North Carolina
USDOT Grant Application

I-85/I-40/NC-540

Foundations for Automated and Safer Transportation

ARTIFICIAL INTELLIGENCE

BROADBAND

UPGRADES

MAY 2020

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPLICATION INFORMATION

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The full application, all appendices, and all supporting documentation can be found at:

https://connect.ncdot.gov/resources/BUILD2020-I85/Pages/default.aspx

DUNS Number: 788142946

PROJECT INFORMATION	
Project Name	**I-85/I-40/NC-540 Foundations for Automated and Safer Transportation**
Was a BUILD application for this project submitted previously?	Yes
If yes, what was the name of the project in the previous application?	I-85/I-40 Foundations for Automated and Safer Transportation
Previously Incurred Project Cost	$6.03M
Future Eligible Project Cost	$25.713M
Total Project Cost	$25.713M
BUILD Request	$8.213M
Total Federal Funding (including BUILD)	$8.213M
Are matching funds restricted to a specific project component?	No
Is the project or a portion of the project currently located on National Highway Freight Network?	Yes
Is the project or a portion of the project located on the National Highway System? • Does the project add capacity to the Interstate system? • Is the project in a national scenic area?	Yes No No
Do the project components include a railway-highway grade crossing or grade separation project? • If so, please include the grade crossing ID	No
Do the project components include an intermodal or freight rail project, or freight project within the boundaries of a public or private freight rail, water (including ports) or intermodal facility?	No
If answered yes to either of the two component questions above, how much of requested BUILD funds will be spent on each of these project components?	N/A
State(s) in which project is located	North Carolina
Small or large project	Large
Urbanized Area in which project is located, if applicable	Fiber-optic cable and safety improvements will traverse the mostly urban corridor between Raleigh and Charlotte.
Population of Urbanized Area	Raleigh (884,891); Durham (347,602); Greensboro (311,810); and Charlotte (1,249,422)
Is the project currently programmed in the: • TIP • STIP • MPO Long Range Transportation Plan • State Long Range Transportation Plan • State Freight Plan	Some ITS elements of the project, primarily fiber-optic trunkline, are programmed in the STIP: I-3802AA, I-3802B, C-5600E, I-3306.

I. PROJECT DESCRIPTION

Executive Summary

The North Carolina Department of Transportation (NCDOT) I-85/I-40/NC-540 Foundations for Automated and Safer Transportation Project will improve safety, increase travel time reliability, and add communications infrastructure to one of the most traveled corridors in North Carolina. The Project proposes to accomplish these goals with a suite of transportation technology improvements.

The Project will complete the NCDOT fiber-optic trunk line connection between the state's two largest Transportation Management Centers (TMC) along I-85-I-40. This will create opportunities for NCDOT and the private sector to jointly utilize communications infrastructure. New wireless communication infrastructure will support future connected and automated vehicle technology. Two new safety systems at pilot locations along I-85/I-40 (as well as full deployment along the Toll NC-540) will deter wrong-way driver and curve departure crashes. The Project will add technology to interstate alternate routes and will aid in integrated corridor management. Finally, the Project proposes to deploy state-of-the- art advanced analytics to detect dangerous behavior and conditions on the interstate.

By deploying these systems, and enhancing existing systems, NCDOT will continue to be a leader in using technology to manage congestion, improve driver safety, stimulate economic growth, and proactively work with the commercial sector.

Project Corridor Safety

The safe and efficient movement of vehicles, both passenger and freight, is a critical component of economic competitiveness and prosperity. The occurrence of crashes on North Carolina's interstates, and the congestion resulting thereof, cause major social costs and economic impacts.

In 2017, over 28 million motorists traveled along the I-85 corridor throughout the state of North Carolina. This corridor also serves as a major commerce route with truck traffic making up over 11 percent of the total volume. The total number of reported crashes along this I-85 corridor experienced an increase of three percent from 2016 to 2017 while the total number of reported fatalities experienced a decrease of 11 percent over the same timeframe. The fatal crash rate in 2017 was 0.46 per 100 million vehicle miles traveled (MVMT) while the fatal crash rate for crashes involving commercial motor

Table 1: Volume and Duration of Significant Delays on I-85/I-40 Project Corridor

Year	<30 (min)	31 to 60 (min)	61 to 90 (min)	91 to 120 (min)	121 to 180 (min)	>181 (min)	Avg Length of Incident-Based Delay over 180 min
2016	488	822	394	231	99	54	303
2017	436	832	350	251	88	57	342
2018	522	619	363	212	112	85	352
2019**	253	256	142	78	34	34	294

*Incident-Based delays queried were "Vehicle Crash" and "Disabled Vehicle" Source: NCDOT Travel Information (TIMS)
**Through May 2019

vehicles was 0.16 per 100 MVMT. The I-40 corridor, as a comparison, had a similar fatal crash rate of 0.49 per 100 MVMT but had a lower fatal crash rate involving commercial motor vehicles of 0.07 per 100 MVMT.

Table 1 on the previous page summarizes the volume of incidents by duration along I-85 and I-40. With continued traffic growth, among the highest along this segment of I-85 in North Carolina, average annual growth in AADT has ranged between 3.4 percent and 4.2 percent for the last five years, intensifying safety challenges on this route. Toll NC-540 is not included in this table due to negligible impacts from incident related delays on the toll road.

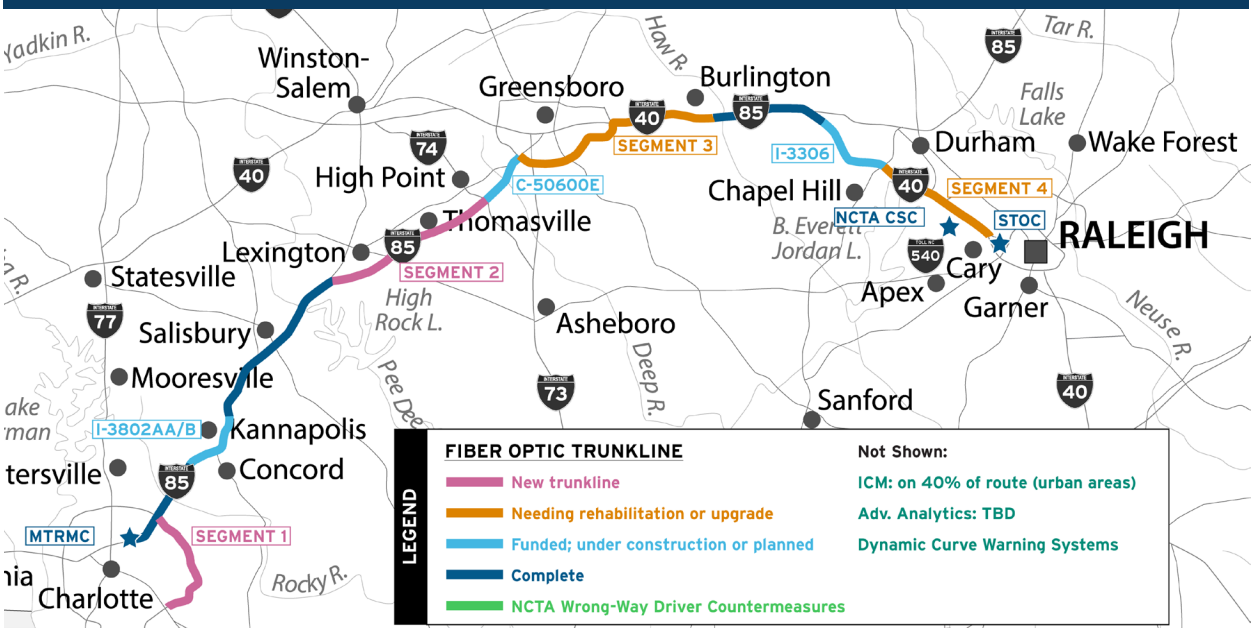
Integrated traffic operations initiatives and sophisticated incident management have been limited due to the lack of technology connectivity within the corridors.

The Project will address these challenges and improve safety by providing solutions that are needed, innovative, and cost-effective. The Project will provide vital redundancy to recover from crash events and other occurrences that cause congestion. The Project corridor is shown in **Figure 1**. The key components of the Project package are:

1. **Fiber-Optic Trunkline Completion** – The lack of completed fiber-optic connections between the state's three largest metro areas has long been a hindrance toward achieving maximum sharing of traffic data and video feeds between TMCs. The Project will eliminate this hurdle, and provide the infrastructure needed to support future connected and autonomous vehicle infrastructure.

2. **Wrong-Way Vehicle Detection and Notifications Systems – I-85/I-40 Corridor** – The occurrence of wrong-way driving crashes, though rare, is often deadly in nature. This Project will identify ten locations, based on proven national data, where the highest probability of a crash will occur, and

Figure 1: 1-85/I-40/NC-540 ITS and Safety Improvements — Project Corridor



deploy state-of-the-art Wrong-Way Driving (WWD) countermeasures that will immediately notify the TMC, first responders and the public. A preliminary map of sites under consideration can be found here:

https://connect.ncdot.gov/resources/BUILD2020-i85/Pages/default.aspx

3. **Dynamic Curve Warning System (DCWS)** – A low-cost and proven effective tool, DCWS are placed at horizontal curve locations (e.g. interchange loops) where unsafe vehicle speeds indicate a potential crash before it occurs. The system detects oncoming vehicles traveling at an unsafe speed and warns drivers to slow down with electronic sign feedback. The Project will identify five locations for deployment. A preliminary map of sites under consideration can be found here:

https://connect.ncdot.gov/resources/BUILD2020-i85/Pages/default.aspx

4. **Advanced Analytics** – The Project will utilize the North Carolina Transportation Analytics Center (NC TAC) to detect high-danger activities, such as roadway obstacles, wrong way drivers and potential human trafficking behavior, using existing NCDOT traffic cameras and edge analytics.
5. **Wrong-Way Vehicle Detection and Notifications Systems – Toll NC-540 Corridor** – The Project will deploy the wrong-way driver countermeasures described in Component 2 above at all off-ramp locations on the North Carolina Turnpike Authority's Triangle Expressway. A map of all sites along Toll NC-540 can be found here:

https://connect.ncdot.gov/resources/BUILD2020-i85/Pages/default.aspx

Detailed Description of Project Package

Component One: Fiber-Optic Trunkline Completion

NCDOT manages traffic operations along its interstate routes from three transportation management centers (TMCs):

1. The Metrolina Regional TMC (MRTMC) located in Charlotte along I-85,
2. The State Transportation Operations Center (STOC) located in Raleigh along I-40, and
3. The Triad Regional TMC (TRTMC) located in Greensboro along I-40.

   Note: Although the TRTMC is not on the Project corridor, the center will benefit from the Project completing the connection to the other centers.

The STOC monitors all state roads not otherwise in the region of a TMC, and serves as the overnight monitoring entity for all major state roads, as it is staffed 24/7/365.

Currently, these TMCs have constrained connectivity to one another due to the lack of fiber connection between them. NCDOT Information Technology (IT) currently maintains expensive leased facilities for this purpose, and far fewer video streams can be viewed over these connections than desired. The completion of this link, including new facilities and upgrades to existing infrastructure, will eliminate this problem and reduce dependence on the leased lines.

The installation of fiber-optic cable along the Project will enhance the ability of NCDOT's Traffic Systems Operations Unit (TSOU) to manage incidents along

the corridor. NCDOT is currently using Integrated Corridor Management (ICM) for selected large interstate construction projects involving extended lane closures, complex work zones and long project durations. ICM uses detour routes, traffic signal timing and static and electronic signage to proactively manage traffic for varying levels of congestion caused by workzones and workzone incidents. ICM often relies on the NCDOT's closed-loop traffic signal systems which serve traffic signals at the ramp terminals of the interchanges, as well as nearby arterial signals. As of 2019, there are 23 such closed-loop signal systems on the I-40/I-85 corridor, as well as nine municipal signal systems. Currently most of these closed-loop systems are on unreliable and slow dial-up modems, which hinders TSOU's ability to conduct ICM. Connection to the fiber-optic trunkline will eliminate this issue.

Other elements of the ICM deployment as a part of the Project include:

- Putting all traffic signals along potential alternate/detour routes on the state's centralized control Advanced Traffic Management System (ATMS) software;
- Upgrading all signals along potential alternate/detour routes to use high-resolution data-capable controllers (2070LX); this will give NCDOT the unique ability to analyze performance data during traffic incidents; and
- Installing CCTV cameras along potential alternate/detour routes for monitoring rerouted traffic during incidents.

ICM project elements are anticipated to be deployed on approximately 65 miles of the Project corridor, in areas of heaviest congestion and temporary or extended work zone activities.

The Project will maximize the innovative contracting opportunities that arise from allowing the private sector to have access to the trunkline and the NCDOT Controlled Access (CA) in general.

The Project allows the State to use public right-of-way to address this digital revolution while simultaneously addressing mobility challenges.

A joint implementation of fiber can make in-roads close the internet service gap between urban and rural households in central North Carolina. As technologies have advanced, applications increasingly require download speeds that exceed what can be achieved using traditional copper wire or landline. Increasingly, it is not just the connection, but the speed of the connection that determines service.

According to the FCC's 2016 report on broadband progress, about 20 percent of North Carolina's rural residents do not have access to 25 Mbps/3 Mbps versus only one percent of urban residents. Moreover, the definition of "adequate" service is a moving target as technologies and demand for speed and data capacity grows over time. Although 25 Mbps/3 Mbps bandwidth supports most current needs, it will likely become inadequate in the next few years. In addition, the prospect of adding 5G cellular network has created the incentive for the private sector to upgrade their size and the reach of their fiber networks.

The installation of fiber-optic trunk lines in the highway right-of-way prepares this corridor for adoption of connected and autonomous vehicles (CAV). While the rate of adoption for connected and autonomous vehicles is growing and the subject of much industry speculation, the transportation industry has agreed that it is no longer a question of if there will be connected and autonomous vehicles but rather when they will be prevalent. The Project proactively positions the I-85/I-40 corridor to be prepared for this transportation revolution.

The NC Turnpike Authority (NCTA), which currently has toll roads in the Raleigh and Charlotte metro areas, must rely on expensive leased line communications facilities to move secure toll transactions from the Monroe Expressway roadside host located in the MRTMC, to the NCTA customer service center in Morrisville. The portion of this project on I-485 that will connect the Expressway to the fiber-optic backbone will allow NCTA's toll integrator to significantly reduce their reliance and cost on the leased lines, which in turn will reduce NCTA's operating costs.

Finally, the completion of the connection between the TMCs will advance the NCDOT goal of interconnecting all the weigh stations in the state. Currently, only the Hillsborough static weigh station is on the Project corridor. However, two studies are currently underway by NCDOT that may add new freight nodes to the Project corridor:

1. **Weigh Station Feasibility Study Update** — This update to the original 2004 study may recommend additional static or mobile Virtual Weigh Station using Weigh in Motion technology (WIM) to the heavily traveled I-85 corridor.
2. **ITS Truck Parking Study** — Intelligent transportation systems (ITS) truck parking is relevant as the corridor contains three rest areas. Rest areas (and their unused overnight parking) are often a part of a package of solutions to address truck parking issues. The 2017 NC Statewide Multimodal Freight Plan identified the I-85 corridor as having a deficit amount of truck parking, causing potentially hazardous conditions as trucks may stay on the interstate past their operating hours in search of safe overnight parking.

Component Two: Wrong-Way Driver Detections and Notifications Systems – I-85/I-40 Corridor

On average, wrong-way driving (WWD) crashes are much deadlier than other types of vehicle to vehicle crashes. While only accounting for approximately three percent of all highway crashes each year, WWDs cause 27 more deaths per 100 crashes than non-WWD fatal crashes. The NCDOT I-85/I-40/NC 540 Foundations for Automated and Safer Transportation Project will improve safety for one of the most traveled corridors in the state. The Project proposes to accomplish these goals by deploying state-of-the-art technology to deter wrong-way driver crashes.

Intelligent Transportation Systems (ITS) offer a proven solution to reducing the number of WWD deaths. ITS technology manages real-time data and deploys warnings to motorists of an impending danger and will dispatch first responders in a timely manner to intercept and prevent wrong-way drivers from causing a

potentially fatal crash. Depending on the system, accuracy and area of deployment, turn-around rates in the 80 percent range have been observed with WWD countermeasures system.

The elements of ITS technology proposed by this Project to deter and detect wrong-way drivers and notify TMCS of this behavior:

- Use of radar, LIDAR, or thermal technology to detect wrong-way vehicle movement.
- Two or four wrong-way signs with built-in red-light emitting diodes (LED) or rectangular flashing beacons (RFB) (also referred to as "smart signs), activated by the detection, to get the drivers attention to turn around prior to entering the highway.
- Fixed cameras to record the wrong-way behavior.
- Real-time notifications using email and texts over a fiber or cell network to relay a warning (with attached camera snapshots) to a TMC.
- Use of a "tracking camera" to have the system automatically follow a wrong-way vehicle, for an operator to determine whether the vehicle self-corrected.
- Software interface at the TMC to log and store wrong-way events, and provide audible warning of such events.

Figure 2 (images 1-4) show a vehicle turning around after two (2) red rectangular flashing beacon (RFB) wrong-way warning signs were activated by a detection system on Central Florida Expressway (CFX). The images were immediately sent via the ITS to be processed by researchers the TMC

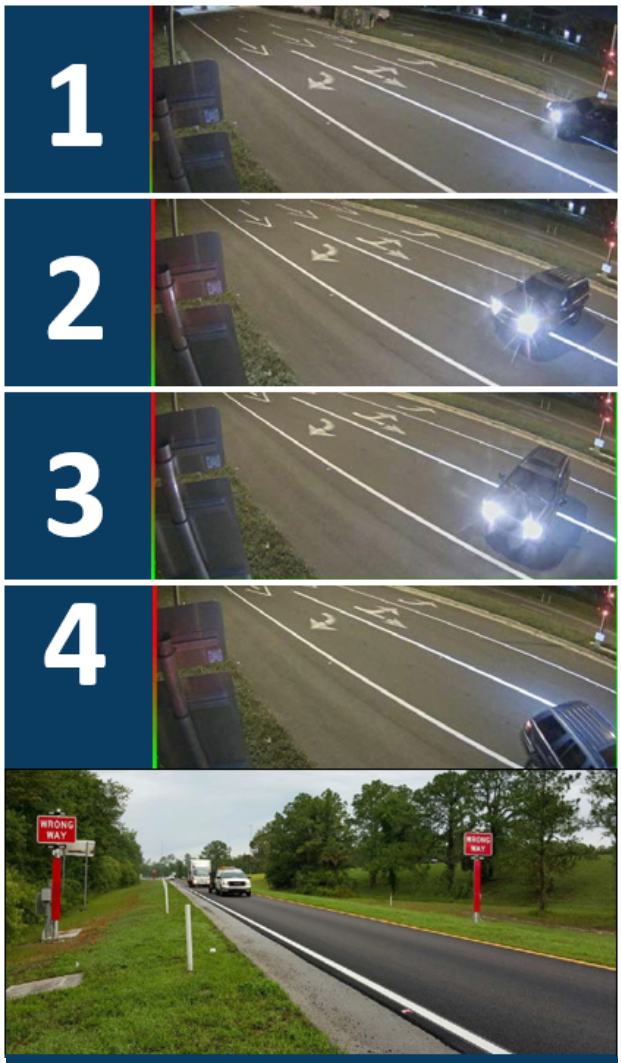
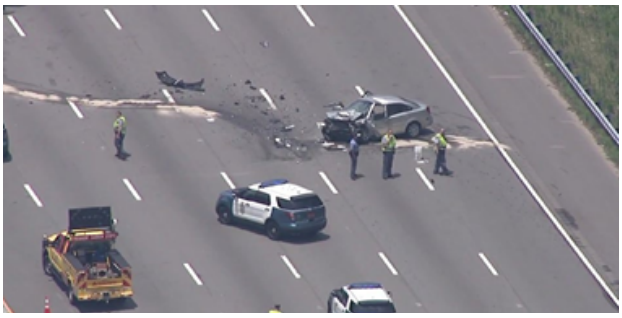


Figure 2: Wrong-way Countermeasures System

staff to determine if the call was an actual WWD event, allowing time for the center to dispatch first responders if needed. Details on how WWD countermeasures are proposed to be deployed at an off-ramp can be found in Component Five.

By deploying these systems, and enhancing existing systems, NCDOT will improve safety on a heavily travelled section of road. Since 2000, 555 crashes and 164 fatalities have been attributed to WWD in North Carolina. In 2018 alone, North Carolina experienced 1,442 fatalities on their highways, with 276 incidents

classified as WWD between 2000 and 2017 (North Carolina Department of Transportation, 2018 Traffic Crash Facts).



Wake County woman killed in wrong-way crash on I-40.

In 2017, over 28 million motorists traveled along the I-85 corridor throughout the state of North Carolina. This corridor also serves as a major commerce route with truck traffic making up over 11 percent of the total volume. The total number of reported crashes along this corridor experienced an increase of three percent from 2016 to 2017 while the total number of reported fatalities experienced a decrease of 11 percent over the same timeframe.

Troopers gather at the site of a wrong-way crash at I-73 bridge in Greensboro, NC.

Public interest and support are high for preventing deaths caused by WWD crashes. Due to public awareness, increased media coverage, and governmental involvement, over the last several years state and local transportation agencies and universities have taken a proactive approach by investing time and resources into the prevention of WWD fatalities.

A man was killed when he crashed into a tractor trailer while driving the wrong way on I-485 near Moores Chapel Road in west Charlotte, NC.

By installing these WWD countermeasures on the busy I-85/I-40 corridor, NCDOT can support future economic growth and work proactively with the commercial sector to save the lives of North Carolina's growing citizen population. In a recent presentation to NCDOT, Michael Cline, State Demographer, estimated that Raleigh-Durham and Charlotte, Transportation Divisions 5 and 10 respectively, will account for approximately 52 percent of all growth from now through 2038. As the second fastest growing state on the East Coast, and the tenth fastest growing state in the U.S., North Carolina's growing population will benefit from this lifesaving technology.

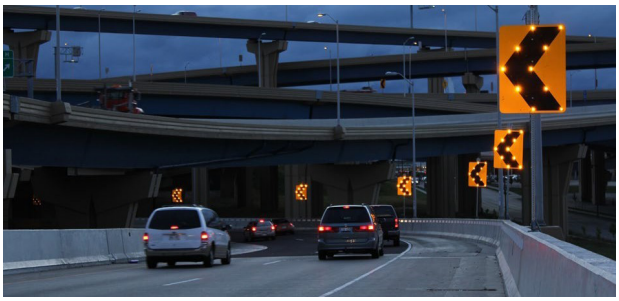
Component Three: Dynamic Curve Warning Systems

Horizontal curve crashes are a serious problem taking the lives of many people across all age groups. The average crash rates are three times higher than tangent roadway segments and account for 25 percent of all highway fatalities. Studies show crashes on curves rise exponentially during precipitation events. North Carolina has an annual precipitation rate or 52 inches annually – about 1.7 times more than the national precipitation average of 30 inches – and a quickly growing population that supports a thriving economy for both urban and rural areas.

Dynamic Curve Warning Systems (DCWS) play a key role in preventing these types of crashes. Deployment of ITS equipment can effectively communicate real-time warnings, speed violators, and crashes to local TMC's. With backend participation, this technology will produce enhanced results. The curve system being proposed is a sequential DCWS designed to warn motorists to reduce speed prior to the curve via ITS field applications.

The elements of ITS technology proposed by this Project to slow down the vehicle while providing positive guidance to safely navigate the horizontal curve include:

- Chevron signs with embedded LEDs, predicated on the Manual on Uniform Traffic Control Device (MUTCD)
- Improved pavement markings
- Improved corridor regulatory and advisory signing
- Speed and precipitation sensors to intelligently manage the LED chevron signs based on driver behavior
- Relay of a warning message to a traffic management center (TMC) in real-time
- Software interface at the TMC to log and store events, and provide audible warning of such events



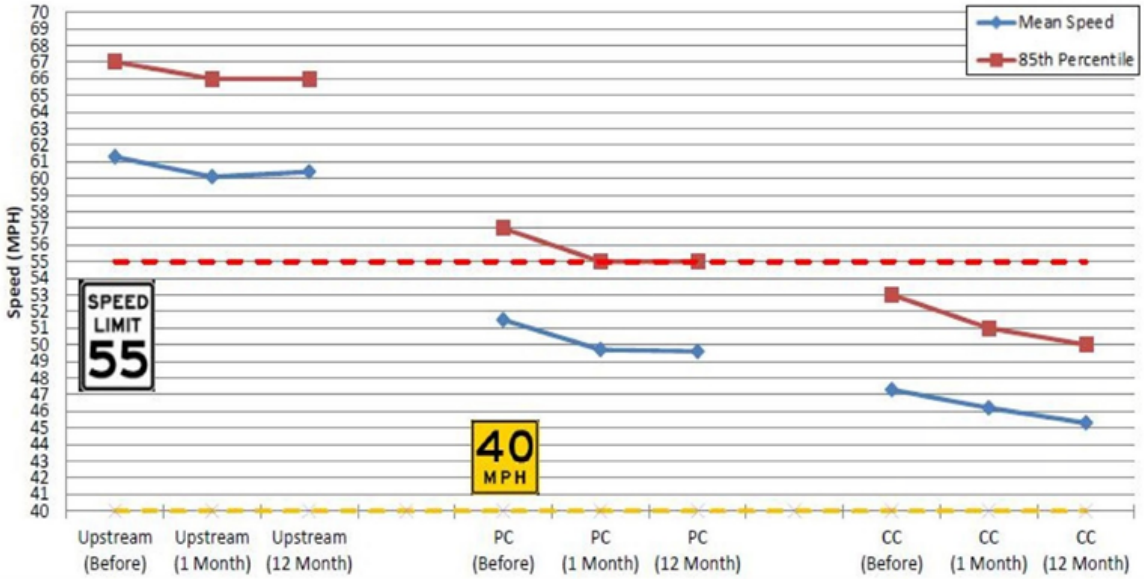
Nighttime DCWS application

Sequential DCWS during the day

Real-time notifications will increase likelihood that a response can occur immediately, by dispatching first responders, activating preset dynamic messaging signs (DMS), and mobilization of other communications to warn drivers of crashes, and reduce the likelihood of a secondary incident within the vicinity of the curve.

Studies on DCWS have shown a consistent reduction in the speeds of vehicles on the road. The sites studied had a 11 percent decrease on average in the proportion of vehicles exceeding the curve advisory speed by five or more mph. Additionally, data shows a downward trend of vehicles exceeding the advisory speed

Figure 3: Speed Impact



and speed limit by showing the percentage of vehicles exceeding both at each time period. Furthermore, the fraction of vehicles exceeding the posted or advisory speed limit showed reductions during all data collection periods from as early as one month after the DCWS was installed, as shown in **Figure 3**.

The proposed system is also CAV adaptable which brings additional benefits for agencies migrating to these emerging technologies. By addressing the issue of horizontal curve crashes and using a DCWS when warranted, engineers, planners and safety officials are pursuing the highest standards of social and community responsibility.

Component Four: Advanced Data Analytics and the North Carolina Transportation Analytics Center Overview

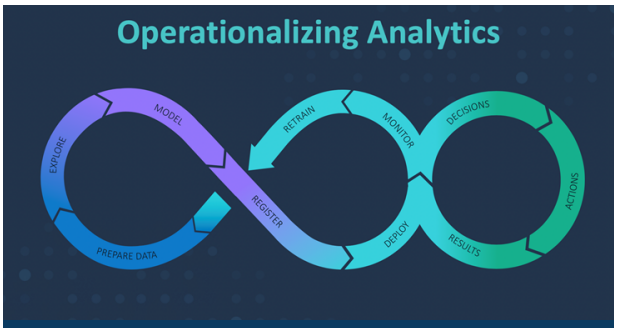
Since 2013, the North Carolina Transportation Analytics Center (NC TAC) has used advanced analytics and data integration from multiple state agencies to help with data-driven decision making to reduce costs as well as improve operational efficiency, outcomes, and customer service. It builds on previous success of a budget and revenue forecasting workstream to identify new ways to use data and analytics to stay ahead of rapid growth, evolving infrastructure demands and disruptive developments.

The forecasting solutions were critical to planning and executing program adjustments as NCDOT faced unprecedented storm impacts, a state court ruling that greatly increased the cost of right of way purchases for certain projects, and revenue challenges related to the COVID-19 pandemic.

The NC TAC uniquely positions North Carolina to enhance the Project by leveraging new and emerging technologies to build analytic insights that drive the safe and efficient movement of passenger and freight vehicles throughout the

State. NCDOT has extended its use of an analytics platform with capabilities for artificial intelligence, open access to all data types, open language processing, and cloud deployments, to power its pioneering TAC.

Using a single platform for managing data, building analytic modules, and deploying operational and policy results to the agency has enabled NCDOT to develop analytic maturity throughout the organization. The analytics platform supports the full lifecycle of the decision management process, from data preparation through modeling and analytics, rule development and decision design, deployment, and monitoring.



Analytics lifecycle

General Approach to Data Management

General analytic solutions use data repositories to enable a wide range of analysis and insights, including historical analysis, trend and pattern analysis and prediction and forecasting – answering questions such as what happened, what is likely to happen, and what is the best course of action.

The NC TAC recognizes that quality, reliable, accurate and timely data is the foundation to building advanced analytics and reporting to improve safety and mobility. The NC TAC provides a consistent approach for:

- Data integration to share and combine vital information across various transportation agencies in an efficient and effective way so that decision makers can formulate plans and policies that will address traffic safety issues in a holistic way
- Data quality to ensure the most accurate and complete data is available to build analyses and reports
- Data management to develop master data management processes that build a unified view of the information and manage that master view of data over time

With high quality data, the NC TAC can apply advanced analytic techniques, including:

- Data exploration to allow all users, both internal and external, to have access to the right information, in the right format and the right time to gain insights to answer a wide variety of business questions
- Advanced analytics, like predictive analysis and forecasting, to identify transportation trends and patterns and to anticipate the issues that will be faced in the future and determine the best path forward
- Analytics-Based Reporting to ensure that analytics based on all available data are consumable through self-service applications that embed analytics capabilities into reporting technology

Users can apply sophisticated analytics and machine learning to automate decisions, augment analytical decisioning models with both pre-set business rules and real-time contextual influences, and improve governance and traceability for analytically driven decisions. The capabilities can extend to virtually any operational decision needed.

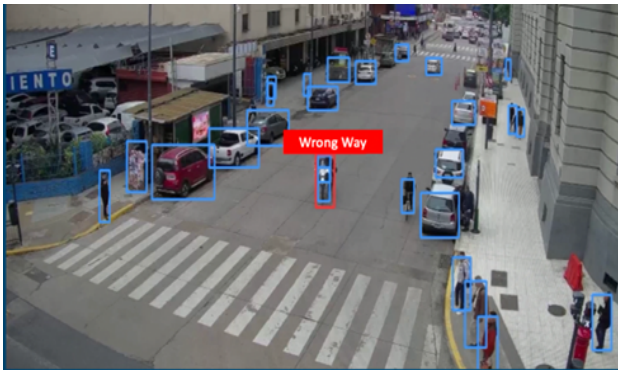
Edge Analytics

The world of transportation is comprised of constantly changing variables making real-time information critical to proactive, effective and timely decisions to reduce congestion and improve safety. Edge analytics provides the capability to analyze data where it is created, from thousands of different devices, including electrical and mechanical sensors, mobile communications, video, and more. Where traditional analytic approaches store data for later analysis, edge analytics occurs in real-time, as data passes through, enabling us to identify and understand patterns of interest as the data is being created, resulting in instant insights and immediate action.

The event stream processing enables immediate understanding of current conditions and rapidly changing scenarios, but also allows for evaluation and prediction of future scenarios. Key data elements can be stored for building long-term insights into trends, patterns of behavior, and projected outcomes.

Wrong-Way Vehicles and Impaired Drivers

Computer vision capabilities can detect wrong-way maneuvers on roadways. Computer vision is a field of artificial intelligence that trains computers to interpret and understand the visual world. Using digital images from existing or upgraded cameras and videos along with deep learning models, machines can accurately identify and classify objects — and then react to what they "see." The NC TAC proposes using computer vision video surveillance and advanced algorithms, implemented with event stream processing engine to monitor traffic images and immediately detect wrong-way movements in real-time as data is transmitted from video cameras (focusing primarily on the mainline interstate movements rather than the ramp countermeasures in Components Two and Five).



Detecting WWD through computer vision

Similarly, behavior indicating impaired or distressed drivers can also be detected. When the analytics identify wrong-way or impaired driving, real-time alerts can be sent to driver notification systems and first responders. Through combining the computer vision capabilities with geographic and other information such as speed and direction, analytics can provide updates on the movements and location of the vehicles to guide first responder in intercepting the vehicle.

Human Trafficking

According to the National Human Trafficking Hotline, in 2018, North Carolina

had 287 reported human trafficking cases. This statistic ranks North Carolina 10th in the U.S., in terms of the number of reported human trafficking cases. Using computer vision and deep learning models, the NC TAC plans to deploy machine learning analytics to monitor video feeds at select locations, including two rest areas, within the Project corridor that may identify activity that could be related to human trafficking.

Road Conditions

Driver and vehicle safety are also impacted by road conditions, including the physical condition of pavement, structures (i.e., bridges, walls, etc.), and other assets. Computer vision capabilities can be used to detect changes from normal conditions on the roadway, structures and assets. By capturing and storing digital images of normal conditions, image comparison analysis can quickly pinpoint anomalies in the road conditions and generate alerts for quick action on issues like flooding, snow, cracks, potholes, or debris in the road. Computer vision can also detect damage or changes to structure, missing or downed signage, and other impacts that could impair driver safety.

Component Five: Wrong-Way Driver Detection and Notification Systems – Toll NC-540 Corridor

The North Carolina Turnpike Authority (NCTA), a division of the NCDOT, has been among the nation's leaders in the deployment of WWD technology. However, sadly, in March of 2020, NCTA experienced its first wrong-way driver fatality on the Monroe Expressway (**Figure 4**), further underlining the tragic nature of these types of crashes and the need for expanded protections on North Carolina's roads.

The NCTA has taken a proactive approach to implement new measures to prevent WWD occurrences on its facilities through the development of a WWD Detection and Notification (WWDDN) Pilot Program. NCTA's WWDDN Pilot Program began in 2018 and implemented multiple advanced WWDDN systems that expand upon the existing North Carolina standard practice of using static "Do Not Enter" and "Wrong Way" signs at ramp entry points to deter wrong-way entries.

The objectives established for the NCTA WWDDN Pilot Program were to:

- Detect a wrong-way vehicle
- Alert the wrong-way vehicle driver to encourage self-correction
- Notify transportation management center of wrong-way vehicle occurrences
- Notify law enforcement of wrong-way vehicle (as needed)
- Track wrong-way vehicle
- Log wrong-way incidents

As part of the Pilot Program, NCTA worked with several vendors to install various

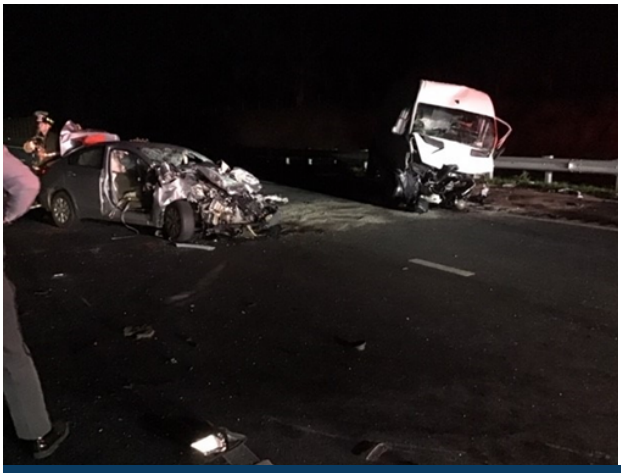


Figure 4: Monroe Expressway WWD crash

advanced WWD detection systems at several pre-determined test locations on the Triangle Expressway outside Raleigh. These test locations were selected based on those that had the highest number of historical WWD occurrences. The six test locations are described below:

1. Davis Drive Off-ramp: Full deployment of smart signs (four), cameras, and microwave detection devices, in addition to improvements to signs and traffic signal indications, with TMC notifications.
2. Davis Drive Off-ramp: At same location as #1, thermal camera and detection, with TMC notifications.
3. Salem Street Off-ramp: Full deployment of smart signs (four), cameras, and microwave detection devices, in addition to improvements to signs and pavement markings.
4. Green Level Off-ramp: Deployment of LIDAR detection and thermal tracking camera, with TMC notifications.
5. NC-54 Off-ramp: Deployment of microwave radar with TMC notifications.
6. Green Level Mainline Toll Site: Deployment of smart signs (four) tied to nearby toll zone loop detections, with TMC notifications.

Figure 5 shows an RRFB sign deployed by NCTA on the Triangle Expressway as a part of pilot site 6. The pilot program tested equipment from five different vendors, including four different types of smart signs, three different types of detection, and three different camera technologies.

Figure 5: An RRFB sign at NCTA pilot site

NCTA is in the process of closing out the pilot program and planning for a full deployment of these safety countermeasures at their expressway facilities in current operation (the Triangle Expressway and the Monroe Expressway). Draft conceptual plans of the two types of deployments and other details and photos of the NCTA WWDDN pilot sites can be found in on the project website:

https://connect.ncdot.gov/resources/BUILD2020-i85/Pages/default.aspx

The proposed technology is further discussed in Component Two.

For the 2020 FAST Project, the application proposes to fully implement wrong-way driver countermeasures on all off-ramps on the Toll NC-540 corridor (the Triangle Expressway). This includes 18 locations on the existing facility and 11 locations

currently under construction (known as "Complete 540"). For the Complete 540 locations, the three design-build teams (STIP R-2721A, R-2721B, and R-2828) are constructing some of the infrastructure needed for these sites including two sign pedestals and fiber-optic cable drop. This component will:

- Complete the infrastructure for Complete 540 (add two sign pedestals);
- Install detection, cameras and smart signs; and
- Provide the integration into system-wide notification and logging software

For the Triangle Expressway sites, the Project will provide all elements of the WWDDN system:

- Sign pedestals (four per site);
- Detection;
- Smart signs;
- Notification camera and tracking camera;
- Connection to the fiber-optic network; and
- Provide the integration into system-wide notification and logging software.

II. PROJECT LOCATION

The Project is located in North Carolina, the second fastest growing state on the East Coast. The I-40/I-85/Toll NC-540 corridor is an important part of the local, regional, state, and national transportation system. It traverses over 200 miles through 10 counties in North Carolina (Wake, Orange, Durham, Alamance, Guilford, Randolph, Davidson, Rowan, Cabarrus, and Mecklenburg) and, at the local level, functions as a major arterial that connects the three largest metropolitan areas of the state (see **Figure 1**).

Because of their statewide and regional importance, both I-85 and I-40 have been designated as a Strategic Transportation Corridor (STC) by NCDOT. The STC initiative represents a timely effort to preserve and maximize the mobility and connectivity on a core set of transportation corridors, while promoting environmental stewardship through maximizing the use of existing facilities to the extent possible, and fostering economic prosperity through the quick and efficient movement of people and goods.

Broader Context of the Project

The Project is part of a much larger program of state investment to build out the fiber network in North Carolina. The goal of the program is to connect the major transportation and freight hubs into one efficient and resilient network. **Figure 6** illustrates the evolution of this network.

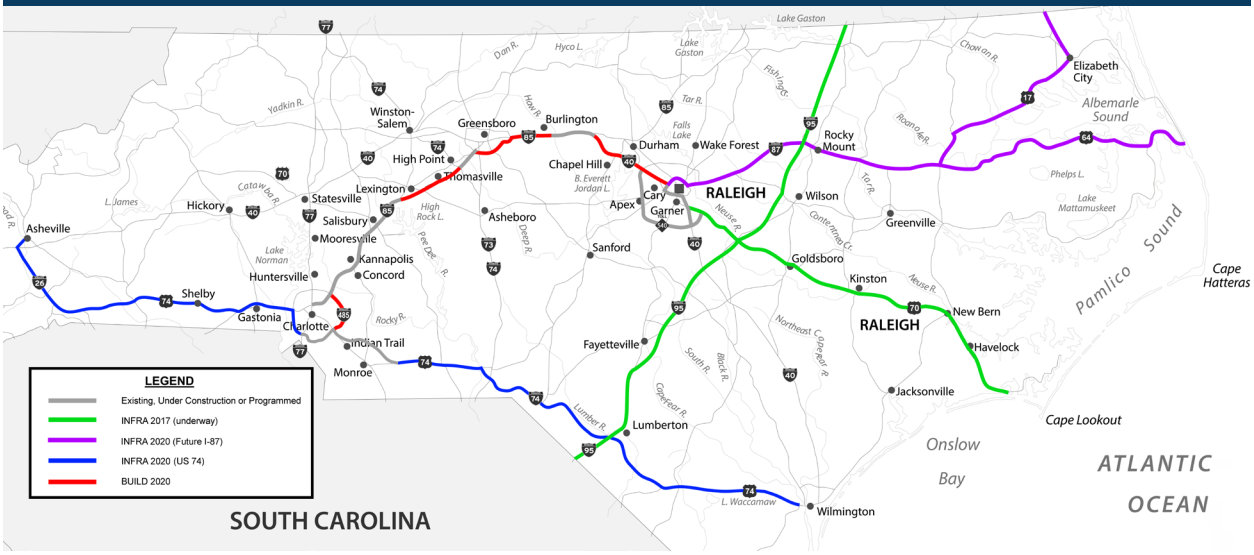
There are three other initiatives underway to install fiber along NC's interstate and US route network. The fiber shown in the "2017 Build-out" was recently advertised for a Request for Qualifications under project I-5986C & R-5777D. The Department has submitted INFRA grant applications with components of fiber east of I-95 and from Wilmington to Hickory.

Finally, this BUILD 2020 will complete the fiber infrastructure along I-85 and I-40.

Opportunity Zones

The Project is not located in an Opportunity Zone.

Figure 6: Fiber Network Evolution



Project Parties

The North Carolina Department of Transportation will deliver the Project.

North Carolina Department of Transportation (NCDOT)

NCDOT is responsible for maintaining approximately 80,000 miles of roadways and 18,000 bridges and culverts across North Carolina, as well as regulating and implementing programs to support rail, aviation, ferry, public transit, and bicycle and pedestrian transportation. The department also includes the Governor's Highway Safety Program, NC Division of Motor Vehicles and NC Turnpike Authority, as well as NC State Ports Authority and NC Global TransPark – both of which help expand economic opportunities in the state.

With an annual operating budget of about $5.3 billion, the NCDOT is responsible for building and maintaining the state's transportation network as well as overseeing the state's Division of Motor Vehicles. Federal funding accounts for a little over 20 percent of NCDOT's overall annual budget and about 45 percent of its construction budget, generated through the federal motor fuel tax and vehicle fees (mostly on trucks). NCDOT understands USDOT reporting and administration requirements and will continue to comply with them.

The Department's role(s) includes:

- BUILD 2020 Discretionary Grant Applicant
- Funding partner
- Owner of the right of way
- Grant Recipient responsible for administering the grant if selected
- Aids in ensuring efficient integration of the BUILD 2020 Project into the existing intermodal operations surrounding I-85/I-40, as well as planned projects
- Oversight of project delivery
- Develops and monitors operations and maintenance standards for outsourced services (see the Innovation section of the application narrative)

» Innovative contracting partner in P3/P4 opportunities, generating revenue from the fiber-optic cable in the corridor right-of-way.

Multiple stakeholders have written in support of the Project. Their letters are available at:

https://connect.ncdot.gov/resources/BUILD2020-i85/Pages/default.aspx

III. GRANT FUNDS, SOURCES AND USES OF PROJECT FUNDS

The estimated cost of the overall project is $25.713 million. The State is requesting BUILD funding to leverage state investment, unlock private investment, and accelerate improvement to one of the nation's oldest and busiest interstate corridors and one of its future interstate routes. The Project will improve safety, reduce travel times, enhance freight movement, and improve the network's resiliency to non-recurring delay and natural disasters.

Previously Incurred Expenses

NCDOT has already made or committed substantial investment in the Project area. Based on the 2019 NCDOT Final STIP, committed investments related to ITS and/or WWD prevention by Project component are as follows:

a. I-3802AA = $1.9M
b. I-3802B = $1.017M
c. C-5600E = $332K
d. I-3306 = $2.44M
e. R-2828, R-2721A = $330K

In short, NCDOT has invested almost $6.03M in the Project area to advance these corridors.

Source and Amount of Funds

All non-Federal match funds are state funds. The source is North Carolina's Highway Trust Fund.

Documentation of the Funding Commitment for Non-Federal Funds

Two letters committing the state's Non-Federal match funds is included in the supplemental materials provided with this application. The location of supplemental materials is:

https://connect.ncdot.gov/resources/BUILD2020-i85/Pages/default.aspx

Federal Funds Applied to Future Costs and Source of any Required Non-Federal Match

No Federal funds will be used for beyond the BUILD funds requested in this application.

Budget Showing Sources and Uses of Funds

NCDOT requests $8.213M in BUILD funding. This represents 31.9 percent of the total Project cost. The Project funding sources are allocated across the major project components in **Table 3**.

Documentation of Contingency

A contingency of 45 percent is included in the estimates for miscellaneous and mobilization items in all projects, consistent with NCDOT practice.

IV. SELECTION CRITERIA

Introduction

The Project will support the North Carolina region's economy over the long-term by providing the workforce and residents of North Carolina with improved interstate and freeway facilities, generating travel

Table 2: Major Project Component by Funding Source, 2020 $			
Description	**Committed NCDOT and NCTA**	**BUILD**	**Total**
Component 1			
Fiber-Optic Trunkline	$3.500M	$5.967M	$9.468M
Integrated Corridor Management	$7.251M	$0	$7.251M
Component 2			
Wrong-Way Driver Detection and Notification Systems (I-85/I-40)	$1.802M	$0	$1.802M
Component 3			
Dynamic Curve Warning Systems (I-85/I-40)	$1.674M	$0	$1.674M
Component 4			
Advanced Analytics	$773K	$0	$773K
I-85/I-40 SUBTOTALS:	**$15M**	**$5.967M**	**$20.968M**
Component 5			
Wrong-Way Driver Detection and Notification Systems (NCTA)	$2.5M	$2.245M	$4.745M
I-85/I-40/NC-540 TOTALS:	**$17.5M**	**$8.213M**	**$25.713M**

time savings, improving reliability, auto emissions reductions, reducing the likelihood for crashes, providing potential new fiber internet connections for rural counties, and providing the infrastructure to support future autonomous vehicles.

Safety

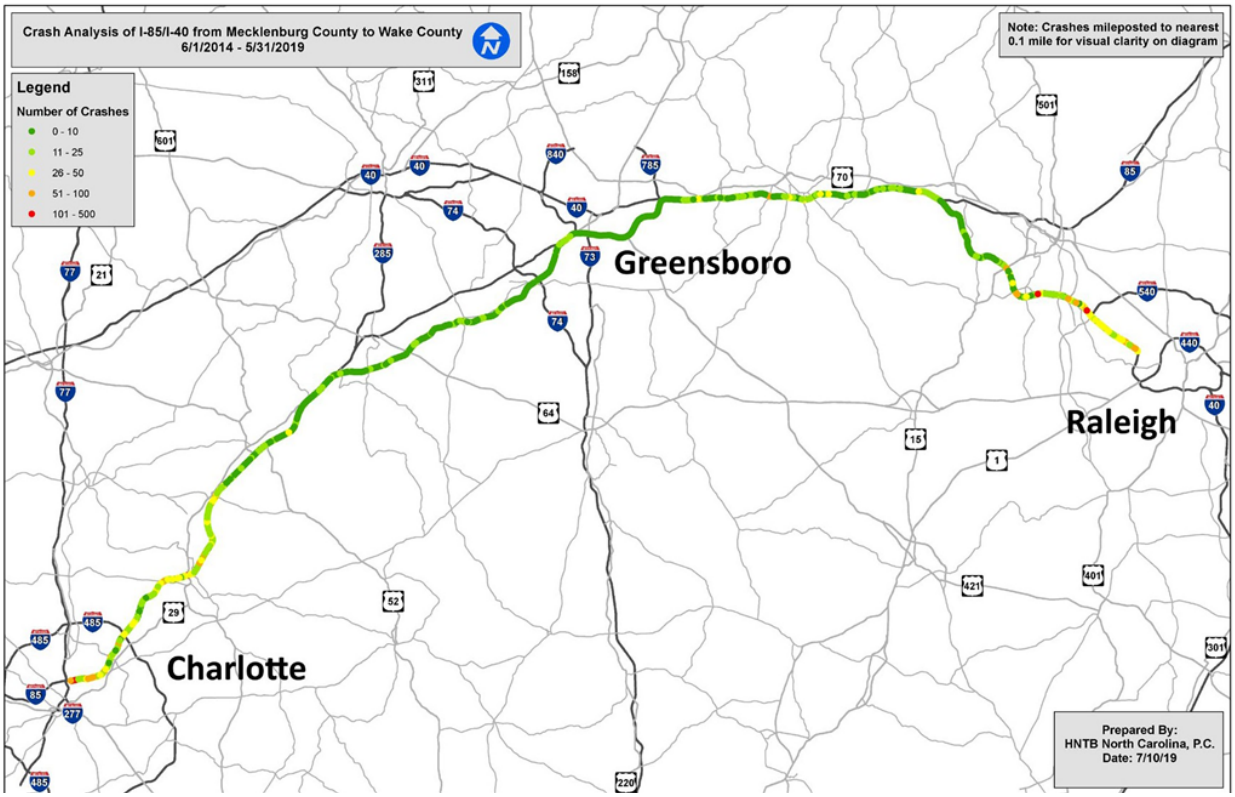
As noted in the Project Summary, safety is an important part of the transportation challenge addressed by the Project.

Figure 7 shows the crash locations along the I-85/I-40 corridors in the study area. The provision of fiber-optic communications improves public safety and emergency response capabilities as law enforcement and emergency responders are better able to access databases and coordinate responses from the roadside. The improvements collectively improve the resiliency of the network, streamlining evacuation during natural disasters.

The wrong-way driver and dynamic curve warning systems have a demonstrated capacity to turn around wrong way drivers, alert motorists to these dangerous situations, and reduce first responder costs due to false calls. Finally, advanced analytics offer a wide range of tools for identifying risky road conditions and illegal or inadvisable driver behavior.

See narrative in Components Two, Three, and Five for further discussion of enhancement of safety.

Figure 7: Crash Locations (2012-2016), Source: High Frequency Crash Location Section Scores 2012-2016 dataset from NCDOT



Economic Competitiveness

The Project supports economic competitiveness in a variety of ways.

a. **Technology —** The installation of fiber allows for more accurate use of navigation apps that allow users to anticipate traffic conditions and plan ahead appropriately. The transportation system is therefore used more efficiently. In addition, emergency services, natural disaster evacuations, public safety, and roadside safety can all be improved with better broadband connectivity. The installation of fiber also provides the groundwork for the future of autonomous vehicles.

   As connected and autonomous vehicles move into the consumer fleet, preparing the transportation infrastructure for these new vehicle capabilities allows for the continued safe and efficient movement of people and goods along corridors. The evolving utilization of the connected and autonomous vehicles will further improve safety.

b. **Travel time and cost savings —** The introduction of Integrated Corridor Management techniques supported by the introduction of fiber will improve the resolution of incident delay, improve reliability, and allow for better management of the network, including the ability to re-route travelers. Collectively, this saves travel time and reduces costs.

Environmental Benefits

Transportation is a large generator of emissions. When the efficiency of the road network improves, there is less idling and delays. This reduces the amount of emissions released into the environment and their associated avoided costs.

Secondary Selection Criteria

Innovative Technology

As discussed in the narratives of Components Two through Five, the Project proposes a suite of innovative technology to address driver safety and improve the efficiency of first responders.

Innovative Project Delivery

NCDOT has continued to seek innovative ways to partner with the private sector to advance innovation and delivery of projects. One solution includes the installation of fiber-optic cable along the Project corridors that could lead to a public-private partnership opportunity to concession the use of the fiber to private companies, while leveraging its use for safety and operational needs, improving internet access and quality in rural areas of the state with poor internet and cell coverage, and generating revenue that can be used to operate and maintain the Project.

NCDOT is in the process of pursuing an innovative delivery for a previous awarded INFRA Grant for fiber installations along I-95 and a stretch of US 70. The Department has recently advertised a Request for Qualification (RFQ) for the I-5986C/R-5777D Broadband project, which includes three potential tracks for the proposer:

- Design-Build
- Operations, Maintenance and Commercialization
- Design, Build, Finance, Operate, Maintain and Commercialization

That advertisement can be found here:

https://connect.ncdot.gov/letting/Pages/Design-Build-Letting-Details.aspx?let_id=Broadband%20I-5986C%20and%20R-5777D

Leveraging Federal Funding

For the Project, NCDOT will invest $17.5M in non-Federal, state funds. Applied across the Project components, this yields a non-Federal, state funds to requested federal BUILD funds ratio of:

- 2.13 for the Total Project

In short, every $1.00 of BUILD funding received is matched by another $2.13 of state funding.

The Project cannot be delivered in a timely way using traditional funding approaches because of the State's Strategic Transportation Investments (STI) legislation. Receipt of discretionary BUILD funds will permit NCDOT to deliver these necessary improvements 5 to 10 years earlier than in the absence of BUILD support.

This section discusses NCDOT's efforts to advance the Project and how receipt of BUILD funds would accelerate the Project.

Description of NCDOT's Activities to Maximize the Non-Federal Share of the Project Funding

On January 1, 2018, North Carolina's gas tax changed, based on a statutory formula that takes into consideration population and energy cost inflation. Thus, the State has taken steps to protect the purchasing power of a critical revenue source. As noted in the Innovation section, the State plans to use the fiber-optic capabilities of the Project as the basis for a P3/P4 arrangement to generate revenue that it will use for the operations and maintenance of the Project under an outsourced arrangement.

Description of any Fiscal Constraints that affect the Applicant's Ability to use Non-Federal Contributions

All required NCDOT investments for the Project have been secured and are not subject to any known constraints that would affect a project of this size.

Description of the Non-Federal Share Across the Applicant's Transportation Program

State funding accounts for about 80 percent of NCDOT's overall budget of $5.3 billion. Approximately 50 percent of state transportation funding is based on revenues from the Motor Fuel Tax; 30 percent comes from driver and vehicles fees collected by the North Carolina Division of Motor Vehicles; and 20 percent is from the Highway Use Tax on vehicle title transfers.

The 2015-16 Long Session of the NC General Assembly increased the transportation revenues of both NC transportation funds. These two funds are:

1. Highway Fund (HF) mainly used for maintenance and operations and
2. The Highway Trust Fund (HTF) used exclusively for capital projects (along with Federal-aid funds). Below is a summary of these changes which are part of Session Law 2015-2 (SB 20) and Session Law 2015-241 (HB 7).
    - Modernized the 30-year variable rate Motor Fuel Tax (MFT) formula. The Motor Fuel Tax is indexed to energy inflation and adjusted for population
    - Changed the almost 25-year MFT distribution of revenues between the HF and HFT
    - Reduced the MFT revenue deductions to other funds
    - Increased most vehicle and driver fees by 30 percent with quadrennial adjustments for inflation.
    - Increased certain Highway Use Tax (HUT) caps
    - Stopped transfers from the HF to the NC General Fund – resulting in increased transportation budget authority

Description of the Applicant's Plan to Address the Full Lifecycle Costs Associated with the Project including Operations and Maintenance Funding Commitments

NCDOT's approach to providing funding for operations and maintenance of the fiber is one of the innovations of the Project. The upgraded section of the corridor will generate revenues to help support its own operations and maintenance through outsourced agreements within the right-of-way.

Potential for Innovation

The Project offers potential for innovation in several key areas. These are:

1. Through the process in which it will fund and manage operations and maintenance;
2. Using ITS to manage capacity and prepare for autonomous and connected vehicles; and
3. Leveraging transportation infrastructure to support education and economic development in North Carolina's rural communities.

Funding and Managing Project Operations and Maintenance

As the cornerstone of the Project, NCDOT will be installing missing sections of fiber-optic cable in the right-of-way of I-85 and I-40. The trunk line cable has several innovative applications as discussed in the following section. The inclusion of this work in the Project also offers an opportunity to partner with the private sector to generate revenue. Specifically, the Project will capitalize on the incentive and opportunity for receiving fair market value of the right-of-way in exchange for private telecommunications expertise and capacity to further both public sector and private corporate objectives.

Using ITS to Manage Capacity and Prepare for Connected and Autonomous Vehicles

The new fiber-optic cables have both near-term and long-term applications. In the near term, NCDOT can connect communications and monitoring equipment to implement ICM practices and jointly manage I-85 and I-40 to obtain more reliable throughput. Utilizing this new communications infrastructure to manage traffic through ICM is anticipated to reduce the incidence of crashes, reduce emissions, and utilize capacity more efficiently. ICM enables the application of a variety of operating policies to manage the Project area more efficiently as highlighted in **Figure 8**.

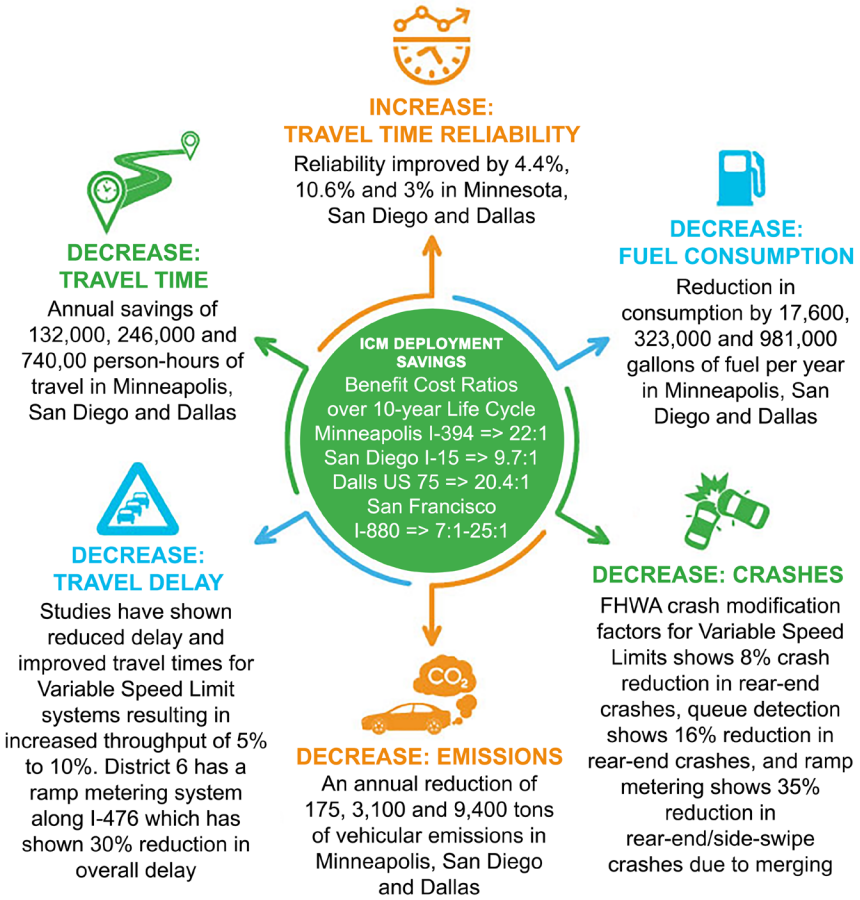
Longer-term, the provision of fiber cable prepares the corridor for eventual adoption and use of autonomous and connected vehicles. At this early stage in the transition between conventional vehicles and autonomous ones, there are many unknowns concerning technology standards and how the eventual evolution to connected and autonomous vehicles will be achieved. By installing this communication backbone as NCDOT reconstructs these corridors, the agency is proactively preparing these corridors for future technologies as the market evolves. The ability to accommodate future technologies is important given the critical role that I-85, I-40 and NC-540 play in the national interstate travel network. The benefit cost assessment prepared for this Project includes benefits from the future utilization of autonomous and connected vehicle technologies in the Project area.

Leveraging Transportation Infrastructure to Support Education and Economic Development in North Carolina's Communities

The Project utilizes transportation infrastructure investment to accomplish more than just transportation. NCDOT will be working with its State Agency partners to utilize this new communications backbone to deliver these types of benefits.

As the recent COVID-19 crisis has clearly demonstrated, reliable high-speed internet

Figure 8: Illustrative Integrated Corridor Management Benefits



access has never been more necessary to maximize the educational opportunities of NC's students and give work at home employees the productivity to maintain our economy.

Performance and Accountability

North Carolina regularly uses performance metrics to track outcomes over time and assesses investments through the STI process to ensure that the state uses its dollars in the most efficient way to obtain long-range objectives. There are several innovations in this Project, and NCDOT has developed two initiatives to assess performance and to ensure accountability in the delivery of the proposed Project described in this application. Each is outlined on the next page.

1. If selected for award, NCDOT proposes to negotiate a set of milestone dates for monitoring the remaining pre- construction activity. Once these milestones are established for each major Project component, NCDOT agrees to not seek reimbursement (fund out of their own budget over and above funds already committed to the Project) for pre-construction costs that fail to deliver the Project to construction by the agreed upon date.

2. If selected for award, NCDOT proposes to return five percent of the Project component cost for any component not opened to the public for public use by the agreed upon date.

Using this approach, USDOT can monitor NCDOT's performance in managing the Project and hold NCDOT accountable.

V. PROJECT READINESS

Should the Project be approved for BUILD grant funding, NCDOT is ready for obligation as soon as the necessary documentation can be executed. The Project site is located within an active highway corridor, with no change in the existing land use. The environmental process should be greatly simplified.

Technical Feasibility

The cost information presented in the Supplemental Materials is based on recent similar successfully completed projects by NCDOT. There is a 45 percent contingency on miscellaneous and mobilization items in each major Project component. All costs and designs have been prepared by or reviewed by NCDOT's or NCTA's engineering staff.

NCDOT has deep experience in delivering the state's highway program and has delivered similar facilities throughout

the state. The technical challenges are well understood through its experience operating the current facilities in the Project areas, and its experience designing and delivering new facilities across the state.

Project Schedule

Table 3 depicts the Project Schedule. Assuming awards are made in late 2020 and it takes the balance of the year to complete an agreement, construction could begin on several of the project elements immediately in 2021. All project funds will be expended by 2026 or earlier.

Right of Way

Right of Way acquisition is not anticipated for this project.

Timely Obligation of Funds

Due to the minimal approvals needed, and lack of environmental document, project funds will be obligated well before September 30, 2022.

Timely Expenditure of Funds:

Due to the technological nature of the Project, and the lack of hard infrastructure such as bridges to be constructed, project funds will be fully expended well before September 30, 2027.

Required Approvals

The following describes the status of required approvals:

Environmental Permits and Reviews

Based on project experience elsewhere in the Project area, it is anticipated that the appropriate National Environment Policy Act (NEPA) action is a documented Categorical Exclusion (CE). However, it is recognized that the Lead Federal Agency will make the determination regarding the NEPA action required.

Legislative Approvals

No legislative approvals are required.

Table 3: Project Schedule

	2020				2021				2022				2023			
Component:	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
BUILD ITS Projects:																
ICM, AA, WWD, DCWS																
BUILD Fiber Projects:																
Toll 540 WWD																
Segment 1																
Segment 2																
Segment 3																
Segment 4																

Legend: Initiation | Env. & Design | ROW/Utils | Construction

State and Local Planning

All existing or planned components of the Project were vetted through a data-driven planning process that coordinated transportation and land-use planning decisions and encouraged community participation. The STI process has three major "tiers" for investment. These tiers are based on their function in the overall transportation system. Projects on the interstates such as I-85 and I-40 are part of the statewide investment tier; projects on other US or NC designated routes are part of the regional investment tier, and everything else on the state system is part of the division tier. The statewide tier projects are selected purely on a data-driven basis. Once selected, they can go into the STIP. Regional projects are evaluated against each other in a two-division geography and receive input from NCDOT engineers and regional planning organizations. In short, projects are thoroughly assessed before they are added to the STIP.

Federal Transportation Requirements Affecting State and Local Planning

Many of the Project components are identified in one of the following documents:

1. Statewide Multimodal Freight Plan (2017)
2. ITS Strategic Deployment Plan for the Triangle
3. ITS Strategic Deployment Plan for the Triad
4. ITS Strategic Deployment Plan for the Metrolina

Assessment of Project Risks and Mitigation Strategies

An assessment of potential project risks indicates that the proposed project will not be affected by procurement delays, environment document uncertainties, or real estate acquisition costs. The NCDOT has completed work similar to

the proposed project and experienced no procurement delays of any significance. The Project site is currently utilized for highway purposes and is situated within an active transportation corridor. The proposed project is a rehabilitation of existing highway land use.

The Project will be managed by a dedicated Project Team that will have full authority to ensure the successful management of any risks, and is responsible for the delivery of established performance metrics. No environmental uncertainties are expected. The NCDOT is familiar with federal funding obligation and construction procedures.

Urban Project Determination Summary

The Project is classified as an urban project, (as described in Section C.3.ii of the BUILD NOFO) as a majority of the project cost will be spent across four urban areas, all of which total well above 200,000 people each.

VI. BENEFIT COST ANALYSIS

The project improvements work hand-in-hand to facilitate the efficient movement of travelers and freight in an environmentally responsible manner. While each of the components could be constructed independently, the full benefits of each are not fully realized until both are completed. Project Benefit Cost. The Project construction is expected to be complete in 2023. In order to capture a full 20 years of operation, a benefits period of 2023-2048 was selected. When the stream of costs and benefits are discounted at 7 percent, the Benefit Cost Ratio for the Project is 2.95.

Figure 9 shows the benefit cost analysis for the Project and its two major parts. For details on the Benefit Cost Analysis and the methodologies used, please see the technical memo included as an Attachment, and BCA spreadsheet workbook included within the provided support materials.

Figure 9: Benefit Cost Analysis

NCDOT 2020 BUILD I-85/I-40/NC-540 FAST	Total Project 20 Year Analysis Period (2024-2043) Values stated in 2020 $M Discounted at 7%
Costs	
Capital Costs	$16.7
Total Costs	$16.7
Benefits	
Safety	
Reduced Highway Fatalities and Crashes	$11.1
Sub-Total Safety Benefits	$11.1
Economic Competitiveness	
Fiber 3rd Party Leasing Benefits	$6.9
Reliability Savings from ICM	$36.2
NCDOT / NCTA Fiber Savings	$0.6
Sub-Total Economic Competitiveness	$43.7
O&M Costs	-$5.4
Net O&M	-$5.4
Total Benefits	$49.4
BC Ratio	**2.95**
Net Present value	**$32.7**