North Carolina
USDOT Grant Application

I-85/I-40
Foundations for Automated and Safer Transportation

JULY 2019
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ATTACHMENTS
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Attachment 2: Letters of Support

APPLICATION INFORMATION

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Supplemental Materials are available online at:
https://connect.ncdot.gov/resources/BUILD2019-I85/Pages/default.aspx

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<td><strong>Project Name</strong></td>
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<td><strong>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?</strong></td>
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I. PROJECT DESCRIPTION

Executive Summary
The NCDOT I-85/I-40 Foundations for Automated and Safer Transportation Project will improve safety, increase reliability and add communications infrastructure to one of the most traveled corridors in the state. 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. This will create opportunities to lease NCDOT communications infrastructure to the private sector. New wireless communication infrastructure will facilitate connected and automated vehicle technology. Two new safety systems at pilot locations 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 economy growth, and work proactively 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, is a major economic and social cost to our state.

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. 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 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

<table>
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<tr>
<th>Year</th>
<th>&lt;30 (min)</th>
<th>31 to 60 (min)</th>
<th>61 to 90 (min)</th>
<th>91 to 120 (min)</th>
<th>121 to 180 (min)</th>
<th>&gt; 181 (min)</th>
<th>Avg Length of Incident-Based Delay over 180 min</th>
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<td>2016</td>
<td>488</td>
<td>822</td>
<td>394</td>
<td>231</td>
<td>99</td>
<td>54</td>
<td>303</td>
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<td>2017</td>
<td>436</td>
<td>832</td>
<td>350</td>
<td>251</td>
<td>88</td>
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<tr>
<td>2018</td>
<td>552</td>
<td>619</td>
<td>363</td>
<td>212</td>
<td>112</td>
<td>85</td>
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<td>2019**</td>
<td>253</td>
<td>256</td>
<td>142</td>
<td>78</td>
<td>34</td>
<td>34</td>
<td>294</td>
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*Incident-Based delays queried were “Vehicle Crash” and “Disabled Vehicle.”
**Through May 2019
Source: NCDOT Travel Information (TIMS)
fatal crash rate involving commercial motor vehicles of 0.07 per 100 MVMT.

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

Table 1 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.

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 & Dedicated Short Range Communications (DSRC)** – The lack of a completed fiber-optic link that connects the state’s three largest metro areas has long been a hindrance toward achieving maximum sharing of traffic data and video feeds between traffic management centers. The project will eliminate this hurdle, and provide the infrastructure needed for the deployment of connected and autonomous vehicle infrastructure.

2. **Wrong-Way Vehicle Detection and Notifications Systems** – 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 deploy state of the art Wrong-Way Driving (WWD) countermeasures that will immediately notify the TMC, first responders and the public.

![Figure 1: I-85/I-40 ITS and Safety Improvements – Project Corridor](image)
A preliminary map of sites under consideration can be found here: [https://connect.ncdot.gov/resources/BUILD2019-I85/Pages/default.aspx](https://connect.ncdot.gov/resources/BUILD2019-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 crash problem. 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/BUILD2019-I85/Pages/default.aspx](https://connect.ncdot.gov/resources/BUILD2019-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.

**Key Components of Project Package**

**Component One: Fiber-Optic Trunkline Completion & DSRC**

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 also serves as the overnight monitoring entity for all major state roads, as it is staffed 24/7/365.

Currently, these TMCs have very constrained connectivity to one another due to the lack of fiber connection between them. NCDOT 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 and microcell towers 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 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 proximate arterial signals. 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 this 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
» 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 allows the State to use its public right-of-way to address this digital revolution as it simultaneously addresses mobility challenges.

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.

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 1 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 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 trunklines and DSRC mini-cell towers in the highway right-of-way prepares these two corridors 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 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 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 & Notifications Systems**

In 2016, North Carolina experienced 1,441 fatalities on their highways, with 164 incidents classified as wrong-way between 2000 and 2017 (North Carolina, 2017 Traffic Crash Facts). Incidents occurring from wrong-way driving (WWD) account for about three percent of all highway crashes each year, making them rare, difficult to predict and challenging to analyze. What makes this three percent prominent is the percentage of fatalities that occur due to WWD. WWD crashes are often head-on collisions translating to 27 more fatalities per 100 fatal crashes than fatal crashes in general.

Due to public awareness, increased media coverage and governmental involvement addressing this issue, state and local transportation agencies and universities over the last several years have taken a proactive approach by investing time and resources to combat this preventable safety issue.

State transportation agencies in North Carolina, Florida, Texas, Arizona, Pennsylvania, Rhode Island, California among others are deploying various forms of detection and evaluating the performance of each applied countermeasure. Each system is observed and studied with data collected to determine the best performing applications, system application refinements, system cost to benefit ratios, system data to determine area hot-spots, best sites for future system deployment, and develop a comprehensive back-end management plan. At the backend, agencies are utilizing ITS technology to manage real-time data and deploy warnings to motorists of an impending danger and dispatch first responders in a timely manner to intercept and prevent wrong-way drivers from causing a potentially fatal crash.

Systems vary from improved static signs, pavement markings, and raised curb at extended left turn lanes onto the ramp. Other options employed to obtain driver attention and avoid entering an off-ramp the wrong way are ITS features such as enhanced wrong-way signs with built-in red light emitting diodes (LED) or rectangular
flashing beacons (RFB) with simple inductive or microwave detection to get the drivers attention to turn around prior to entering the highway. Other systems use radar, sonar, thermal and laser technology in combination with enhanced signing and video detection to monitor, warn motorists, and relay a warning to a TMC in real-time of actual WWD events. These events can then be immediately analyzed and managed by dispatching first responders, preset ITS dynamic message signs (DMS) and mobilization of other communications to warn right way drivers of impending danger.

Florida’s Turnpike Enterprise (FTE), along with the Florida Department of Transportation (FDOT) and the Central Florida Expressway Authority (CFX), have deployed successful WWD countermeasure systems along some of Florida’s busiest limited-access tolling corridors. Findings from studies and evaluation by the University of Central Florida (UCF) along with FDOT, FTE, and CFX have indicated remarkable results with CFX being awarded the International Bridge, Tunnel and Turnpike Association (IBTTA) National Toll Excellence Award for its WWD Detection and Prevention Pilot Program in 2016.

The results indicate lives will be saved, public trust will be enhanced, and roadways will be safer.

As the above projects demonstrate, public agencies currently planning implementation or employing existing and emerging technologies with WWD should focus on forming regional planning partnerships. These relationships are critical to link multi-jurisdictional roadways to share a common goal in the deployment of WWD technology for the overall benefit of the traveling public, regardless of which roadway segment is traveled. Using a similar technology platform that is interfaceable and scalable to meet regional, statewide, and interstate needs will prove both useful and prudent to protect all motorists, including commercial and multimodal applications from the deadly potential of the wrong-way drivers. With proper planning and analysis of an organization’s WWD safety needs and budget, appropriate WWD countermeasure systems can be developed, deployed, managed, and maintained.

Crash Information
As previously noted, WWD crashes account for only three percent of all crashes on high-speed divided highways, but often result in fatalities or serious injuries according to National Transportation Safety Board (NTSB 2012). WWD crashes resulted in 27 more fatalities per 100 fatal crashes than fatal crashes in general. As per a CBS Channel 2 Pittsburgh report, there were 1,302 fatalities attributable to WWD crashes in four years, from 2007 to 2011, ranking Pennsylvania the worst in the nation (National Highway Traffic Safety Administration 2013). More recently between 2011 and 2015, 435 people were killed and 1,486 were injured in Florida due to WWD crashes (2016 Florida Strategic Highway Safety Plan). Furthermore, this safety plan classified WWD crashes as an extreme example of a lane departure.

Public Awareness in North Carolina
North Carolina has taken measures to combat WWD crashes by implementing a pilot countermeasures system on the Triangle Expressway. According to Beau Memory, formerly of the NC Turnpike Authority, existing infrastructure has aided in system deployment with other roadways such as the Monroe expressway and I-40 being considered as test pilot sites. NCDOT and NC Turnpike officials are taking measures to mitigate the 555 crashes and 164 fatalities that have been attributed to WWD in North Carolina since 2000.
Crashes involving vehicles going the wrong way on North Carolina highways killed 164 people between 2000 and 2017, according to the state Department of Transportation, where engineers are testing technology that they hope will turn those statistics around.

Many states have implemented WWD studies, pilot programs and have teamed in consortiums to trade information, share data and update each other with various WWD systems and ITS applications. Also, local media in North Carolina has been persistent in bringing WWD incidents to the public attention and questioning local officials regarding steps to combat this type of crash and resulting fatalities by putting pressure on officials to do something about these WWD incidents. In this section are links to recent local news reports of WWD driving fatalities.

**Applied ITS Technology**

Below is a vehicle turning around after two (2) red rectangular flashing beacon (RFB) wrong-way warning signs were activated by a detection system on CFX. The images were immediately sent via the ITS system to be processed by researchers at UCF and the Regional Traffic Management Center (RTMC) staff to determine if the call was an actual WWD event. See images 1 through 4 on the following page.
Below is an image from CFX looking to the off-ramp at the WWD signs and ITS countermeasures system. Note the additional pair of signs and RFB approximately 500-ft further up the off-ramp prior to the mainline freeway. Systems vary from enhanced signing and protection to a full visual ITS application tying in alerts to a back end managed system. Depending on the system, accuracy and area of deployment, turn-around rates in the 80 percent range have been observed with WWD countermeasures system.

**Backend Processing and TMC Management**

For agencies requiring more from their system, manufacturer software can gather, record and compile reports based on the systems detection capabilities. Images can be sent with minimal latency and processed at the TMC for communication with the public and immediate dispatch of first responders. **Figure 2** is a draft SOP that RTMC/TMC dispatchers will be following to properly administer a WWD event calmly, effectively and efficiently. In such a situation, even seconds matter.

**Conclusion**

WWD is a serious problem that has taken the lives of many people, young and old. This type of crash with proper countermeasures in place is highly preventable and thus, more effort needs to be made to address this issue. Many federal, state, and local agencies are considering how to proactively implement and maintain WWD countermeasures. Emerging technologies such as CAV will help to equip a new generation of vehicles to avoid driving the wrong-way. Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) concepts will pave the way to safer driving conditions and quality of life. Communications with first responders such as state trooper barracks, safety patrols, regional traffic control centers and others are key to proactively engaging and intercepting a WWD before they can cause any harm. By addressing the issue of WWD, engineers, planners, and safety officials are pursuing the highest standards of social and community responsibility.

**Component Three: Dynamic Curve Warning Systems**

Horizontal curves exhibit average crash rates 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. Considering statistics, and the desire for public agencies to increase safety and reduce crashes, the private sector has investigated and designed a state-of-the-art approach by evaluating data, implementing emerging technology, and developing an optimization model that is best suited to achieve a low cost, high crash reduction factor that will meet required safety and operational objectives. This state-of-the-art system focuses on horizontal curve safety best practices, effectiveness, and cost. Currently, existing countermeasure treatment types to enhance safety along horizontal curves include the following: basic signing and pavement marking, enhanced signing combined with other traffic control devices, pavement and geometric design improvements involving realignment or reconstruction. The Federal Highway Administration (FHWA) Toolbox of Countermeasures and Their Effectiveness for Roadway Departure

Crashes and the Florida Department of Transportation (FDOT) of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects (April 2005) were utilized to evaluate potential countermeasures. Based on the private sector’s planning and research, a sequential DCWS was chosen for design and deployment in Central Florida.

To determine the optimum treatment strategy based on existing conditions, the following methods were considered: improve superelevation, improve horizontal alignment, improve pavement friction (increase skid resistance), and install a DCWS.

These countermeasures were evaluated based on their potential effectiveness in treating roadway departure crashes. The criteria used to gauge the effectiveness of the various treatment strategies includes the Crash Reduction Factor (CRF) and relative cost. The CRF is the percentage of crash reduction that might
be expected after implementing a given countermeasure. The relative cost provides a basis of comparison for implementation for the given countermeasure, which would typically include planning, design, construction, and construction engineering and inspection (CEI) costs. While the safety effectiveness would be generally high, changes to the geometric design of a curve (such as improving superelevation and/or horizontal alignment features) will be the costliest methods of improving safety, as they would require reconstruction of the entire ramp. Improving pavement friction is a less costly option; however, it has a lower crash reduction and lower life-cycle potential as compared to alternative countermeasures. Considering the findings presented in Table 2, implementation of DCWS would yield higher safety benefits while being most cost effective when evaluated against the other treatment strategies.

Table 2: Crash Reduction Factors and Relative Costs of the Safety Countermeasures (*wet pavement)

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<th>CRF¹,²</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve superelevation</td>
<td>40</td>
<td>Moderate/High</td>
</tr>
<tr>
<td>Improve Horizontal Alignment (e.g., increase curve radius)</td>
<td>58</td>
<td>High</td>
</tr>
<tr>
<td>Improve pavement friction (increase skid resistance)</td>
<td>30</td>
<td>Low/Moderate</td>
</tr>
<tr>
<td>Dynamic curve warning sign system</td>
<td>17-91³</td>
<td>Low/Moderate</td>
</tr>
</tbody>
</table>


A combination of ITS devices will be used to communicate to the driver a visual aid to slow down prior to the curve based on a defined speed and environmental factors affecting the pavement. This system will aid by analyzing incidents in real-time, so response can occur immediately by dispatching first responders, preset ITS 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. Furthermore, this system is CAV adaptable which brings additional benefit for agencies migrating to these emerging technologies. By addressing the issue of horizontal curve crashes and using a DCWS if warranted, engineers, planners and safety officials are pursuing the highest standards of social and community responsibility.

Curve warning systems utilize sequential spaced Chevron static signs, predicated on the Manual on Uniform Traffic Control Device (MUTCD) with embedded LED, improved pavement markings, improved corridor regulatory and advisory signing as well as speed and precipitation sensors to intelligently manage the LED Chevron signs based on driver behavior. The intent of these measures is to slow down the
vehicle while providing positive guidance to safely navigate the horizontal curve. Other systems utilize ITS technology such as radar, Sound Navigation and Ranging (SONAR), thermal and laser technology in combination with enhanced signing, Road Weather Information System (RWIS) and video detection to monitor vehicle movement. A combination of these systems is used to warn motorists to reduce speed via ITS field applications and can relay a warning message to a TMC in real-time. These systems can aid to analyze incidents in real-time and response can occur immediately by dispatching first responders, preset ITS 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. Best of all, this system is a low-cost application verses other costlier options with proven results endorsed by FHWA-15-CAI-012-A3.

With proper planning, including regional partnerships and analysis of an organization’s safety needs and budget, optimum DCWS countermeasures can be developed, deployed, managed, and maintained. This system, based on FHWA based sponsored testing indicate positive impacts of DCWS by reducing entry speed prior to the curve, thereby minimizing the risk of crashes and just as importantly, enhancing public safety, and trust.

**Data Collection Protocol and Quality Assurance**

Proper performance measures are required to properly evaluate the system and its benefits. Speed patterns can vary due to weather and time of year; therefore, the purpose of the upstream data collection was to measure any changes in speed that may have occurred independent of the sign installation. The upstream data collection locations were placed outside of the DCWS radar detection area, so that they would not be affected by the sign and would not adjust driver behavior. The upstream locations also allowed vehicles to be tracked through the point of curvature and center of curve to determine individual vehicle speed reductions. Speed and volume data were collected for at least 24 consecutive hours during the weekdays for the before installation and one month, 12 months, and 18 months after installation. For the final data collection period (24 months after installation) at least 48 consecutive hours of data were collected to analyze the day and night effects of the signs. During data collection, the equipment was spot checked to determine whether any problems had occurred. The data was reduced after each site collection period and a few speed metrics were calculated for the direction of travel toward the DCWS. They include average speed, standard deviation of speed, 50th and 85th percentile speeds, and percent of all vehicles traveling 5, 10, 15, or 20 mph over the posted speed limit and curve advisory speed. In addition to calculating these statistics for all vehicles collected, the dataset was further reduced by “tracking vehicles” through the curve. Although data was collected and analyzed for all vehicles within the curve, vehicle tracking was used to remove vehicles with speeds impacted by turning movements or other vehicles. This allowed the analysis to focus on the effect of DCWS.

Pre-processing was also performed in the field during data collection to identify problems early, and the full data sets were processed when data collection was complete.
Key Findings
The DCWS was shown to be effective at reducing speed during all data collection periods from one month to 24 months after installation. The change in mean speed was consistent between all data collection periods with reductions between 1.7 mph for the one month after data collection and 1.3 mph during the 12 and 18 months after the data collection periods. The 85th percentile speed also showed reductions with a decrease of 1.7 mph during the one month after data collection period. Furthermore, the fraction of vehicles exceeding the posted or advisory speed limit showed reductions during all data collection periods. The sites on average had a 11 percent decrease in the proportion of vehicles exceeding the curve advisory speed by five mph or more. The proportion of vehicles exceeding the advisory speed by 10 mph or more decreased by an average of 22 percent, and the decrease was 30 percent for the proportion of vehicles exceeding by 15 mph or more.

An average decrease of 32 percent was shown in the proportion of vehicles exceeding the advisory speed by 20 mph or more. Additionally, data shows a downward trend of vehicles exceeding the advisory speed and speed limit by showing the percentage of vehicles exceeding both at each time period. The highest changes occurred in the percentage of vehicles exceeding the advisory speed by 10 mph with 54.3 percent of vehicles exceeding before installation and less than 46.7 percent of vehicles exceeding during all after periods.

At both the point of curvature and center of curve, the tracked vehicle statistics were slightly higher or similar to the speed statistics for all vehicles. The tracked vehicle removed influences of trailing and following vehicles and showed that the vehicles only influenced by the DCWS had a larger reduction in speed. See before and after findings at typical curves in study in Figure 3.

Figure 3: Speed Impact
While there was a reduction in the overall range of speeds, most agencies have a desire to lower the high-end speeds, which can substantially increase the safety of the curve. The results at both the point of curvature and center of curve suggest that the signs had an impact on high-end speeds during all data collection periods. Reductions were found in all vehicles exceeding the advisory speed, but the largest decreases occurred in the vehicles exceeding by 20 mph or more. Higher decreases were found at the point of curvature suggesting that vehicles were reducing their speed prior to entering the curve and selecting an appropriate speed to negotiate the curve. The speed results also indicate that the DCWS was effective at reducing speed consistently between one and 24 months after installation. This suggests the signs may have a long-term impact on the speeds through the curve. With very little change in the mean and 85th percentile speed over time, the human factors impact of having a new or different sign had little effect.

Conclusions
Overall, the DCWS treatment appeared to be effective in reducing average speeds and crash frequencies. The speed analysis showed small but consistent reductions in mean and 85th percentile speeds. The analysis also showed the reduction in the percent of vehicles exceeding the speed limit or advisory speed limit by 5, 10, 15, or 20 mph, particularly in the higher end of the speed spectrum. This identifies the positive impact of the DCWS in improving curve navigation and safety. Agencies considering implementing the DCWS should consider the following factors before installing the devices:

1. **Location**: Solar power is necessary for proper operation of the DCWS (if A/C power is not readily available). Locations should be investigated to ensure a proper view of the southern sky is feasible.
2. **Maintenance**: During the two-year study, very few maintenance issues were encountered. However, it is recommended that agencies pay attention to the operation of the devices to make sure they are functioning.
3. **Vandalism**: Although devices with solar panels can be the subject of vandalism, the DCWS solar panel does not attract much attention because of the relatively small size. No vandalism was reported during the two-year study.
4. **Threshold settings**: Due to the limited number of installations, one threshold setting – recommended by the manufacturer – was used. For operational use, agencies might want to experiment with speed threshold and blinking pattern settings to maximize the effectiveness of the devices.

Applied ITS Technology
Below is a typical horizontal curve on a two-lane highway with a DCWS installed. FHWA – Low-cost treatment for horizontal curve safety;


Sequential Dynamic Curve Warning System
ITS applications are key to enhancing standard static signs and other conventional visual aids by using advanced technology to transform and enable public agencies to operate a more effective, efficient, and safer transportation system. ITS systems can set up with valuable metrics to measure system performance and record data for predictive analysis and other important planning and transportation related information. ITS technology holistically combines real-time roadway conditions, back-end management, and first responders in a way that simplifies their job and mobilizes results quicker, such as deploying variable speed limits, dynamic message sign warnings to vehicles and enhanced reaction time for first responder dispatch when needed. With the advent of CAV and their on-board units (OBU), real-time updates and advisories will be shared with everyone. ITS technology is paving the way for a reduction in crashes through automated information – provided from ITS systems integration.

In the past and even to this day, standard advisory speed signs along with Chevrons spaced per the MUTCD are typical on horizontal curves to help as a visual aid in maintaining a safe speed while navigating through the curve. In some cases, additional high intensity amber barrier markers have been placed to the barrier wall, if one is present. Although traditional applications have been shown to be somewhat effective at many locations, as speed increases over the posted or advisory speeds, crashes trend upwards, especially during precipitation events.

To slow traffic down to a safe speed, flashing beacons and/or a combination of flashing beacons and DMS have been used throughout the nation as an effective countermeasure enhancement. However, in terms of CRF and associated costs of other types of applications, the DCWS solution rated among the best. The FHWA tested DCWS system allows for multiple flashing patterns to be applied to meet an agency’s needs and preference. Also, having the ability to adjust patterns allows an agency to conduct a study to determine which pattern would be most effective. Furthermore, a DCWS system can be initiated by triggers such as excessive speed (above posted, 85th percentile) or environmental information from a Road Weather Information System (RWIS). Studies have shown that constantly flashing most types of warning systems desensitizes the public to their importance. Having the system react in real-time as needed is a best practices approach and will provide the best results.

As discussed earlier, flashing patterns can be configured per the agencies needs or preference. Alternate flashing on/off patterns as well as multiple sequential patterns can be programmed and studied to determine which flashing plan is more effective for the ramp the LED Chevrons are deployed on. If the curve has 15 Chevrons, they could be programmed to flash sequentially 1 through 15. If the visibility is obstructed, they could be programmed to flash in patterns. Depending on line of vision and the radius of the curve, one agency is spacing 10 Chevrons 110 feet apart and flashing a rotating sequential pattern; 1, 5 and 9; 2, 6, and 10; 3 and 7; 4 and 8 then repeat. According to a recent Penn State study sponsored by FHWA SA-18-075, the optimum flashing pattern is when a speed-activation threshold is five mph above the advisory speed for the horizontal curve; initiate a simultaneous flash sequence; with a flash rate of three flashes per second.
However, Manual on Uniform Traffic Control Devices (MUTCD) Chapter Four must be taken into consideration; Beacons shall be flashed at a rate of not less than 50 or more than 60 times per minute. The illuminated period of each flash shall be a minimum of 1/2 and a maximum of 2/3 of the total cycle. With that being the current requirement, the second most responsive flashing pattern that meets the current MUTCD requirement is a flashing pattern away from the driver, at a 1 Hz flashing rate, with a speed-activation threshold equal to the curve advisory speed; flash rate is one flash per second was the optimal setting for the DCWS.

LED Chevrons are placed and spaced throughout the curve until a point of tangent (PT) with the straightaway is reached. Some systems run flashing patterns 24 hours a day and are complemented with overhead static signs with or without flashing beacons that read “SLOW DOWN.” Studies have shown signs that flash 24 hours a day after time can lose their effectiveness and desensitize drivers to the urgency that beacons and/or flashers convey when triggered due to unsafe travel conditions.

Furthermore, studies have shown crashes in horizontal and “S” shaped curves greatly increase with wet pavement conditions, by exceeding the vehicles maximum lateral acceleration limits. To provide additional safety measures to a curve where a high percentage of crashes are due to speeding and precipitation, a more robust DCWS would include additional ITS components such as a RWIS system. An RWIS, as part of overall ITS solution can measure roadway precipitation or fog conditions and trigger upstream advisory signs, amber LED beacons, overhead DMS and sequentially lit LED Chevrons from the PC through the center of curve (CC) to the PT.

Systems that use both speed threshold and wet pavement detection triggers provide additional safety to commuters. Standalone systems will provide measurable results, however having network capabilities including remote monitoring by a TMC or State Trooper Barracks will provide real-time speeding information, as well as crash information so first responders can immediately be dispatched to implement proper traffic control and resolve incidents in less time aiding in reducing secondary crashes.

Other ITS Components
To plan, develop, procure, construct, deploy, and maintain a DCWS that will best fit an agency’s needs, many factors come into play. One of the most important things to consider during the planning stage is the agency’s needs, budget and developing a system which employs a best practices solution. A basic standalone DCWS can be a network or non-network system. Generally upstream of the curve speed regulation signs are replaced with advisory signs per the MUTCD and other design standards prior to the point of curve (PC).

![PROGRAMMABLE VARIABLE FLASHING PATTERNS](image)

Figure 4: Sample Activation Timeline (programmable at any interval, to millisecond accuracy)
Backend Processing and TMC Management
For agencies requiring more from their system, manufacturer software can gather, record, and compile reports based on the systems detection and data archiving capabilities. Existing network closed circuit television (CCTV) or procuring inexpensive fixed CCTV’s can provide images to be sent to the local TMC via modem or network connection. This technology aids in more efficient communication with the public and immediate dispatch of first responders.

Strive for Excellence in Transportation Safety
Innovative technologies are constantly being tested throughout the nation. With multiple detectors such as laser, Doppler Radar, sonar, thermal, infrared, and others as well as RWIS the private sector is constantly testing and refining products to provide the best results and improve the quality of life. Achieving the highest level of detection accuracy is the goal of manufacturers, so the public is not misinformed or desensitized by false messages. Reliability during periods of power outages is extremely important, as well. Many systems are supplemented with a back-up Uninterruptable Power Supply (UPS), capable of powering the DCWS system during power outages until power is restored. Some agencies link to a network UPS which can alert the backend operation when the system transfers over to the DC backup. The advent of connected vehicle technology (CV) as well as autonomous vehicles (AV) may also play a key role in reducing the chance of a crash on horizontal or “S” curves throughout America. Cars equipped with On-Board Units (OBU) will be able to receive real-time messages from the roadside ITS devices such as speed and curve warnings.

As the government creates mandates favoring these safety initiatives, society will experience enhanced safety and a reduction in human related traffic crashes.

Conclusion
Horizontal curve crashes are a serious problem taking the lives of many people, young and old. This type of crash can be greatly reduced and is highly preventable with proper ITS countermeasures in place and thus, more effort needs to be made to address this issue. The public and media are aware of the problem and have approached their local government officials for solutions. Many federal, state and local agencies are considering traditional and innovative ways to implement and maintain horizontal curve safety countermeasures along America’s limited access, urban and rural roads. With initiatives implemented by Florida, Texas, Wisconsin, Washington, Missouri, Iowa, and technology advances in the private sector, pilot systems are being developed and deployed with the aim to analyze such systems and employ sound practices to assist in optimizing an agencies budget for maximum systems utilization. Systems do not have to be expensive to be effective, however the more data collected from a system the more chances there are for refinement and better performance.
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. Emerging technologies such as CAV will help to equip a new generation of vehicles to maintain a safe speed and alert the driver via V2I and OBU of speed and pavement conditions. V2V and V2I concepts will pave the way to safer driving conditions and better quality of life.

Communications with first responders such as state trooper barracks, safety patrols, regional traffic control centers and others are key to proactively engaging and intercepting speed violators before they can cause harm. Furthermore, by having real-time ability to dispatch first responders to a crash, proper traffic control can be set up quicker thereby reducing the risk of secondary crashes. By addressing the issue of horizontal curve crashes and using a DCWS if warranted, engineers, planners, and safety officials are pursuing the highest standards of social and community responsibility.

**Component Four: Advanced Analytics**

1. **Data Analytics and NC Transportation Analytics Center Overview**

The NC TAC integrates data from multiple agency departments to improve customer service and reduce costs across NCDOT. It builds on the previous success of a budget...
and revenue forecasting project to identify new ways to use data and analytics to solve transportation needs. The NC TAC analytics platform supports the full lifecycle of the decision management process from data preparation through modelling and analytics, rule development and decision design, deployment, and monitoring.

Using a single platform for managing data, building analytic modules, and deploying operational and policy results to the agency has allowed NCDOT to develop analytic maturity throughout the organization. See the typical analytic lifecycle in Figure 5.

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.

2. 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 the questions of 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 solve transportation safety and efficiency challenges. The NC TAC provides NCDOT with 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; and

» 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, NC TAC can apply advanced analytic techniques including:

» Data exploration allows 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; and

» 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.

3. 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.

Edge analytics and event stream processing will enhance the Project.

Wrong-way Vehicle 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 cameras and videos along with deep learning models, machines can accurately identify and classify objects — and then react to what they “see.” 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). Similarly, behavior indicating impaired or distressed drivers can also be detected. When the analytics identify a wrong-way or impaired driving, real-time alerts can be sent to driver notification systems and first responders. 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
In 2017, North Carolina had 221 reported human trafficking cases according to the National Human Trafficking Hotline. This statistic ranks North Carolina 8th among all 50 states, in terms of the number of reported human trafficking cases. Using computer vision and deep learning models, NC TAC plans to deploy machine learning analytics to monitor video feeds at select locations, including two rest areas or weigh stations, within the project corridor to identify and monitor for 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, 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 or potholes or debris in the road. Computer vision can also detect damage or changes to structure, missing or downed signage and other impact that could impair driver safety.

II. PROJECT LOCATION
The Project is located in North Carolina, the second fastest growing state on the East Coast. The I-40/I-85 corridor is an important part of the local, regional, state, and national transportation system. It traverses 160 miles through ten 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 2). 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 two other initiatives to install fiber along major US routes east of I-95. Finally, BUILD 2019 will complete the fiber infrastructure along I-85 and I-40.

**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 $4.8 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 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 requirements and maintains the records and accounting systems that will allow it to comply with USDOT’s reporting and administration requirements.

The Department’s role(s) for the project includes:
- BUILD 2019 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 2019 Project into the existing intermodal operations surrounding I-85/I-40, as well as planned projects.
- Oversight of the 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/BUILD2019-I85/Pages/default.aspx

III. GRANT FUNDS, SOURCES AND USES OF PROJECT FUNDS

The estimated cost of the overall project is $23 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 Draft STIP, committed investments 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

In short, NCDOT has invested almost $5.7M 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

A letter 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/BUILD2019-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 the project beyond the BUILD funds requested in this application.

Figure 6: Fiber Network Evolution
Budget Showing Sources and Uses of Funds
NCDOT requests $8M in BUILD funding. This represents 34.8 percent of the total Project cost. The Project funding sources are allocated across the major project components in Table 3 (next page).

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 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 for autonomous vehicles.

Safety
As noted in the Project Summary, safety is an important part of the transportation challenge addressed by this 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 state police and emergency responders are better able to access databases and

![Figure 7: Crash Locations (2012-2016), Source: High Frequency Crash Location Section Scores 2012-2016 dataset from NCDOT](image-url)
coordinate responses from the roadside. The improvements collectively improve the resiliency of the network, streamlining evacuation during natural disasters.

**Competitiveness**

The Project supports economic competitiveness in a variety of ways.

**a. Technology.** The installation of fiber allows for more accurate use of apps such as Waze and others that allow users to anticipate traffic conditions and plan ahead appropriately. The transportation system is therefore used more efficiently. In addition, emergency services, evacuation, public safety, and roadside safety can all be improved with better broadband connectivity. The installation of fiber along the corridor also provides the groundwork for the future of autonomous vehicles. As CAVs move into the consumer fleet, preparing the transportation infrastructure for these new vehicle capabilities allows for the continued safe and efficient movement of goods and people along corridors. The eventual 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 cost.

**Environmental Benefits**

Transportation is a large generator of emissions. When the efficiency of the road network improves, there is less idling in delays. This reduces the amount of emissions released into the environment, an avoided cost.

**Leveraging Federal Funding**

For the Project, NCDOT will invest $15M in Non-Federal, state funds. Applied across the Project components, this yields a Non-Federal, state funds to requested federal BUILD funds ratio of:

» 1.88 for the Total Project

**In short, every $1.00 of BUILD funding received is matched by another $1.88 of state funding.** Moreover, as described in the narrative below, 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 of the narrative, 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. Thus, the upgraded section of the corridor will generate revenues to help support its own operations and maintenance.

Description of all Evaluations of the Project for Private Funding
NCDOT has continued to seek innovative ways to partner with the private sector to advance its program. One solution includes the installation of fiber-optic cable in order to provide and 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. According to an internal NCDOT analysis, the estimated value of the fiber concession is approximately $7.4M over 20 years.

Description of any Fiscal Constraints that affect the Applicant’s Ability to use Non-Federal Contributions
All required NCDOT investment for the project has been secured and is 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 $4.8 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 Life-cycle Costs Associated with the Project including Operations and Maintenance Funding Commitments
NCDOT’s approach to providing for operations and maintenance funding is one of the innovations of the Project. An internal study has determined that NCDOT could potentially generate $7.4M over a 20-year period by allowing private communications vendors to lease the use of portion of the fiber-optic cable installed as part of the Project. This revenue will be used to pay for the Project’s maintenance under a Flexible Asset Management Services (FAMS) contract that outsources these activities to the private sector. Under this approach, performance standards and levels of service will be established under the contracts to ensure the lowest life-cycle costs are achieved. Background information on the FAMS approach is provided with the supplemental information provided in this narrative.

Potential for Innovation
The Project offers potential for innovation in several key areas. These are:
1. Through the manner in which it will fund and manage operations and maintenance,
2. Through its use of 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.

Each innovation is described in more detail below.

Funding and Managing Project Operations and Maintenance
As the cornerstone of the Project, NCDOT will be installing missing sections of fiber-optic cable and microcell towers in the right-of-way of I-85 and I-40. The cable has several innovative applications as discussed in the following section. It’s inclusion 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 sharing the highway right-of-way in exchange for private telecommunications expertise and capacity to further both public sector and private corporate objectives. An internal department assessment of similar transactions suggests that NCDOT could generate $7.4M over a 20-year period by allowing private communications vendors lease the use of portion of the fiber-optic cable as part of this Project. This revenue will be used to pay for the Project’s maintenance under a Flexible Asset Management Services (FAMS) contract.

Briefly, FAMS is an approach that provides DOTs with the ability to choose customized maintenance and operations services. FAMS offerings range from fully staffed maintenance crews working under the direction of DOT managers,
to comprehensive performance-based maintenance programs delivering continuous performance 24/7 under a single FAMS contract. Performance metrics and level of service requirements will be included as part of the contract to ensure lowest life-cycle costs are achieved. The FAMS Program enables DOTs to customize the procurement to meet their specific needs by allocating work requirements into an appropriate combination of four contracting methodologies for optimum efficiency to include:

» Lump-sum performance-based maintenance services
» Unit/cycle pricing for identified maintenance activities (be it specialized equipment or material dependent activities)
» Staff augmentation
» Individual staff hours for technical management and/or engineering services.

Case studies have shown that a FAMS approach to outsourcing services:

» Typically results in the largest cost savings to the agency due to a larger and more efficient grouping of work activities;
» Optimizes Agency efficiency by reducing its efforts to oversee and administer;
» Transfers risk to the Contractor for determining the annual quantity of work needed to meet the established performance measures; and
» Assures the Contractor has a stake in the game and will act/behave more like an Owner.

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

The fiber-cable and micro-cell towers have both near-term and longer-term applications. In the near term, NCDOT can connect communications and monitoring equipment to implement integrated corridor management practices and jointly manage I-85 and I-40 to obtain more reliable throughput. Utilizing this new communications infrastructure to manage traffic through integrated corridor management (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 and micro cell towers 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 two 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 and I-40 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**

Finally, 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.

**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 a number of 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 below.

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 proposed to return up to 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 designs and cost information presented in the Supplemental materials are 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 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 4 depicts the project schedule. Assuming awards are made in Spring 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.

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.

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 such as US-70 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-

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, environmental 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 be 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 5.70. This ratio rises to 8.10 when benefits and costs are discounted at 3 percent.

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.