U.S. DEPARTMENT OF TRANSPORTATION (USDOT) AUTOMATED
DRIVING SYSTEM (ADS) DEMONSTRATION GRANTS
FUNDING OPPORTUNITY NUMBER: 693JJ319NF00001
MARCH 21, 2019

INTERSTATE & ARTERIAL ROAD DEMONSTRATION FOR THE SAFE FREIGHT OPERATION OF A CLASS 8 AUTOMATED VEHICLE

PART 1 - PROJECT NARRATIVE AND TECHNICAL APPROACH

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

ROY COOPER
GOVERNOR

JAMES H. TROGDON, III
SECRETARY

March 21, 2019

Ms. Sarah Tarpgaard, HCFA-32
U.S. Department of Transportation (USDOT)
Federal Highway Administration (FHWA)
1200 New Jersey Avenue, SE; Mail Drop: E62-204
Washington, DC 20590

Re: USDOT Notice of Funding Opportunity #693JJ319NF00001 – Automated Driving System Demonstration Grants

Dear Ms. Tarpgaard:

The safe and efficient movement of people, goods and services is critical to the economic vitality and continued growth of the State of North Carolina, the Mid-Atlantic region and our nation. As North Carolina continues to grow, the preservation of our culture, resources and quality of life is becoming endangered by these conflicting demands. The North Carolina Department of Transportation believes that technological solutions offer opportunities to manage the challenges that come with growth without sacrificing quality of life.

In response to this Automated Driving Systems Notice of Funding Opportunity, NCDOT has partnered with Volvo Group, the Florida Department of Transportation, HNTB, Oak Ridge National Laboratories and Pennsylvania State University to conduct a Level 4 on-road demonstration of a class 8 automated vehicle. This demonstration will be conducted on arterial and interstate transportation facilities using dedicated short-range communications and CV2X technologies. This demonstration will include real-time data exchange for edge case scenarios, including work zones, traffic crashes, emergency vehicle response and inclement weather driving conditions.

NCDOT and our partner members look forward to showcasing this level 4 freight demonstration project. If you have any questions, please contact Mr. Dennis Jernigan at 919-707-2705 or at dwjernigan@ncdot.gov.

Sincerely,

James H. Trogdon
Secretary

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PART 1. PROJECT NARRATIVE AND TECHNICAL APPROACH

Summary Table	
Project Name/Title	Interstate & Arterial Road Demonstration for the Safe Freight Operation of a Class 8 Automated Vehicle
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	North Carolina Department of Transportation/ North Carolina Turnpike Authority 1578 MAIL SERVICE CENTER Raleigh, NC 27699-1578
Point of Contact (Name/Title; Email; Phone Number)	Dennis Jernigan, PE Director of Highway Operations dwjernigan@ncdot.gov (919) 707-2705
Proposed Location (State(s) and Municipalities) for the Demonstration	Verification tests – SunTrax, Florida On-Road Demo – Greensboro to Charlotte, NC
Proposed Technologies for the Demonstration (briefly list)	Vehicle automation, including LiDAR and camera (L3, L4); high definition mapping converted to real-time traffic simulation to benefit safety analysis, DSRC and CV2X communications.
Proposed duration of the Demonstration (period of performance)	October 2019 through June 30, 2023
Federal Funding Amount Requested	$ 8,582,425
Non-Federal Cost Share Amount Proposed, if applicable	$ 937,954
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$ 9,520,379

1. EXECUTIVE SUMMARY

Introduction

The North Carolina Department of Transportation (NCDOT)/North Carolina Turnpike Authority (NCTA) seeks to demonstrate a field deployment of automation capability by implementing an end-to-end freight automation system. The scope of proposed work seeks to advance the state of practice from research demonstration and controlled experiment testing to customer deployments fielded on public roads. Central to this effort is the coordination and methodical advancement of vehicle, infrastructure, data delivery and regulatory capabilities. The project we envision, titled "Interstate & Arterial Road Demonstration for the Safe Freight Operation of a Class 8 Automated Vehicle," will have a significant impact to both improving safety and efficiency of our roadway systems.

a. Vision, Goals and Objectives

The vision of the NCDOT/NCTA, along with our esteemed public and private partners, is to safely demonstrate an autonomous tractor-trailer on 90 miles of freeway and arterial segments. The goal of this effort is to transition blue-sky, highly-controlled prototype demonstrations of trucking automation (conducted with little coordination with infrastructure systems and with minimal data transparency or regulatory clarity) into functional capabilities integrated with daily real-world operations, carefully coordinated with infrastructure (with secured public data delivery and collection) and development of associated regulatory and procedural definition.

The specific objectives are to build out the data and infrastructure systems and processes to support operation of automation, test these strategically in progressively more realistic test cases, leading to fielded operation across at least 90 miles of real-world operational use.

In essence, the NCDOT/NCTA Team (introduced in the next section) intends to demonstrate trucking automation capability by implementing an end-to-end automation system, developing from research demonstration capability to customer deployments. This demonstration will focus on an operational environment between the Society of Automotive Engineers (SAE) Level 4 (L4) Automated Driving System (ADS) freight vehicle and the arterial and interstate highways that represent how the vast majority of heavy duty (HD) trucks operate. It will demonstrate how the infrastructure on the roadways will support the next generation of automated vehicles (AVs).

The vehicle Original Equipment Manufacturers (OEM) and in-vehicle technology development experts are diligently working with the technology that is directly connected with the vehicles. This includes sensing/perception technologies, on-board ADS technologies, fleet management systems, vehicle motion management technologies and off-board communications technologies. This domain of technology has received extreme attention, huge development and verification investments, and is moving ahead very rapidly.

The environment surrounding these AVs and the interaction between the ADS vehicles and their surrounding environment is not experiencing the same level of development and advancement. There are significant opportunities to improve the interactions between the ADS vehicle and physical roadways, authorities, emergency personnel, construction zones, highway interchanges and recommended interactions with other road users (maneuvers, signaling, conspicuity).

The focus is on using a vehicle equipped with state-of-the-art in-vehicle technologies and working to evaluate and improve the interoperability between these types of vehicles and the surrounding environment. There will be a plethora of opportunities for each of the partners involved in this project — some with the vehicle's functions to be "tuned and adapted" for better integration with the surrounding road users, and others for the tuning and adaptation with the infrastructure.

b. Key Partners, Stakeholders, Team Members and Other Proposed Participants

NCDOT maintains approximately 80,000 miles of roadways, which is the second highest miles of public roads maintained by a state DOT in the United States. NCDOT also maintains 18,000 bridges and culverts across North Carolina, and regulates and implements programs to support rail, aviation, ferry, public transit, bicycle and pedestrian transportation.

The NCTA is a unit of NCDOT created in 2002. NCTA has been authorized to study, plan, develop, construct, operate and maintain toll highway projects in North Carolina, including the Triangle Expressway and the Monroe Expressway.

The Triangle Expressway is approximately 19 miles in length and extends south, as

NC 147, from the I-40 interchange in the Research Triangle Park to the Northern Wake Expressway. It continues northeast to the Northern Wake Expressway (NC 540)/NC 54 interchange and south to the NC 55 Bypass in Holly Springs. It is a six-lane, 70 miles per hour (mph), fully access controlled facility that consists of 10 interchanges and 18 all-electronic toll (AET) collection zones. **The Triangle Expressway was designated in 2017 as one of 10 Autonomous Vehicle Proving Grounds (AVPG)** until those designations were rescinded with the issuance of NHTSA 3.0.

The Monroe Expressway is also approximately 19 miles in length and extends between Marshville and Indian Trail just east of Charlotte. It is a four-lane, 65 miles per hour (mph), fully controlled access facility that consists of eight interchanges and 14 AET collection zones.

Both facilities are the most interoperable toll facilities in the nation and are the only toll systems in the nation that are capable of reading all three different types of toll transponders that are used in the United States. This cutting-edge interoperability, along with the aforementioned AV efforts, evidence NCTA's appetite for technology that yield safer highways and provides enhanced driver experiences for motorists.

NCDOT and NCTA's primary roles in this proposed demonstration are to provide the infrastructure necessary for on-road testing and to ensure that appropriate safety protocols are in place and followed for any testing performed on an open facility. The North Carolina State Legislature and the Department of Transportation are encouraging the advancement of self-driving technology to help reduce the frequency and severity of crashes involving motor vehicles and to extend mobility options to those under-served by the current state of technology.

Dennis Jernigan, PE, the NCTA Director of Highway Operations, is the NCTA lead for this effort and served as the Designated Safety Officer for the AVPG activities that occurred on the Triangle Expressway. **Kevin Lacy, PE** is the NCDOT lead and is the Director of Transportation Mobility and Safety/State Traffic Engineer. Kevin has been active in various connected and autonomous vehicle (CAV) activities in North Carolina. Both Dennis and Kevin are involved in the North Carolina General Assembly Fully Autonomous Vehicle Committee.

Assisting the NCDOT/NCTA in this demonstration and delivering the project goals are our trusted and highly experienced partners and team members:

The Florida Department of Transportation (FDOT) is an executive agency that reports directly to the Governor. FDOT's primary statutory responsibility is to coordinate the planning and development of a safe, viable and balanced state transportation system serving all regions of the state, and to assure the compatibility of all components, including multi-modal facilities. A multi-modal transportation system combines two or more modes of movement of people or goods. Florida's transportation system includes roadway, air, rail, sea, spaceports, bus transit, and bicycle and pedestrian facilities.

For this demonstration, FDOT will make available its SunTrax test site to demonstrate SAE Level 3 and higher AV features as it relates to infrastructure readiness. This testing will be conducted in a controlled environment within SunTrax.

HNTB is a leading provider of CAV program technical support services to clients throughout the United States. State DOTs and toll authorities across the country are developing plans that incorporate CAV technologies and applications while also preparing for the effects of AV implementation. HNTB has been supporting clients, such as the USDOT, NCDOT, Michigan DOT, FDOT, the Tampa-Hillsborough Expressway Authority (THEA) and the Miami-Dade Expressway Authority (MDX), with technical advice and expert guidance regarding their CAV programs.

As part of this collaboration, HNTB will provide the technical expertise in the assessment of the current roadway environment, identify and design the communications platforms required for the demonstration project corridor, conduct installation inspections, configure the wireless communication system(s) and collaborate with our partners to generate the systems engineering documentation that will be used as part of this demonstration. HNTB will also serve as the project sponsor's (NCDOT/NCTA) representative providing overall project management of this demonstration.

Volvo Group North America's parent company, Volvo Group, is one of the world's leading manufacturers of trucks, buses, construction equipment, marine and industrial engines, selling products in more than 190 markets from its production facilities in 19 countries. As a global OEM, Volvo Group has a robust and well-established industry presence that ensures any new product meets stakeholders' expectations for quality, service support, parts, warranties and integration into remote diagnostics/connected truck systems. Volvo Group is experienced at managing R&D efforts funded through grants and developing reasonable time frames, protocols and communications procedures to manage complex projects such as this initiative.

For this demonstration, Volvo will provide the HD Class 8 truck which will operate at L4 for the autonomous demonstrations at both the Florida facility and North Carolina public route. Along with our partners, Volvo Group will integrate all data necessary for the safe control of the vehicle demonstration. Volvo Group will also be a discussion partner assisting the team in the establishment of safety edge cases, communication data requirements and the identification of the process required to scale and replicate L4 autonomous freight operations in other locales.

Oak Ridge National Laboratory (ORNL) is the largest science and energy national laboratory in the Department of Energy (DOE) system by size as well as annual research budget. As the largest DOE multi-program science and energy laboratory, ORNL is engaged in a wide range of activities that support DOE's mission: ensuring America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions. To execute these activities, ORNL integrates and applies a remarkable set of core capabilities that comprises talented staff and distinctive scientific facilities and equipment.

This capability extends into the automotive and transportation space. ORNL has been recognized for its Vehicle Systems Integration (VSI) Laboratory which is the lead hardware-in-the-loop (HIL) facility for DOE. This medium duty (MD) and HD power-train HIL facility is fully capable of simulating truck power-trains driving with virtual traffic objects and networks.

For this demonstration, ORNL will support data definitions, vehicle-to-everything (V2X) virtual testing of autonomous controls in edge case situations and validation of controls and algorithms within the HIL Laboratory testing.

PENNSTATE

The Pennsylvania State University (Penn State) is one of the largest degree-granting universities in engineering, and has been a Preferred Academic Partner to Volvo Group for decades. Through research activity with the Larson Transportation Institute, Penn State operates its own test track facility – home of the Federal Bus Testing Program – and has a fleet of test vehicles that include experiment-ready vehicle systems with research-grade instrumentation, including steer-by-wire tractor-trailers, a university-owned mapping vehicle, and a dedicated short-range communications (DSRC) radio network. Penn State's ongoing research work focuses particularly on map-based estimation and data-fusion/data-compression systems.

For this demonstration, the Penn State team will provide high-definition mapping from their mapping vehicle to produce feature specifications of the route, estimated to be approximately 90 miles of I-85 for this phase of system deployment. As Penn State regularly operates and maintains CAV systems, they will also provide key data analysis support for identification of testing edge cases, manage certification requirements and define the data management and operational processes for vehicle and roadway certification, including DSRC communication to traffic systems and 3/4/5G communication should these be used for data delivery and/or messaging.

Road Infrastructure

Road Infrastructure (RI) provides highway infrastructure industry expertise to support the deployment of the dual band infrastructure solutions as well as best practices regrading highway infrastructure readiness. Their subsidiary, Eberle Design, Inc. (EDI) is a worldwide developer and manufacturer of electronic monitoring and detection products for the traffic, railway, parking and access control markets. EDI products include signal monitors, vehicle detectors, power supplies, flashers, load switches, and other vital infrastructure devices. These products enable transportation and access control professionals to easily integrate, automate, and manage traffic, highways and intersections efficiently and safely.

c. Issues and Challenges and the Demonstrated Technologies to Address Such

The issues and challenges addressed in this demonstration include vehicle systems deployment, infrastructure improvement and management, data management and delivery, regulation and societal impacts and fault and edge-case analysis. Below, we have provided technologies/solutions to address/mitigate each.

1. **Vehicle Systems Deployment:** The team will develop and deploy, vehicles to support on-road public automation. A key aspect of this work is transitioning strategies presently in operation within controlled experiments by this industry partner, to fielded operation on public highways.
2. **Infrastructure Improvement and Management:** The team will develop authoritative assessments to determine the importance of connectivity and infrastructure

(physical and digital) to the effectiveness of SAE J3016 L4 automated systems. This will allow public agencies to understand how their investments in cooperative infrastructure at traffic signals and along the highway are likely to affect transportation system performance.

3. **Data Management and Delivery:** The team will study, integrate and develop an overall vehicle-to-infrastructure (V2I) communication protocol that is necessary for the safe operation of the L4 demonstration. We will define key data packet information to be delivered and received from vehicles and/or infrastructure elements as well as security standards for data. The team will develop both in-house and public-facing databases to manage data.
4. **Regulation and Societal Impacts:** The team will assess the broader societal impacts of L4 technology, especially with respect to the freight sector. Safe interaction between HD and light duty vehicles are just one of the many benefits. Understanding both the positive and negative impacts will be critical to this demonstration's value. The team will build upon the existing regulatory framework that balances protection of public safety with encouragement of new technological innovations.
5. **Fault and Edge-Case Analysis:** We recognize that autonomous systems will be defined by their use-case scenarios. Therefore, it will be important to not only define these cases via discussions of the processes and best practices, but also to define operational and shut-down conditions related to L4 systems (e.g., interactions with other motorists, law enforcement, emergency responders, general public, construction and weather conditions).

d. Geographic Area or Jurisdiction of Demonstration

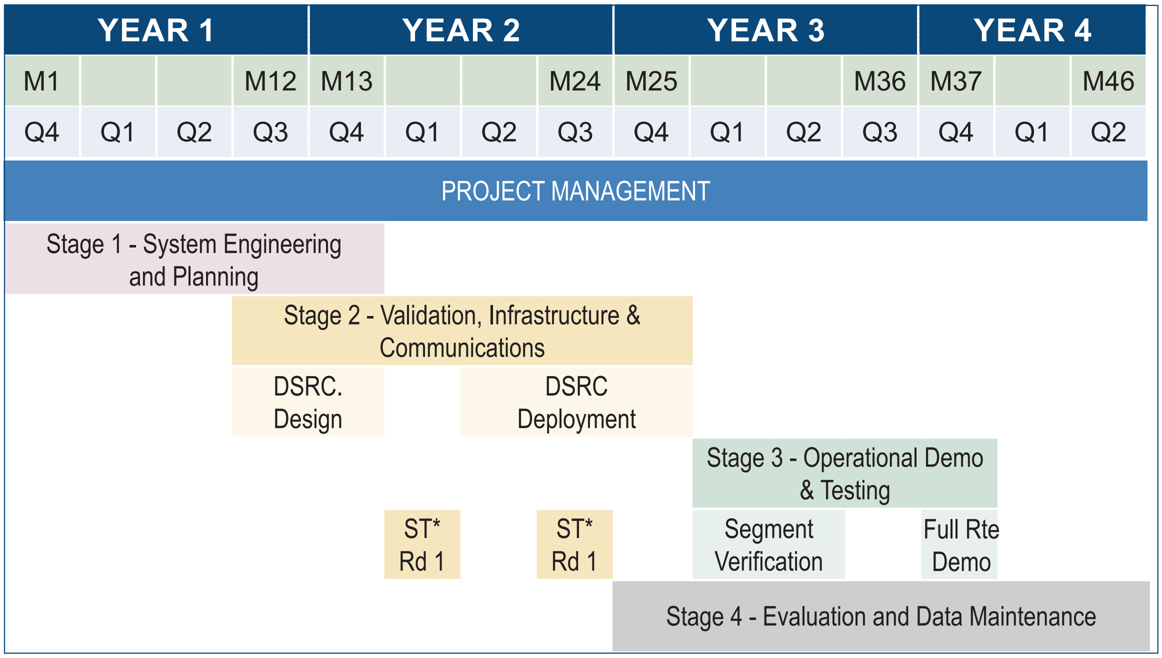
The geographic location of testing is focused primarily on the I-85 corridor from Greensboro to Charlotte, NC, chosen due to its proximity to Volvo Group's R&D facility in Greensboro, NC. This site is advantageous to deployment as well as due to the close collaboration with NCDOT. Additionally, the site's climate supports year-round testing with few weather-related closures. The test track facilities of SunTrax, located in Florida and managed by FDOT, are used in intermediate stage testing to enable systems-level testing without interruption of normal traffic behavior. We have provided more details on the demonstration area in Section 5. Approach.

e. Proposed Period of Performance

We anticipate the demonstration to occur in four stages over a four year schedule. Each stage will be approximately one year with required deliverables submitted at key milestones as directed in the Notice of Funding Opportunity (NOFO). Below, we have summarized activities that will take place in each of the stages. On the following page, is a high-level preliminary schedule (Figure 1 on the following page) highlighting project activities and deliverables.

- **Stage 1: Systems Engineering and Planning:** efforts include system specification and definition, data collection, vehicle/infrastructure preparation and development of certification standards. This will include the System Engineering Management Plan (SEMP), Concept of Operations (ConOps), System Requirements, Project Management Plan, Data Management Plan and Evaluation Plan.

Stages



*ST = SunTrax

Milestones

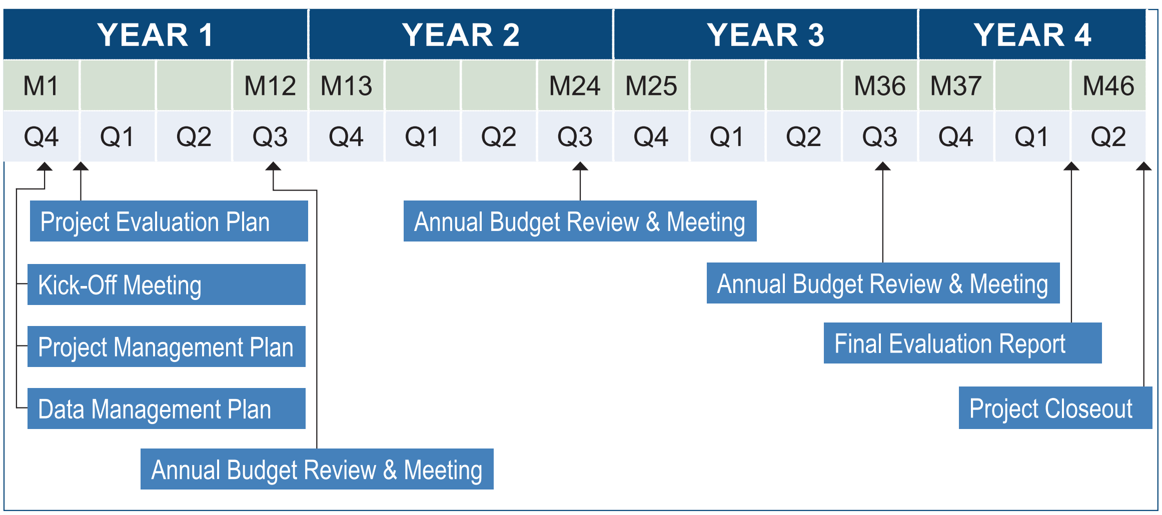


Figure 1. High-Level Preliminary Schedule

- **Stage 2: Validation Infrastructure and Communications:** efforts include field testing on closed-access test tracks and closed-access highway testing, transitioning from nominal operational testing to edge-case definition and fault testing/compliance, including definition of operational staging and data delivery standards.
- **Stage 3: Operational Demonstration and Testing:** efforts include integration of operational systems within in-use infrastructure operation, with integration of vehicle operation within infrastructure management systems currently used by NCDOT and in-use public-facing databases for route automation and collection of field information to carefully examine operational performance.

- **Stage 4: Evaluation and Data Maintenance:** stage will complete the project evaluation and closeout and support the ongoing data maintenance.

2. GOALS

The National Highway Traffic Safety Administration (NHTSA) initiated a Framework for Automated Driving System Testable Cases and Scenarios study in October 2016 to develop a preliminary objective testing and evaluation approach. That framework was constructed for use by industry and others to help guide procedures for verifying and validating the safe operation of ADS (SAE J3016 Levels 3 through 5) concept features and behaviors. That research took the first steps of partitioning the ADS concept performance space as a framework of independent performance factors composed of Operational Design Domains (ODD), Object and Event Detection and Response (OEDR) capabilities and maneuvers (i.e. tactical, competency and/or behavior). (DTNH22-14-D-00328L).

Building from the foregoing NHTSA work, the practical goal of our proposal is to deliver an L4 AV demonstration of an HD Class 8 truck in a commercial freight operational domain. All relevant safety data related to vehicle behavior, traffic conditions, necessary DSRC communications, safety edge cases and redundant safety data will be shared. This demonstration will highlight the ways in which a freight ODD can be scaled and structured in any locale by focusing on the "process" required to provide safe operation for an AV in freight operation.

Additional salient goals of the program include:

1. Explore safety challenges with integrating ADS to transportation systems
2. Conduct R&D and physical demo of L4 system
3. Investigate V2X/infrastructure framework to support safe operation of ADS
4. Devise data collection and a governance framework for safety analysis and innovative policy design
5. Facilitate multi-stakeholder collaboration, including public agencies, universities and end users

a. Safety

A statistical analysis of truck accidents results in a finding that approximately 5,000 people in passenger vehicles die every year in automotive accidents involving semi-trucks. Additionally, about 700 individuals in semi-trucks die each year in these crashes. This represents 15% of all traffic fatalities.

This demonstration intends to improve the safety for connected freight vehicles by providing real-time communications information with the infrastructure, emergency vehicles and work zones. The project will demonstrate full origin-to-destination operating environments on arterials and on the interstate highway, how ADS vehicles can benefit by cooperative communications, and will address several edge cases.

b. Data for Safety Analysis and Rulemaking

The project will gather all vehicle dynamics and infrastructure communications data with direct connections to a cloud environment. The team will secure this data for authorized access. We will define this data in the DMP document developed for the project. The data will be made available for at least five years after the project demonstrations are complete

c. Collaboration

In 2017, the North Carolina General Assembly enacted a new Article 18 (Session Law 2017-166 (H 469)) in Chapter 20 (G.S. § 20-400 – 403) to regulate the operation of fully autonomous vehicles. The bill further specifies that a driver's license is not required for an autonomous vehicle operator and requires an adult to be in the vehicle if there are any passengers under the age of 12. This legislation also preempts local regulation of autonomous vehicles and establishes the Fully Autonomous Vehicle Committee. The committee includes members of NCDOT, state and local law enforcement, insurance agencies, university research, AV industry, including Volvo Group and General Motors, trucking industry, urban and rural planners, and Senate and House representatives.

The Committee meets at least four times a year to consider matters relevant to fully autonomous vehicle technology, review state motor vehicle laws as they relate to the deployment of fully autonomous vehicles onto the state highway system and municipal streets, make recommendations concerning the testing of fully autonomous vehicles, identify and make recommendations for DOT traffic rules and ordinances, and make recommendations to the General Assembly on any needed changes to state law.

3. FOCUS AREAS

Freight transport in the United States is projected to grow by 4% (150 million tons/year) over the coming 25 years (Figure 2 below).

The safe and efficient freight transport along the United States interstate and arterial highways are of significant

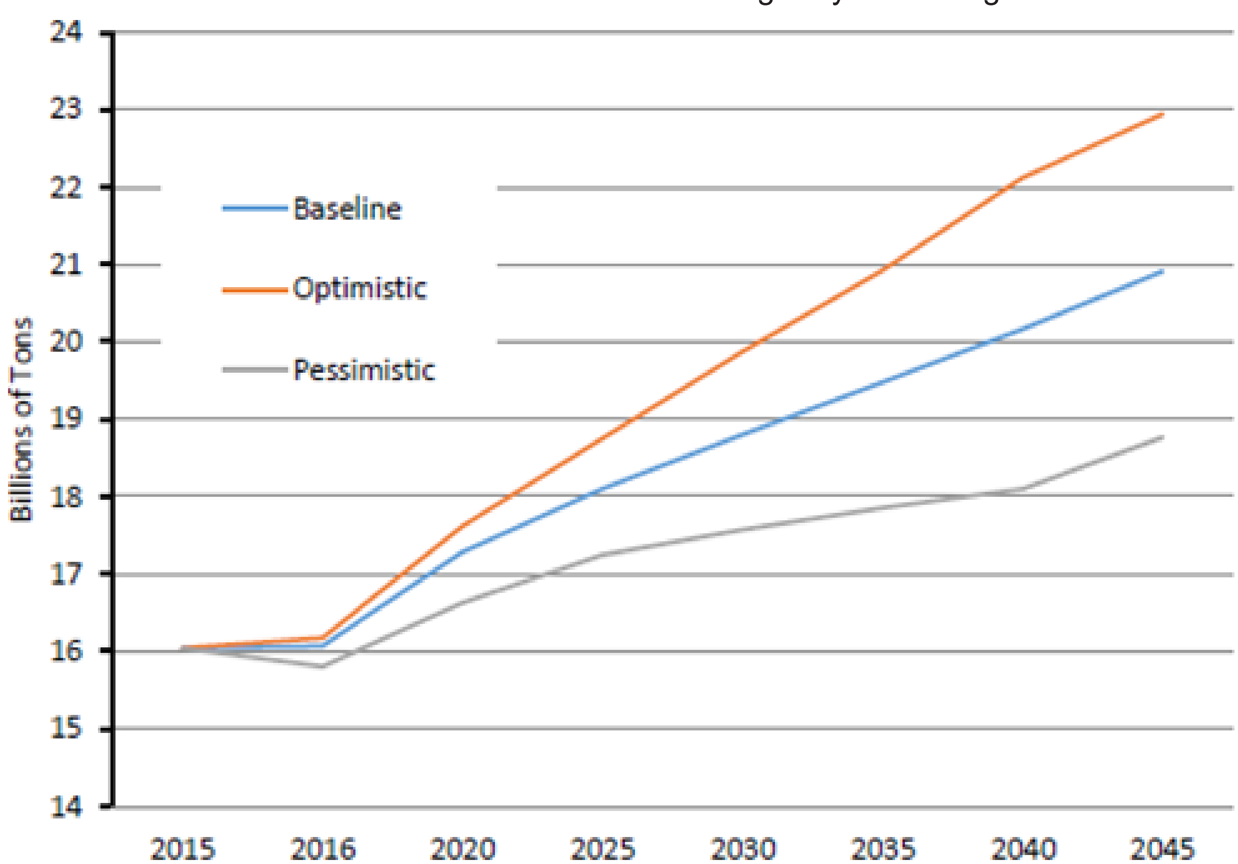


Figure 2. FHWA Freight Analysis Framework Inter-Regional Commodity Flow Forecast Study

importance to the continued growth of our economy, but cannot be conducted at the expense of safety for the traveling public, nor can it result in unnecessary congestion and delays to the traveling public.

We are at a critical time in the development of our transportation system, when the application of information technology has the potential to make significant contributions to its safety, efficiency and productivity. However, these improvements will not be driven only by the private sector (e.g., automakers, technology developers). Public sector engagement and action are imperative for the society to fully capitalize on this opportunity to solve our transportation problems and contribute to the health of our information technology industry. State and regional public agency leadership is required to engage the general public in open discussions regarding automated driving technologies and their concomitant societal benefits, thereby fostering acceptance and driving the necessary technology sustainability.

a. Significant Public Benefits

The project will provide significant public benefit in moving the needle on how automated freight vehicles can cooperate with the infrastructure to better manage their automation in difficult edge cases not easily manageable with sensors alone. It will also help define the cooperation of ADS vehicles with public authorities in the field.

b. Addressing Market Failure and Other Compelling Public Needs

Since early AV testing, there are many edge cases that have proven difficult for ADSs to safely navigate. For example, work zones can change daily and there are no consistent marking and notification protocols for work zones. ADSs have had difficulty implementing solutions through work zones, especially those that frequently change. Interaction with emergency responders at an incident has also proven to be a difficult area for automated sensors to handle. This project will provide desperately needed data on how work zones and emergency responders, among other edge cases, can assist ADSs in understanding the characteristics of the work zone or incident and how to behave while approaching and navigating through the area. Standards organizations will be able to use the data gathered from this demonstration project to direct the approaches that should be used in and around these areas.

c. Economic Vitality

Freight vehicle crashes can greatly impact the economy not only via reduced movement of freight and property damage, but also loss of life, in severe cases. The safe movement of freight through work zones, crashes, congestion and arterials will be a key focus of the demonstration.

Between 2007 and 2016, 125 billion tons of freight were shipped by trucks domestically, and $105 trillion of value was shipped by trucks, which transported 70 percent of all domestic freight. There were more than $40 billion in costs to freight shippers and $2.7 trillion in economic costs between 2007 and 2016 due to traffic congestion. Fatalities in crashes involving large trucks increased by 9% to 4,761 in 2017. Over a 10-year period, there was a 12% increase in the total number of people killed in large-truck crashes. The benefit and importance of conducting our L4 demonstration with an HD Class 8 truck for both the economy and the safety of the traveling public is obviously enormous.

Today, as the number of trucks increase on our highways, it is estimated that approximately 15% of the needed truck driving positions are going unfilled. This problem will only be exacerbated as freight growth continues to expand at around 4% per year. If this issue is not resolved, it will have a negative effect on the gross domestic product. The ability to develop a freight-based L4 HD truck will promote safety and provide efficient solutions to fleet owners. Furthermore, the registration processes, communication protocols and infrastructure used to promote our safe, autonomous freight solution will also be translatable to bus and multiple passenger vehicles on our interstate highways.

d. Complexity of Technology

The ability of artificial intelligence (AI) to control an AV is a function of the sensory input it receives and the complexity of the environment it is trying to navigate. The changing nature of work zones, conflicting markings and inconsistent placement of temporary traffic control devices make the work zone a very complex edge case for ADS technology. The project will help define ways to address these edge cases with V2I technology. In addition, sensing the presence of emergency responders and knowing how to react to manual instructions can be beyond sensor capabilities. Adding communications can provide the AI with the additional sensory data it can use to safely process these environments.

Communication protocols, integration of infrastructure hardware and collaboration and data sharing will be a key aspect of our team's success. The team will fully develop the necessary communication protocols based on how, when and where specific pieces of the basic safety message (BSM) need to be shared should vehicle actions need to occur. We will analyze what aspects are necessary with DSRC and understand if there is a role that cellular vehicle-to-everything (CV2X) can play for less urgent messages. The team will review data related to emergency responders, work zone construction, traffic signals, traffic density, dynamic transit operation and freight traveler information so that safety edge cases can be developed and solved.

e. Diversity of Projects

This project offers a unique case study for meeting an ADS requirement that will assist standards organizations and OEMs in developing the technology needed to improve infrastructure cooperation with vehicles and provide a road-map for future staging and operation.

f. Transportation-Challenged Populations

This demonstration will not directly address accessible input/output user interfaces. The technology being developed in this demonstration, however, will be transferable to other transportation modes such as bus and other multi-modal fleet vehicles which will serve this demographic. Onboard human machine interface (HMI) design will address accessibility for those with a wide range of physical abilities.

g. Prototypes

The project will use two prototype Class 8 vehicles from Volvo, shown in Figure 3 below, to demonstrate operation in the wide range of scenarios and operating conditions defined for this project.

Figure 3. Volvo Prototype Class 8 Vehicle

Initial testing will use a truck that is not fully ready for the road test demo. Learnings from this early verification phase will assist in completing the final demo truck configuration which will be used on the public road demonstration.

4. REQUIREMENTS

This project will address all the requirements defined in the NOFO Section A as described below.

a. Research and Development (R&D) of Automation and ADS Technology

This project will demonstrate the behavior of an HD Class 8 L4 truck in a wide range of operating environments. It will include L4 operation from the truck facility in Greensboro through arterials with connected intersections, onto I-85 through various operational conditions, and exit the interstate on to arterials in Charlotte to its destination. As an L4 vehicle, it will still have a safety operator onboard at all times.

b. Physical Demonstration

In addition to the simulation and test track demonstrations, the project will provide physical demonstrations in several different live operating environments. These environments will include an interstate highway work zone, traffic congestion, adverse physical conditions, simulated weigh station, rest areas and arterial signalized intersections. These will also be demonstrated under various weather conditions throughout the year. It is anticipated that the vehicle will operate under automation from origin to destination many times under these various conditions. The safety operator will have the ability to engage and disengage the system at all times.

c. Gathering and Sharing of Relevant and Required Data

The project will gather all vehicle dynamics and infrastructure communications data with direct connections to a cloud environment. This data will be made secure for authorized access. The team will define this data as well as the interface formats with the vehicle systems in the Data Management Plan (DMP) document developed for the project. The data will be made available for at least five years after the project demonstrations are complete.

Per Amendment 1, NCDOT/NCTA agrees to negotiate and sign a mutually agreeable data sharing agreement with USDOT as a requirement for award.

d. Accessible Input/Output User Interfaces

This demonstration will not directly address accessible input/output user interfaces. However, the technology being developed will be transferable to other transportation modes such as bus and other multi-modal fleet vehicles which will serve this demographic. The design of the onboard human machine interface (HMI) will be sure to address accessibility for those with a wide range of physical abilities.

e. Scalability of Demonstration

The project will provide a wide range of demonstration scenarios and environments that will allow the implementations to be scaled to a variety of roadway environments. The demonstration will be applicable across the nation to similar types of road environments.

f. Outreach

The project will include an outreach task to present findings at several national transportation conferences, and provide submissions of published results in national transportation journals. The project will share demonstration status, results and lessons learned with other jurisdictions and the public, to promote an ongoing technical exchange and transfer of knowledge.

5. APPROACH

a. Technical Approach to Implement and Evaluate the Demonstration

To properly implement and evaluate the demonstration, we anticipate delivering this project in four stages over a period of four years. Our multi-staged approach includes Stage 1. System Engineering and Planning; Stage 2. Validation, Infrastructure and Communications; Stage 3. Operational Demonstration and Testing; and Stage 4. Evaluation and Data Maintenance, each stage fully detailed below.

Stage 1. System Engineering and Planning

The team will develop a system engineering con/ops approach where policies, industry standards and specifications that relate to the performance of AVs in our chosen ODD will be defined and a full set of ADS requirements will be published. With the help of our key stakeholders, we will communicate concept reviews to establish complete program requirements for vehicle, infrastructure, governmental agencies and full AV operational process integration. The team will conduct high definition mapping (LiDAR) of the route and use the data as input to model simulations that predict safety edge cases and identify preliminary solutions. The mapping data is necessary to define road geometry for purposes of CV MAP message generation, traffic analysis and simulation, including centerline locations, intersection geometries, signage and even lane marker locations. We are not proposing to give full 3-D point clouds of the road, as this requires 10 to 100 times the effort.

The data format we are planning to provide is the Open Street Maps XML format, as we found that this is easiest to import into our traffic analysis tools (AIMSUN).

The ODD scope will consist of:

- **Suburban Operation.** Demonstrate autonomous freight pick-up and travel on an arterial road situation with traffic signals prior to interstate entrance and exit (max 50 mph).
- **Interstate Highway.** Four-lane highway operation in typical traffic conditions and work zone slowdowns along typical US interstate segment between two North Carolina cities (max 70 mph).

Stage 2. Validation, Infrastructure and Communications

Once the ODD is fully defined, along with communication protocols and initial safety models, the team will test validation and verification (V&V) conditions. The full V&V plan will be an outgrowth from Stage 1; however, we anticipate testing the initial control and communication algorithms to integrate proper infrastructure communication input/output in the software-in-the-loop (SIL) and HIL rigs at either Penn State or ORNL.

Assimilation

Emphasis on pushing the state-of-the-art of advanced transportation technologies, specifically CAVs, has recently gained significant momentum in both government and industry. Connectivity and autonomous operation of advanced vehicles are paving the way for this transportation paradigm shift within the industry and the nation as a whole. ORNL addresses these areas with demonstrated leadership capabilities across the key aspects of CAVs as well as other smart technologies, including power electronics, sensors, engines, fuels, controls development, powertrain development and cyber-security.

A need has been identified to experimentally evaluate these solutions to ascertain the validity of their respective conditions found by AVs and to generate critical data to feed back into development tools for more detailed analyses of AV technologies. An advanced HIL platform capable of bridging the gap between analytical models and real-world hardware provides the intermediary to identify the most promising technologies that should be fully verified at the vehicle system level.

Model-based design has become the industry standard for developing vehicle supervisory and powertrain control systems. However, this approach misses the complexity of the interactions of physical hardware in “real-world” driving conditions. The novel approach proposed by ORNL and Volvo Group advances the state-of-the-art by exercising actual controller hardware in “real-world” traffic situations, in which the vehicle is expected to be operated, to capture the subtle effects of communication timing/latencies, and other dynamic phenomena. The ability to subject actual control hardware to simulated “real-world” conditions allows diverse scenarios to be simulated for enhancing strategies and algorithms, as well as responding to micro- and macro-level traffic environments that current high-level traffic network models fail to capture. In addition, this framework provides a repeatable, cost-effective environment for rapid development and validation of CAV technologies, including their respective vehicle controls and communications protocols. This capability offers the benefit of absolute safety, since the control algorithms are evaluated thoroughly in a controlled HIL laboratory environment before being targeted to an actual test vehicle for on-road or track testing.

The ORNL VSI Laboratory, shown in Figure 4 below, is recognized by DOE as having core capability in integrated systems research and HIL methodologies, and is already capable of subjecting complete advanced powertrains, ranging from light duty to HD, to limited real-world conditions thanks to a full vehicle model (excluding the hardware in the laboratory), which interacts with the physical powertrains or components in the laboratory in real-time. Realizing the need to further advance CAV technology research, ORNL has made substantial internal investment through

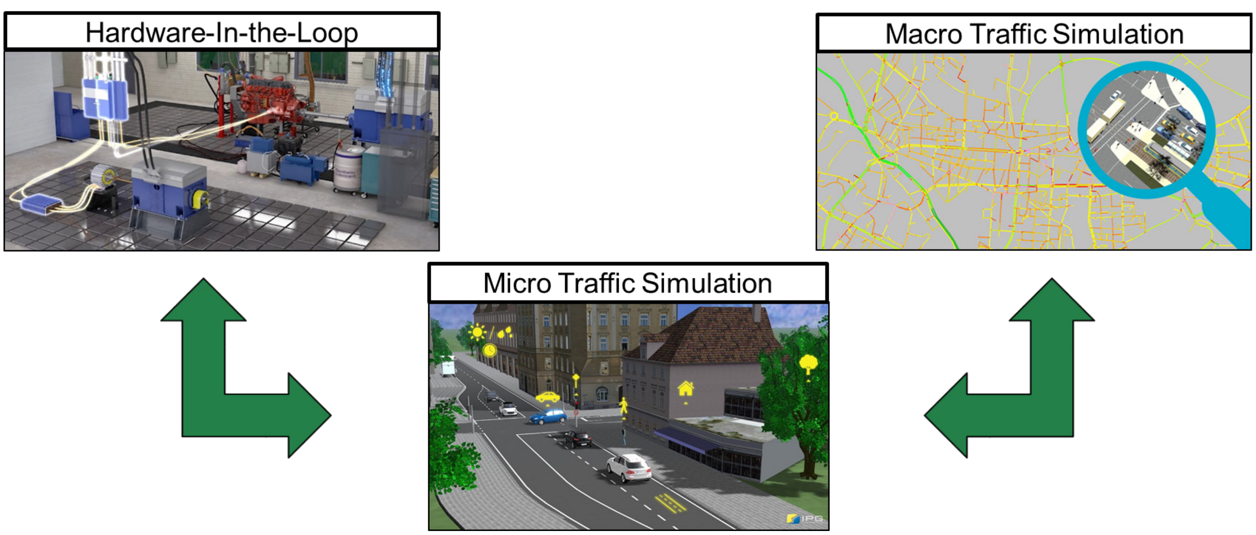


Figure 4. ORNL “Virtual-Physical” Proving Ground

acquisition of an industry-standard traffic and environment simulation package (IPG Car/Truckmaker, VISSIM) as well as integrated open sources tools (CARLA, SUMO) to elevate the current vehicle modeling, simulation and HIL capabilities to allow for interaction with other virtual traffic objects (vehicles, road signs, pedestrians, traffic control devices, connected infrastructure) and to have the ability to pair these with HIL methodologies to test hardware in real-time.

ORNL/PSU Integration of HD I-85 Mapping into ORNL's "Virtual-Physical" Proving Ground

Penn State will generate high definition road maps of the I-85 corridor being used for final testing later in the project in Stage 3. Penn State has already confirmed that they can export the data into the OpenDRIVE Maps format, which can be used to generate the road network for the virtual vehicle environment. This will allow for an accurate digital twin of the road and surface streets to be used for proper traffic flow patterns, allowing for a more accurate representation of the future on-road testing.

ORNL Modeling, Simulation and Analysis of Edge Case Conditions

In the world of autonomous control, the edge cases stand out as one of the hardest factors to account for in-vehicle AV algorithm and decision development. While they are uncommon on the roadways, they ultimately can be the most dangerous set of conditions that the vehicle might have to handle. The ultimate goal of the modeling and simulation testing is not a fully validated set of controls for all edge cases, but a study that will allow the whole team to identify edge cases. This will give Volvo Group an insight into how their controls will handle uncommon or sometimes chaotic situations found on US roadways and interstates. The team will review cases, including, but not limited to, roadworks, construction sites, lane closures, poor markings, poor signage, erratic drivers, merger areas, traffic congestion, vehicle breakdowns in road and shoulders, and emergency responders. ORNL will not only simulate the vehicle environment, but some of the V2V or V2I signals that the team may require during on-road testing.

Test Track

After beta software is available, the closed course verification of hardware will commence at Florida's SunTrax test facility. Utilizing the SunTrax test facility, we aim to:

- Perform controlled testing to successfully demonstrate AV applications;
- Identify infrastructure elements (pavement markings, signs, devices) that can help improve AV performance in the real world; and
- Identify work zone features that can help improve AV performance in real-world work zones.

SunTrax, located off I-4 between Orlando and Tampa, is a large-scale, innovative facility dedicated to the research, development and testing of emerging transportation technologies in safe and controlled environments. SunTrax's 400-acre site has 200 acres for CAV testing. Figure 5, on the following page, shows the layout of SunTrax with the numbers representing the type of facility as listed below:

1. Main Access Building
2. Complex Urban
3. High-Speed Oval
4. Roadway Geometry Track
5. Dynamic Test Pad
6. Environmental Test Chamber
7. Pick-Up/Drop-off/Multi-Modal
8. Loop Track
9. Urban
10. Ring Track

Figure 5. FDOT SunTrax Facility

The outer high-speed oval (#2) is 2.25 centerline miles with a design speed of 70 miles per hour. SunTrax will have varied lighting conditions at its toll gantry. The outer track will be available for testing in Summer 2019. The inner dense urban environment and the environmental test chamber will be available in mid-2021.

In advance of the opening, FDOT will deliver the equipment described below:

- Two (2) AVs equipped with LiDAR, retro-reflectometers, cameras, and other video/sensor technologies to collect the data
- AVs with cellular communications or wireless access in vehicle environment (WAVE) to feed data to a remote location
- Staff to support data analytics and data sharing for third party sharing
- Staff to operate AVs remotely as well as inside the vehicle

The following CAV applications are of interest for FDOT that are part of Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) 2.0 from AV solutions as it relates to V2I and vehicle-to-vehicle (V2V) communications.

1. **MC07: Work Zone Safety Monitoring** – provides warnings of potential hazards to maintenance personnel within a work zone. It enables vehicles or the infrastructure to provide warnings to workers in a work zone when a vehicle is moving in a manner that appears to create an unsafe condition (e.g., moving at high speed or entering the work zone).
2. **VS01: V2V Basic Safety** – basic safety messages with surrounding CVs to support and augment the safety warning and control automation.
3. **VS03: Situational Awareness** – shares information about potentially hazardous road conditions or road hazards with other vehicles to support enhanced driver warnings and control automation.

4. **VS04: V2V Special Vehicle Alert** – alerts the driver about the location and movement of public safety vehicles responding to an incident, slow moving vehicles, oversized vehicles, and other special vehicles (including work zone vehicles and emergency vehicles) that may require special attention from the driver.
5. **VS05: Curve Speed Warning** – receives information that it is approaching a curve along with the recommended speed for the curve.
6. **VS07: Road Weather Motorist Alert and Warning** – collects road weather data from CVs and uses that data to develop short-term warnings or advisories that can be provided to individual motorists.
7. **VS06: Stop Sign Gap Assist** – helps drivers on a minor road stopped at an intersection understand the state of activities associated with that intersection by providing a warning of unsafe gaps on the major road.
8. **VS08: Queue Warning** – utilizes CV technologies, including V2I and V2V communications, to enable vehicles within the queue event to automatically broadcast their queued status information (e.g., rapid deceleration, disabled status, lane location) to nearby upstream vehicles and to centers (such as the traffic management center).
9. **VS09: Reduced Speed Zone Warning/ Lane Closure** – provides CVs that are approaching a reduced speed zone with information on the zone's posted speed limit and/or if the configuration of the roadway is altered (e.g., lane closures, lane shifts). Reduced speed zones include (but are not limited to) construction/work zones, school zones, pedestrian crossing areas, and incorporated zones (e.g., rural towns)
10. **VS10: Restricted Lane Warnings** – provides the CV with restriction information about the travel lanes, such as if the lane is restricted to high occupancy vehicles (HOVs).
11. **CVO06: Freight Signal Priority** – provides communication between the freight vehicle and the intersections to allow freight to be given priority in the traffic signal cycle. This allows more efficient movement of the commercial vehicle as well as the general public due to reducing the stopping and starting delays of HD vehicles.
12. **SU04: Map Management** – provides up-to-date high definition mapping over the communication channel to the vehicles. This will allow changing lane alignments to be communicated to the vehicles.

At the conclusion of the closed-circuit testing, the team will perform an analysis to establish the results needed to identify safe performance across the chosen ODD and will complete necessary adjustments prior to commissioning Stage 3.

Infrastructure Communication Design

Future cars, trucks and buses will communicate with the infrastructure, as well as to one another, to improve traffic flow and increase safety. The CV Infrastructure deployed in this project will connect the automated truck with 6 smart intersections on each end of the route and with 25 ramp entrances, work zones and emergency vehicles along the highway. Safety applications are intended to be installed on an ADS enabled truck. It is anticipated that the infrastructure deployed will also support other CV projects going forward. The project intends to use SAE data messaging standards for data exchange, but will use Dedicated Short Range Communications (DSRC) and Cellular Vehicle to Everything

(CV2X) radios for communications. CV data will include information of Signal Phase and Timing (SPaT) of traffic signals, signal priority requests, BSMs, MAP lane alignment messages and others as needed. The design of the dual band Roadside Units to be deployed on the arterials, highways and work zones will be completed during stage 2, thus providing one potential roadmap for how future ADS infrastructure can be implemented.

Stage 3. Operational Demonstration and Testing

Following the initial requirements of Stages 1 and 2, communication protocols, ODD development and verification are fully complete, the team will commence the demonstration along I-85. The operational demo will initially be completed in phases. The chosen route consists of a combination of roadway segments and operational challenges. We will prioritize these segments and challenges and fully prove solutions prior to the entire route being demonstrated. For example, the team will operationally test heavy traffic density in the Charlotte area; verify hand-offs between DSRC stations in the more rural highway segment; and complete standard lane maneuvers and traffic signal negotiation in the arterial road segment. Therefore, the operational domain will be proven one step at a time, prior to a full route demonstration.

Proposed Physical Locations

We propose the following locations (Figure 6 on the following page) to be used as the start and end points during this work:

Volvo Group Offices (Greensboro, NC)
7900 National Service Road
Greensboro, NC 27409

Volvo Truck Dealership (Charlotte, NC)
Advantage Truck Center
3880 Jeff Adams Drive
Charlotte, NC 28206

These locations are not associated with any particular fleet customer, as we do not have a fleet customer as a partner in the project. The locations do very closely represent where any typical fleet customer would be located and the routes that their trucks would encounter on a regular basis. The relative locations and the roads connecting to the interstate highway are very representative of many freight company operations.

The operating environment demonstrates several areas of interaction between the infrastructure and vehicles that will be evaluated. They include:

- **Travel on surface streets from a freight terminal to the highway entrance.** This should include:
  - an industrial park area
  - single and multi-lane streets
  - intersections with and without traffic signals
  - different types of traffic control signals and signs
  - pedestrian areas
  - railroad crossings
- **The areas to transition from the surface streets, onto the highway entrance ramp and into highway traffic flow.** This should include:
  - the intersection from the surface street to the highway entrance ramp
  - the entrance ramp areas where the vehicle should accelerate
  - any lane merges (from two lanes to one lane) in these areas
  - the area where the entrance ramp lane and travel lanes are designed for traffic merge
  - any unique requirements on the ADS vehicle or the infrastructure during this set of actions

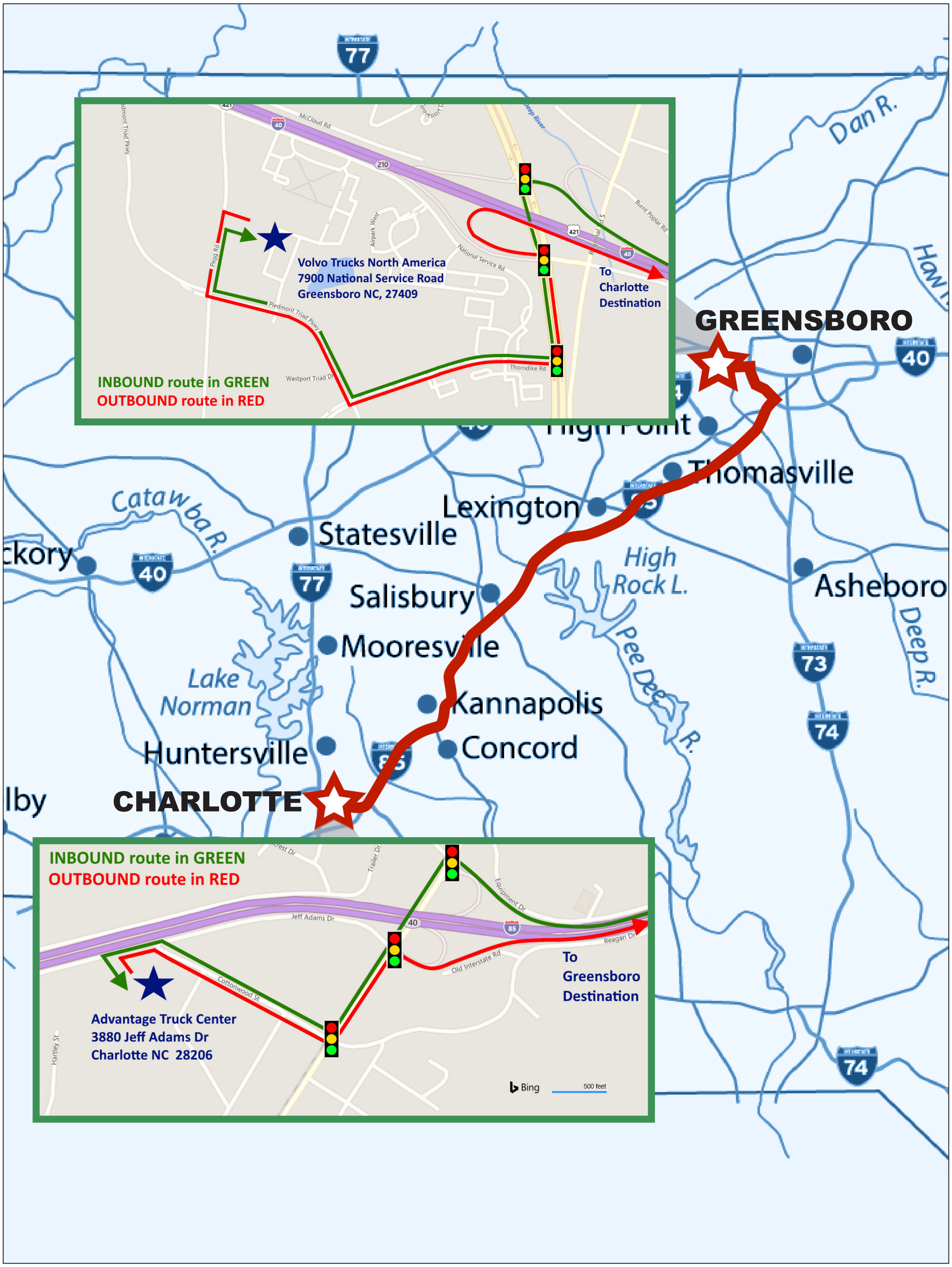


Figure 6. Proposed Demonstration Locations

   - » traffic flow management – differences in speeds, acceleration rates
   - » vehicle signaling – is standard left-turn indicator enough for ADS

- **Traveling on highway.** This should be broken into two main sub-categories — "normal" traffic activities and "typical exception" traffic activities.
  - **Managing "normal flow" on the highway.** This should include the following types of activities:
    - » typical travel lanes on the highway
    - » signs and signals for route information
    - » signs and signals for vehicle operational information
    - » highway interchanges, lanes, shapes, markings, speeds
    - » highway boundary areas (shoulders, barriers)
  - **Managing "typical exceptions" on highway.** This should include the following general types of activities:
    - » how the infrastructure is utilized relative to traffic crashes
    - » encountering work zones
    - » encountering weigh stations and commercial vehicle inspection stations
    - » encountering e-responder vehicles on the roadways
    - » encountering inclement weather
- **The actions to transition from highway traffic flow onto exit ramp.** This should include the following areas:
  - Signage or information about approaching exit ramp
  - Lane structure and markings around the exit merge lane area
  - The exit ramp area, structure, signage
  - End of ramp area, lanes, signals, intersections
- **Travel on surface streets from the exit ramp to the freight terminal.** This is basically the same as the first environment described above.

Proposed Investigation Areas

The project team proposes to focus on the following topic areas with the work:

- **Integration between HD ADS vehicles and roadway infrastructure** - Explore the operational dependencies between HD ADS vehicles and roadway infrastructure.
- **Evaluate the concept of creating an ODD classification rating model** - The existing roadway infrastructure has a very broad mix of geometrical elements and design properties (ODD) that may be either be very conducive to or exclusive of HD ADS vehicles. As an example:
  - Cloverleaf interchanges that have very limited merge areas for both entering and exiting traffic in a common short stretch of merge lane
  - Interactions that have very unusual turn geometries, lane and intersection sizes and shapes that are restrictive toward HD truck maneuvers
- **Explore the concept of creating a method to "scale or rate" the various types of roadway elements** (ODD) that exist on the nation's roadways. This would provide a consistent method for the developers and users of HD ADS vehicles to determine if they should attempt to approach that particular road element and expect to achieve a safe traffic movement.
  - Different classifications for roadways
    - » Consider amount of access, number and quality of lanes, dividing barriers, presence or absence of breakdown lanes, quality of road surface for traction, quality of road surface

for draining water, quality of lane markings
- Different classifications for interchanges
  - » Consider merge zones, visibility, curvature, grade
- Different classifications for weather influences
  - » High wind zones, frequent fog zones, frequent icing

− **Evaluate areas that can be adapted with appropriate technologies to improve safe and efficient flow of ADS vehicles in these domains** - Explore what enhancements/improvements could be made to the existing infrastructure to improve the potential for safe interaction with HD ADS vehicles.

- Road surfaces and lane markings: uniformity across the country; how to make them more visible to ADS technologies, especially during poor weather conditions
- Intersections, entry/exit ramps, highway interchanges, lane structure, merge lanes, and what updates may be needed to more safely maneuver HD ADS vehicles in these types of areas
- How signage and signals associated with route information and traffic control information can be better integrated with ADS vehicles
- Interaction between ADS vehicles and intersections: turn geometries, lane and intersection sizes and shapes for maneuvers, signal timing, getting “caught” in an intersection because of traffic congestion
- Interaction between ADS vehicles and infrastructure associated with vehicle minimal risk maneuvers, e.g. stopping in lanes, move to side of road with and without pull-off lane, actions in merge areas.

− **Interaction between ADS vehicles and highway construction zones** - Explore the interaction of HD ADS vehicles and construction zones commonly encountered on the highways. Determine what types of improvements may be possible through the use of technologies, updated guidelines and methods, recommended vehicle actions

- Technologies to better indicate the location of work zones
- Technologies to communicate specific information about the work zone to the ADS vehicle, such as temporary lane maneuvers, lane closures, speed limits
- Technologies related to enhanced barriers, beacons, indicators, etc. that more closely integrate the ADS vehicle with the work zone
- Technologies to better indicate the locations and actions of personnel within the work zones to the ADS vehicles to potentially allow even more dynamic safety functions in close proximities

− **Interaction between HD ADS vehicles and enforcement and emergency responder personnel** - Explore how HD ADS vehicles and law enforcement and emergency responder personnel interact and develop uniform guidelines and recommendations on how to make this as safe as possible.

- What types of uniform actions should HD ADS vehicles have in response to emergency vehicles (with lights) in vicinity on the roadway
  - » move over, slow down, stop
- What types of uniform actions should HD ADS vehicles have in response to a law enforcement vehicle present on a shoulder
  - » slow down, move over

  - » is it possible to have some sort of longer range signals to the trucks so they can more safely make maneuvers
- How should an HD ADS vehicle and law enforcement personnel interact in situations where hand signals are being used, e.g. motion around accidents, detours.
  - » Guidelines on hand signals and light wand signals
  - » Guidelines on expected and/or capable maneuvers
- Explore the needed interactions at weigh stations
  - » weigh station open/closed signs, overhead traffic signal gantries indicating which lanes to use, guidelines on how to stop on scales at certain locations, utilization of “pre-pass” solutions
  - » how do ADS vehicle and enforcement personnel interact in this environment
    - * how to indicate ADS-equipped vehicle
    - * how to indicate status of vehicle’s ADS systems
    - * how to cause the ADS vehicle to move to an area for inspection
    - * how to interact with roadside inspections
  - » Human Machine Interface (HMI) for enforcement authorities
    - * How to indicate and check status of vehicle systems
    - * How to query status of vehicle systems after an incident
    - * How to deactivate vehicle systems after an incident
    - * Should it be possible for enforcement personnel to initiate/ assist/guide manual maneuvers
- Interaction with emergency responders after an incident
  - » Guidelines for how ADS vehicles communicate with emergency responders after an incident, what technologies, what information
  - » How should emergency personnel determine the status of the vehicle, will it move, is it safe to be around
  - » Guidelines on how to deactivate the ADS systems safely
  - » Should it be possible for emergency personnel to initiate/assist/guide manual vehicle maneuvers, such as move to the shoulder
- How to manage a security concept between enforcement personnel/ emergency responders and an HMI type device on an HD ADS vehicle

– **Interaction between ADS vehicles and other road users**

– **Operation in normal traffic flow** - Explore ideas of how HD ADS vehicles and other motorists on the highway can more safely interact

- Guidelines for uniform lane merge actions, lane change actions
- Are there any special needs for use of indicator signal lamps with ADS vehicle
- Should we explore concepts of enhanced signaling
- Should we explore the potential to increase the conspicuity of the ADS vehicle
- Information and education of the motoring public about how HD ADS vehicles behave

– **Operation as a result of crashes -** Explore ideas for how ADS vehicles should interact with other road users when they have to execute a minimal risk maneuver due to "normal" crashes, such as tire blow outs and driveline breakdown

- What special interactions with other road users during these events
- To what roadway area does the ADS vehicle move
- What to do to indicate that a truck is stopped on the shoulder
  - » what to do instead of safety triangles
- Guidelines on interaction between service vehicle personnel and ADS vehicles

− **Review of applicability of existing regulations and gap analysis with ADS vehicles** - Explore the existing commercial vehicle safety requirements, evaluate if all the existing requirements are applicable with HD ADS vehicles, identify if additional requirements are needed.

Stage 4. Evaluation and Data Maintenance

The final stage will perform the final evaluation and closeout for the project. It will also prepare the data to be maintained for the five-year archive of the project data.

b. Approach to Address Legal, Regulatory, Environment and/or Other Obstacles

In 2017, the North Carolina General Assembly enacted a new Article 18 (Session Law 2017-166 (H 469)) in Chapter 20 (G.S. § 20-400 – 403) to regulate the operation of fully autonomous vehicles. The bill further specifies that a driver's license is not required for an autonomous vehicle operator and requires an adult to be in the vehicle if there are any passengers under the age of 12. This legislation also preempts local regulation of autonomous vehicles and establishes the Fully Autonomous Vehicle Committee. The bill further specifies that a driver's license is not required for an autonomous vehicle operator, and requires an adult be in the vehicle if a person under the age of 12 is in the vehicle. This legislation also preempts local regulation and establishes the Fully Autonomous Vehicle Committee. The committee includes members of NCDOT, state and local law enforcement, insurance agencies, university research, AV industry, including Volvo Group and General Motors, trucking industry, urban and rural planners, and Senate and House representatives.

The Committee meets at least four times a year, to consider matters relevant to fully autonomous vehicle technology, review state motor vehicle laws as they relate to the deployment of fully autonomous vehicles onto the state highway system and municipal streets, make recommendations concerning the testing of fully autonomous vehicles, identify and make recommendations for DOT traffic rules and ordinances, and make recommendations to the General Assembly on any needed changes to state law.

Exemption from Federal Motor Vehicle Safety Standards (FMVSS), Federal Motor Carrier Safety Regulations (FMCSR) or Other Regulations

As part of the NC legislation, the vehicles deployed to public roads have to be certified, in accordance with federal regulations in 49 C.F.R. Part 567, as being in compliance with applicable federal motor vehicle safety standards (FMVSS) and bears the required certification label or labels. This project will comply with that requirement.

Exception under the Buy American Act or to the Terms of the NOFO Clause at Section F, Paragraph 2.J "BUY AMERICAN AND DOMESTIC VEHICLE PREFERENCES

The technology developed under this project will be assembled in the United States.

c. Commitment to Provide Data and Participate in the Evaluation of Safety Outcomes

As required under the NOFO, the project will gather all vehicle dynamics and infrastructure communications data with direct connections to a cloud environment. The team will secure this data for authorized access. We will define this data in the DMP document developed for the project. The data will be made available for at least five years after the project demonstrations are complete.

Per Amendment 1, NCDOT/NCTA agrees to negotiate and sign a mutually agreeable data sharing agreement with USDOT as a requirement for award.

d. Approach to Risk Identification, Mitigation and Management

The team will implement HNTB's Sophisticated Delivery Approach (SDA) to not only identify, mitigate and manage risk, but to also deliver a high quality project on-time and within budget. The SDA process is the accumulation and organization of HNTB's Standards of Performance (SOPs) for project delivery, including the tools and practices used to deliver projects that have been developed and proven over time. This approach is described in more detail in Part 2. Management Approach.

e. Approach to Contribute and Manage Non-Federal Resources

The project team will contribute several cost sharing components to the project. Volvo Group is contributing the use of a Class 8 truck to the project. FDOT is contributing the use of its SunTrax facility for testing of the truck in a controlled operational environment. The facility will be used to test the ADS capabilities in staged environments. NCDOT is contributing the right-of-way for the on-road portion of the project.

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