project study area and that each household will make 5.5 trips/day/household (Source: [Bureau of Transportation Statistics](#)).

It is assumed that reconnecting these communities will lead to a travel mode shift of three percent of all trips to be pedestrian trips and two percent of all trips to be bicycle trips. Additionally, there will be mortality reduction benefits for the new bicycle and pedestrian trips. Refer to Table 1 for the specifics of these assumptions.

Altogether, the bicycling/pedestrian infrastructure and reduced mortality benefits will total \$200.0 million, with a net present value in 2021 dollars of \$51.5 million.

OTHER EQUITY/QUALITY OF LIFE BENEFITS

In addition to the quantified equity benefits, 321 CONNECT will provide educational benefits to area residents. Based on NC Department of Information Technology ([NCDIT](#)) data, at least 1.1 million households in North Carolina lack household access to high-speed internet. This lack reduces opportunities to develop the skills needed to fully participate in a digital economy. North Carolina Governor Roy Cooper has [developed a plan](#) to leverage \$1 billion in federal American Rescue Plan funds and \$30 million in state funds to addressing this “digital divide.” The divide impacts school children, workforce and employers, as well as health care patients and other area residents. North Carolina has developed [broadband adoption scores](#) for all counties in the state. Within the 321 CONNECT project area the adoption score index scores (100 is the maximum positive score) by county are:

- Caldwell County 43.16
- Burke County 37.25
- Catawba County 61.85
- Lincoln County 63.71
- Gaston County 62.25

321 CONNECT will bring critically needed broadband access to a part of the state that is working to develop



as a manufacturing and technology hub for western North Carolina.

Finally, NCDOT has a legislatively mandated Disadvantaged Business Program to ensure disadvantaged businesses have the opportunity to do business with the Department. The NC Department of Administration administers the Historically Underutilized Business Program to promote economic opportunities for historically underutilized businesses in state government contracting and procurement.

Criterion 6 - Innovation Areas: Technology, Project Delivery, and Financing

FIBER/ITS BENEFITS

US 321 CONNECT will include fiber optic cable and ITS improvements from US 74 in Gastonia, NC along US 321 to Lenoir, NC. US 321 CONNECT will extend from the NC/SC state line along I-85 to connect with the fiber optic cable being installed along I-85 from I-485 to the US 74 interchange as part of the 2020 US 74 INFRA Grant. Fiber optic cable and ITS benefits were estimated to provide savings and reliability benefits worth \$48.3 million, with a net present value in 2021 dollars of \$11.7 million.

Innovation is at the heart of many of the improvements proposed for 321 CONNECT. The installation of broadband and ITS infrastructure benefits safety, provides critical infrastructure that can facilitate the use of automated/connected vehicles, reduces congestion, improves regional economic viability and will improve the quality of life for thousands of people in the western Piedmont of North Carolina.

SUMMARY

The analysis resulted in a **1.53 BCR** and a **\$238.2 million net present value of benefits** (refer to Table 5). This is considered a “High” economic analysis rating (the project’s benefits will exceed its costs with a BCR of at least 1.5). NCDOT has concluded that these benefits reasonably justify the costs of 321 CONNECT.

CAPITAL COSTS	\$265,445,000
PROJECT COSTS (NPV 2021)	\$156,456,544
TOTAL NET BENEFIT	\$443,487,245
TOTAL NET BENEFIT (NPV 2021)	\$239,299,697
BENEFIT-COST RATIO	1.53

Supplemental Materials, including the Cost-Benefit Analysis Calculations, can be found on the [321 CONNECT website](#).