The North Carolina Transportation Center of Excellence on Connected and Autonomous Vehicle Technology

NC-CAV

North Carolina Agricultural and Technical State University

NC STATE UNIVERSITY

UNC CHARLOTTE

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

www.NCCAV.com

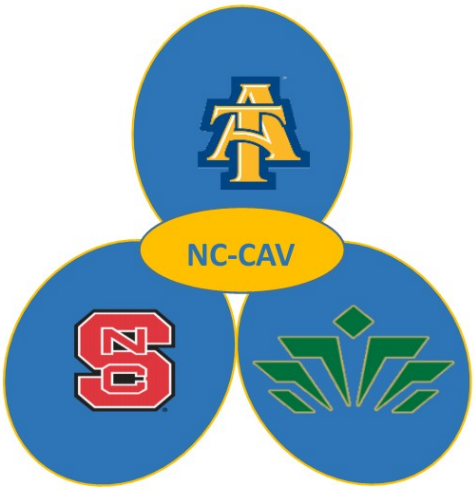
About NC-CAV

The NC Transportation Center of Excellence on Connected and Autonomous Vehicle Technology (NC-CAV) has been funded by the North Carolina Department of Transportation. NC-CAV brings together a strong and diverse team of researchers from North Carolina A&T State University (NCAT), North Carolina State University (NCSU), and the University of North Carolina at Charlotte (UNCC) to conduct innovative, cutting-edge, synergistic, interdisciplinary research on connected autonomous vehicles which will prompt revolutionary transformations in the transportation systems by providing increased capacity, reliability, affordability, and sustainability. The center incorporates three interwoven research thrusts that will progress synergistically:

Thrust 1 (CAV Impacts) investigates the impact of Connected and Autonomous Vehicles (CAV) on North Carolina's transportation system, and associated revenue.

Thrust 2 (CAV Infrastructure) assesses North Carolina's readiness for CAVs in terms of traditional and emerging transportation infrastructure.

Thrust 3 (CAV Applications) explores emerging applications of CAVs and develops and deploys CAVs and Unmanned Arial Vehicles (UAVs) for advancing transportation systems.



NC-CAV Mission

NC-CAV as a multidisciplinary Center of Excellence in "Advanced Transportation Technologies" aims to (1) investigate the adoption, utilization, and deployment of CAVs and their impacts on the transportation system in North Carolina and the nation, (2) serve as a regional and national resource in research and education on CAV technology, (3) provide outreach services in transportation-related areas, (4) facilitate linkage among transportation-related research institutes and centers across North Carolina for researching CAV technology, (5) commercialize NC-CAV technology developments for the benefit of North Carolina and the national economy.

NC-CAV Vision

NC-CAV serves as a recognized regional and national leader in researching and developing CAV technology and its applications and impacts on the transportation system and the associated revenue in North Carolina and the nation. NC-CAV develops roadmaps and strategic long-term plans, and prototypes CAV applications in order to proactively plan for the future development of advanced transportation technologies and the required infrastructure to utilize and deploy CAVs in a mixed transportation system including CAVs, UAVs, and human-driven vehicles.

NC-CAV Goals and Objectives

The **goal** of NC-CAV is to seek long-term view and cutting-edge multidisciplinary approaches to investigate the adoption, utilization, and deployment of CAVs and their impacts on the transportation system in North Carolina and the nation to meet transformative **objectives** including:

Objective 1: Investigating the impacts of CAVs on North Carolina's current transportation system and an assessment of the fiscal impacts that CAVs would impose on North Carolina and its communities;

Objective 2: Assessing North Carolina's readiness for CAVs, investigating the required changes to the existing transportation infrastructure needs to support CAVs, and to explore emerging technologies that can support CAV deployment;

Objective 3: Developing and implementing cooperative control techniques for CAVs and UAVs and exploring their emerging applications via the development of prototypes and analysis of multiple use cases;

Objective 4: Sustaining the Center's activities by attracting larger funding at the national level for advanced transportation systems; and

Objective 5: Developing an outreach program and a diverse and better-prepared workforce with more graduate and undergraduate students, particularly from underrepresented groups, across participating institutions, by exposing them to advanced CAV-UAV transportation technologies.

Courtesy of DOT, US. "Preparing for the Future of Transportation: Automated Vehicles 3.0."

NC-CAV Research Team Members

	**Ali Karimoddini, PhD** Director, NC-CAV Center Director, ACCESS Laboratory Department of Electrical and Computer Engineering North Carolina A&T State University **Research expertise:** Modeling, developing, and the control of autonomous vehicles, reliable and fault-tolerant hybrid control systems, human-machine interactions
	**Wei (David) Fan, PhD, P.E.** Thrust 1 Lead, NC-CAV Center Director, USDOT CAMMSE University Transportation Center Department of Civil & Environmental Engineering UNC Charlotte University **Research expertise:** Big data analytics, multimodal transportation and shared mobility, traffic system operation, transportation system analysis, network modeling
	**Thomas Chase** Thrust 2 Lead, NC-CAV Center Institute for Transportation Research and Education NC State University **Research expertise:** Freeway operations, pedestrian behavior and simulation, traffic signal control, travel time reliability, network modeling and monitoring
	**Abdollah (Ebbie) Homaifar, PhD** Thrust 2 Lead, NC-CAV Center Director, Autonomous Control Information Technology Institute (ACIT), Department of Electrical and Computer Engineering North Carolina A&T State University **Research expertise:** Machine learning and artificial intelligence and their applications to autonomous vehicles
	**Chris Cunningham** Thrust 3 Co-Lead, NC-CAV Center Institute for Transportation Research and Education NC State University **Research expertise:** Traffic signal timing and optimization, ITS research applications, transportation safety, pedestrian accessibility issues
	**John Kelly, PhD** Thrust 2 Co-Lead, NC-CAV Center Department of Electrical and Computer Engineering North Carolina A&T State University **Research expertise:** Security of cyber-physical systems, communication network performance, and engineering education
	**Shih-Chun Lin, PhD** Thrust 2 Co-Lead, NC-CAV Center Department of Electrical and Computer Engineering NC State University **Research expertise:** 5G Wireless communications, Internet-of-Things, intelligent edge computing, and machine learning
	**Nagui Rouphail, PhD** Thrust 3 Co-Lead, NC-CAV Center Department of Civil, Construction, and Environmental Engineering NC State University **Research expertise:** Incident detection and management, urban traffic control, highway capacity, traffic flow, freeway work zone analysis

NC-CAV Research Team Members (continued)

	**Ali Hajbabaie, PhD** Thrust 1 Co-Lead, NC-CAV Center Department of Civil, Construction, and Environmental Engineering NC State University **Research expertise:** Advanced traffic signal control, active traffic management, and simulation of CAV systems including V2I, V2V, and V2X.
	**Daniel Findley, PhD** Thrust 1 Co-Lead, NC-CAV Center Institute for Transportation Research and Education NC State University **Research expertise:** Economic impact analysis, multi-modal transportation studies, human behavior research, and transportation engineering
	**Leila Hashemi, PhD** Thrust 3 Member, NC-CAV Center Department of Built Environment North Carolina A&T State University **Research expertise:** Remote sensing data from airborne and satellite imagery for transportation, environmental management, and risk assessment
	**Steven Xiaochun Jiang, PhD** Thrust 1 Member, NC-CAV Center Department of Industrial and Systems Engineering North Carolina A&T State University **Research expertise:** Human systems integration, visual analytics, and predictive modeling
	**Steve Bert** Thrust 1 Member, NC-CAV Center Institute for Transportation Research and Education NC State University **Research expertise:** Economist/policy analysis, market and non-market valuations, social, health, aesthetic, and environmental costs and benefits
	**Abdullah Eroglu, PhD** Thrust 2 Member, NC-CAV Center Department of Electrical and Computer Engineering North Carolina A&T State University **Research expertise:** Radio Frequency (RF) communications, design of RF sensors and applications particularly for infrastructure and autonomous systems
	**Nicolas Norboge** Thrust 1 Member, NC-CAV Center Institute for Transportation Research and Education NC State University **Research expertise:** Transportation finance policy and analysis, transportation revenue strategy analysis, waterway lock-and-dam finance policy
	**Mubbashar Khan, PhD** Program Manager, NC-CAV Center North Carolina A&T State University **Expertise:** Information systems, business administration, risk management, statistical analysis and reporting, strategy development and marketing

Thrust 1: CAV Impacts

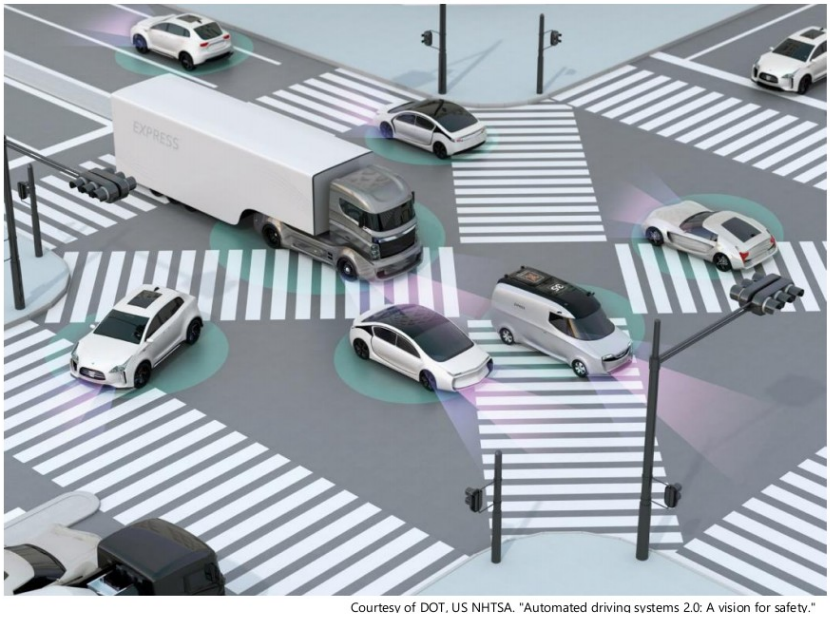
Project 1: CAV Impacts on Traffic Intersection Capacity and Transportation Revenue

Principal Investigator: W. Fan (UNCC)

Other Investigators: ITRE: A. Hajbabaie, D. Findley, S. Bert, N. Norboge; NCAT: S. Jiang

Project Summary: As Connected and Automated Vehicles (CAVs) emerge in North Carolina, we should expect to have substantial impacts on the transportation system, including the planning, design, operations, construction, and maintenance of the infrastructure, as well as on the flow of entities involved (including drivers, vehicles, bicyclists, and pedestrians). In particular, since CAVs will have profound impacts on freeways, arterials, and local streets, they will significantly affect those arteries' capacities and the transportation system's performance. CAVs are also expected to have significant impacts on the economic outlook of North Carolina and will affect both state and local budgets and the revenues associated with motor vehicles, such as motor fuel taxes, sales and use taxes, moving violations, toll receipts and parking fees, among other transportation revenue sources.

This project evaluates the ways CAVs will influence the current transportation system's performance, along with the provision of an in-depth analysis of the required intersection capacity adjustments while explicitly accounting for mixed vehicle fleets with different expected levels of CAV adoption under different traffic situations. This project focuses on the development and provides recommendations on estimating and predicting the capacity of intersections and the associated revenue in the presence of CAVs, in order to lead to a better understanding of how CAVs will impact mobility and safety of the urban transportation systems. Also, this project assesses the fiscal revenue impacts of the transition to CAVs on North Carolina's cities, towns, and households, and how this will affect revenues at NCDOT. It also identifies policy options to mitigate budget impacts and allow North Carolina to reap the maximum benefits from the transition.



Courtesy of DOT, US NHTSA. "Automated driving systems 2.0: A vision for safety."

Research Goals and Objectives of Project 1:

The main **goals** of this research project include an investigation of the impacts of CAV technologies on the current transportation system (specifically on the intersection capacity at different expected market penetration levels of the CAVs) and the assessment of the fiscal revenue impacts of CAVs on North Carolina's cities, towns, and households. The **objectives** of this project are to:

1. Conduct a comprehensive review of the state-of-the-art and state-of-the-practice on CAV technologies and their impacts on intersection capacity and the associated transportation revenues;
2. Develop case studies to illustrate the impacts of CAVs on the traffic systems, particularly at the intersections, suitable intersections will be identified for the case study;
3. Create simulation methods to measure intersection capacity at different CAV possible market penetration levels;
4. Analyze the impacts of the CAV technologies on intersection capacity and provide recommendations for future research directions;
5. Conduct a comprehensive analysis of the revenue impacts and opportunities of automated, connected, electric, and shared vehicles accruing at various adoption rates and policy scenarios in North Carolina, and
6. Integrate and refine findings from this research, including an in-depth review of CAV technologies and their impacts on future transportation revenues and on the planning initiatives such as NC Moves 2050 and the NC FIRST Commission.

Anticipated Research Products of Project 1

The anticipated research products include:

1. A review of CAV technologies and intersection capacity analysis considering mixed vehicle fleets with different expected levels of CAV market penetration.
2. Identification of potential intersection scenarios and collection of the characteristics of each transportation revenue impact scenario, including an assessment and feasibility of new, innovative, and sustainable transportation funding methods.
3. Guidelines on intersection capacity adjustments at different expected CAV market penetration levels.
4. An evaluation of the fiscal impacts of CAV adoption, including policy options to enable North Carolina to reap maximum benefits of CAV adoption.

Thrust 2: CAV Infrastructure

Project 2: Assessing North Carolina Readiness for CAVs in Traditional and Emerging Infrastructure Needs

Principal Investigator: T. Chase (ITRE)

Other Investigators: NCSU: S. Lin; NCAT: J. Kelly, A. Eroglu

Project Summary: North Carolina is preparing for Connected and Autonomous Vehicles (CAVs) through multiple initiatives including an NCDOT-sponsored report "NC Readiness for Connected and Autonomous Vehicles (CAV)" and the Highly Automated Vehicle Committee appointed by the State Legislature. In providing a roadmap for safe deployment of CAVs on North Carolina roads, these initiatives highlight the need to consider modifications to roadway infrastructures. CAVs' infrastructure needs can be broadly categorized either as improvements to existing traditional infrastructure or as emerging infrastructure needs. New infrastructure, including communications hardware to support Connected Vehicle (CV) applications, has been a recent focus of USDOT with three national pilot locations in Tampa, New York City, and statewide in Wyoming. In addition, NCDOT has joined the Signal Phase and Timing (SPaT) Challenge with a CV deployment on NC-55 in Cary. To date, the pilot projects focus on Dedicated Short-range Communication standards for broadcasting informational messages rather than applications that require heavy processing.

In addition to the pilot testing of new infrastructure, recent studies have shown the automated driving systems also rely heavily on traditional infrastructure. CAVs include a suite of detection methods including video, LIDAR, ultrasonic, and radar systems for autonomous vehicles to safely navigate on-road. These systems need high-quality pavement markings, consistent geometric features, and clearly visible signs and traffic signals. NCHRP Projects 20-102(06) on Pavement Markings, 20-102(15) on Level 2 and 3 Automation Needs, and planned projects 20-102(21) and 20-102(24) on Mid-term Infrastructure Needs each highlight necessary changes to existing facilities and assets that NCDOT constructs and maintains. These projects are expected to bring recommended changes to the Manual on Uniform Traffic Control Devices as well to ensure uniformity of CAV infrastructure across the country.

This project assesses current NCDOT Programs that may be impacted by the changes to the traditional infrastructure that would be needed to safely deploy CAVs statewide, 2) expands on a low-latency edge computing architecture that can support CAV applications needing extensive computation or timely response, and 3) provides recommendations to NCDOT units and programs to increase statewide readiness for CAVs in both traditional and emerging infrastructure. The research team leverages their existing relationships with NCDOT as well as National Instruments and the Wireless Research Center to develop actionable recommendations. Project deliverables include presentations for concerned units and division engineers as well as recorded webinars and reports documenting the team's findings and recommendations.

Research Goals and Objectives of Project 2:

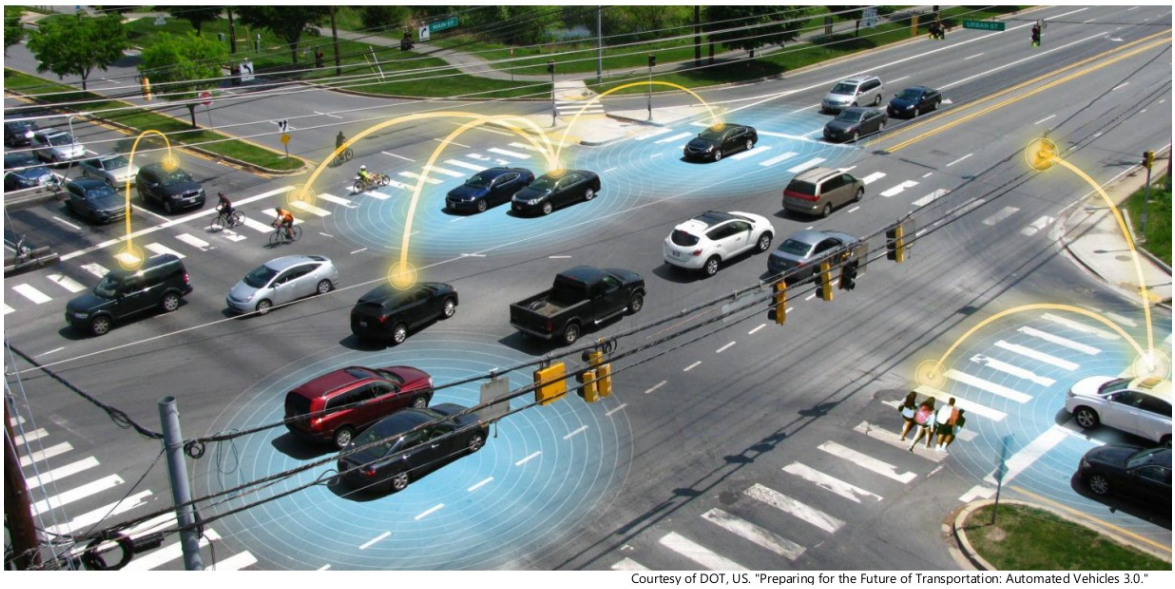
The **goal** of this research project is to investigate both changes to existing infrastructure needs to support CAVs and emerging technologies that support CAV deployment. There are three primary **objectives** of the project:

1. Document NCDOT infrastructure programs impacted by CAV applications.
2. Develop and test a 5G architecture for secure V2I applications.
3. Recommend program enhancements to advance NC-CAV infrastructure readiness.

Anticipated Research Products of Project 2:

The anticipated research products include:

1. A report on the analysis of existing transportation infrastructure and recommendations for its associated maintenance programs for supporting the CAV deployment in the future;
2. A recommendation report for the establishment of a low-latency edge computing infrastructure for North Carolina, and
3. A recommendation report for the enhancement of the readiness of NC infrastructure for CAV deployment.



Courtesy of DOT, US. "Preparing for the Future of Transportation: Automated Vehicles 3.0."

Thrust 3: CAV Applications

Project 3: Developing and Implementing CAV-UAV Collaboration for Advancing the Transportation Systems

Principal Investigator: A. Homaifar (ACIT, NCAT)

Other Investigators: NCAT: A. Karimoddini, L. Hashemi-Beni; ITRE: N. Rouphail, C. Cunningham; UNCC: W. Fan

Project Summary: With advances in control, sensing and perception, high performance computers, cloud computing, and communication technologies, it is becoming possible to have heterogeneous transportation systems incorporating autonomous ground and air vehicles that communicate with each other and also with smart infrastructure to effectively provide transportation services distributed in time and space. Connected Autonomous Vehicles (CAVs) have the capability to communicate with devices both within and outside of the vehicle (including other vehicles and road or network infrastructure) to share and process data in order to improve the safety and performance of individual vehicles and of the overall transportation system. Higher autonomy levels of CAVs along with their connectivity allow for a cooperative control strategy that provides a more flexible and efficient transportation system to serve as an on-demand-mobility solution. Further, cooperative control of CAVs offers a promising solution that increases traffic efficiency and enhances traffic navigation through congested urban environments such as road intersections or unforeseen situations that may arise during travel/transportation. This project develops and experimentally validates cooperative control techniques for CAVs and UAVs which build on NCDOT's experience in the field.

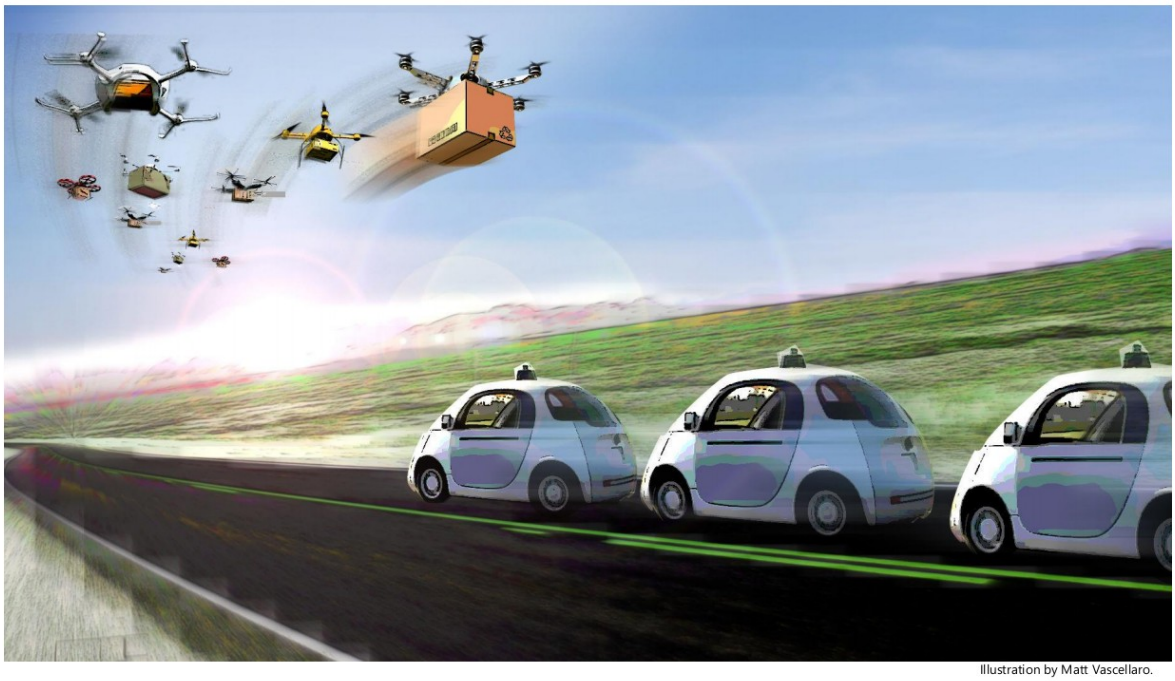


Illustration by Matt Vascellaro.

Research Goals and Objectives of Project 3

The **goa**l of this project is to develop and implement cooperative control techniques for CAVs and UAVs and to explore their emerging applications by achieving the following objectives:

1. **Developing cooperative control of heterogeneous CAVs and UAVs for on-demand mobility applications**

NC-CAV develops cooperative control algorithms for coordinating CAVs (both ground and air autonomous vehicles) to provide transportation services distributed in time and space that meet clients' and stakeholders' needs. Also, NC-CAV uses optimal routing and scheduling to accommodate requested services to reduce delay time while minimizing resource utilization by effectively locating and tasking the CAVs available in the network.

2. **Prototyping a testbed of a network of CAVs**

NC-CAV develops a testbed composed of multiple autonomous vehicles and equips them with the required accessories for autonomous driving and for communication with each other and with the infrastructure to form a heterogeneous network of CAVs to implement advanced cooperative control of CAVs.

3. **Aerial monitoring using CAVs**

NC-CAV explores an aerial monitoring using tethered UAVs to assist in incident and emergency management activities. This possible application of UAVs has strong potential to reduce the impact of incidents on vehicle mobility--especially more severe collisions--to manage the traffic incidents more effectively by providing the data to first responders and law enforcement officers, enabling faster road clearance.

Anticipated Research Products of Project 3

Deliverables for this project include:

1. A design methodology for the use of on-demand mobility solutions for the urban transportation system.
2. A feasibility study report for implementing an on-demand-mobility solution for a use case (connecting NCAT campus to downtown Greensboro).
3. A networked CAV testbed capable of implementing advanced CAV transportation concepts and applications.
4. A report on field test results for the deployment of the developed CAV testbed for potential use cases.

NC-CAV Integration Plan and Use-cases

Lead: A. Karimoddini (NCAT)

Co-Leads: NCAT: A. Homaifar; ITRE: T. Chase and C. Cunningham; UNCC: W. Fan

Other Investigators: All NC-CAV researchers

Use-case 1: Feasibility study for deployment of CAVs between the NCAT campus and Greensboro downtown

NC-CAV in collaboration with NASA Langley Research Center aims the investigation of the feasibility study for the implementation of on-demand-mobility solutions for urban transportation. As a use-case, NC-CAV conducts a feasibility study for connecting NCAT campus to downtown Greensboro with Downtown Greensboro as a stakeholder. This project investigates the required infrastructure, the number of vehicles, the number and location of stops, the average service time, and the service capacity.

The preliminary selected route for connecting NCAT campus to downtown Greensboro via CAVs to be used as an on-demand-mobility framework use-case.

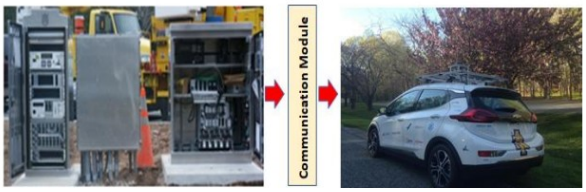
Use-case 2: Prototyping and deploying a CAV-testbed

Another use-case of NC-CAV is to prototype and enhance the autonomy level of two electric golf carts provided by Downtown Greensboro by leveraging the equipment support (sensors and computer systems) provided by NCAT College of Engineering to form a heterogeneous fleet of CAVs to implement the cooperative control algorithms for CAVs. Each vehicle communicates with other vehicles, traffic intersection signaling systems, and handling pedestrians with enhanced autonomy level by equipping the vehicles with autonomous navigation, control sensing, data fusion, and decision-making tools for autonomous driving in urban environments. The use-case further includes the conduct of preliminary tests of the developed testbed on the selected route between the NCAT campus and downtown Greensboro.

NC-CAV also leverages the equipment in the ITRE's *Mobile Remote Sensing and Data Collection Lab* to set up the experiment and evaluate the CAV deployments. Further, the researchers at NC-CAV have access to equipment from the *Signal Control Laboratory* as an outdoor signal laboratory to enable communication with the developed CAV testbed. Verizon and the Wireless Research Center of North Carolina (WRC) supports the CAV-UAV applications by offering 5G communication and portable towers to provide communication links for connecting the vehicles and UAVs.

NC-CAV uses the autonomous car technology developed at NCAT.

Mobile data collection unit at ITRE evaluating the conducted CAV deployments.



With assistance from Signal Control Laboratory at ITRE, the developed CAV at NC communicates with traffic sign signaling systems.

Use-case 3: Demonstration of the UAV application for traffic management: NC-CAV uses a UAV application such as tethered to determine the way a passenger vehicle, could be monitored, how that data could be sent back to a TMC, and the type of data that could be captured and used for traffic management purposes. In addition, the research team provides a list of possible future research directions that can be explored by NCDOT in a similar vein of emergency incident management and include other state departments such as the NCSHP.

NC-CAV researchers use UAVs for aerial traffic monitoring.

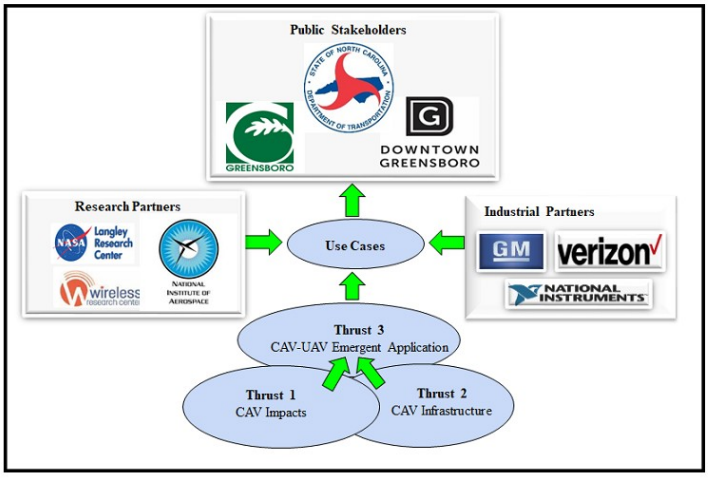
Field experiment and testing: The developed CAV testbed can be tested on NCAT's dedicated test track. Further, the Greensboro Department of Transportation provides access to the intersection at Benbow Road and Bluford Street for testing the developed autonomous vehicles and installing smart signaling equipment to connect with CAVs. Alternately, the field testing of the connectivity of the developed CAVs to transportation infrastructures ca be performed at NCDOT SPaT Challenge Corridor on NC-55 in Cary, NC.

NCAT provides one-mile test track for prototyping and deploying CAVs.

GDOT provides access to the intersection of Benbow Rd. and Bluford St.

NC-CAV Outreach Plan

Engagement of Stakeholders: NC-CAV has an outreach program aimed at internal and external stakeholders to ensure that the developments under the NC-CAV effort are aligned with the stakeholders' objectives and are addressing their real needs. NCDOT, Downtown Greensboro and Greensboro Department of Transportation serve as the other public stakeholders for this project and provide equipment and logistics needed for a pilot program deployment of CAVs in its downtown district from the NCAT campus. NC-CAV also partners with industrial partners such as Verizon, the National Institute of Aerospace (NIA), the NASA Langley Research Center and industrial partners (including General Motors and National Instruments) in developing and deploying innovative CAV-UAV applications that address the needs of the state.



Dissemination of Research Products: NC-CAV aims to prepare visually accessible products designed for executive and public consumption, including informative web pages, summaries, reports, pamphlets, and videos about the NC-CAV's research accomplishments and implementations, and broadly disseminate project findings nationally and internationally via seminars, conferences, and peer-reviewed journal publications. Organization of special sessions and workshops at relevant international conferences and symposia is also target by the NC-CAV. Furthermore, the NC-CAV website (https://www.nccav.com/) is maintained to provide online access to the presentations, publications, technical reports, developed software and toolboxes, and other materials produced during the research.

Curriculum Development: The outcome of this research effort is focused on the development of new graduate and undergraduate courses and/or for integration into existing courses being taught by the PIs. Some of the related courses being taught at the three participating universities are listed below:

NCAT: "Modeling and Control of Drones," "UAV Data Processing," "Advanced Imaging," "Advanced Robotic Systems," "Decision-making and Supervisory Control," "Introduction to Telecommunications," "Computer Vision Intelligence for Robotic Applications," "Advanced Geospatial Analysis," and "Methodologies of Remote Sensing."

NCSU: "Highway Design," "Traffic Engineering," "Sensors, Instrumentation, and Data Analytics for Transportation Networks," "Intelligent Transportation Systems," "Advanced Topics in Wireless Networking," and "Optimizations and Algorithms."

UNCC: "Introduction to Transportation Engineering," "Advanced Traffic Engineering," "Intelligent Transportation Systems," "Transportation Systems Analysis," "Urban Transportation Networks: Operations and Optimization," and "Connected and Autonomous Vehicles."

Sponsors, Stakeholders & Partners

The North Carolina Department of Transportation (NCDOT) is responsible for all modes of transportation in the state, including highways, rail, aviation, ferries, public transit, and bicycle and pedestrian. NCDOT also includes the Division of Motor Vehicles, the Governor's Highway Safety Program, State Ports Authority, Global TransPark, and Turnpike Authority. NCDOT is the major sponsor of NC-CAV.

Downtown Greensboro Incorporated (DGI) is an economic development organization focused on stimulating investment and activity in Greensboro center city. DGI's primary focus is to lead the development of Downtown Greensboro. DGI provides funding and logistics to NCCAV Center to prototype a CAV testbed.

The City's Department of Transportation (GDOT) seeks to increase public safety and mobility through the effective planning, construction and maintenance of transportation infrastructure and operation of municipal transit. Services provided to residents, businesses and visitors include traffic signals and signs, transportation planning, parking, street lighting, sidewalks and bikeways. GDOT supports NC-CAV by providing the logistics for testing the developed CAV testbeds in Greensboro.

Research Partners

The National Institute of Aerospace (NIA) is a non-profit research institute headquartered in Hampton, Virginia, near NASA's Langley Research Center. NC-CAV researchers have access to NASA Langley research facility through NIA for developing and simulating on-demand mobility services.

The Wireless Research Center (WRC) is a private nonprofit research center dedicated to developing products and services that advance wireless technology innovation. WRC provides NC-CAV with the access to portable towers that can serve as mobile base stations to support the connection between the autonomous cars or communication links to UAVs for aerial monitoring.

Industrial Partners

Verizon Wireless is an American telecommunications company that offers wireless products and services. Verizon provides 5G communication and the required technical support to connect the V2V and V2I in NC-CAV testbeds.

National Instruments Corporation (NI) is an American multinational company, which produces automated test equipment and virtual instrumentation software. NI provides NC-CAV researchers with access to key measurement, control, test, and hardware-in-the-loop simulation technologies and the required technical assistance, training, and support associated with NI's technologies.

General Motors Co. is an American multinational corporation that manufactures, markets, and distributes vehicles and vehicle parts, and sells financial services. GM supports NC-CAV by providing technologies and technical support for the development of autonomous vehicles.

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