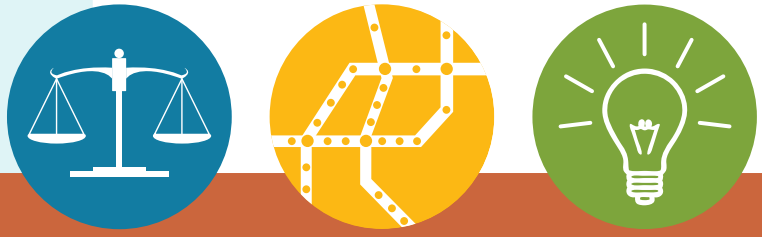

NC READINESS FOR CONNECTED AND AUTONOMOUS VEHICLES (CAV)

FINAL REPORT

NCDOT CAV ROADMAP DEVELOPMENT PROJECT

November 2016

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Introduction

Although we have not entered the Jetsons era of flying cars and talking robots, we are entering a time when advanced computing, sensors, and telecommunications technology are transforming automobile and road-based surface transportation. With these advancements come important policy, legal, investment, and research decisions that governments must consider. As of mid-2016, at least six states and Washington D.C. had enacted legislation to enable testing and, in some cases, operation of autonomous vehicles on public roads. More recently, a few states have taken this one step further and introduced legislation that allows the testing of autonomous vehicles without requiring the presence of a human within the vehicle.

As connected and autonomous vehicle (CAV) advancements expand daily and are introduced into existing transportation systems, certain questions become increasingly pertinent: **Is North Carolina ready**? Can we address safety regulations while simultaneously leveraging opportunity? Can we prepare our workforce, the legal community, and the public for shifts in how the transportation network is used and how mobility is supplied? **Figure 1** captures a sampling of the opportunities and impacts of CAVs.

Figure 1. Opportunities and Impacts of CAV Technologies

This report provides an activities roadmap for the State of North Carolina (NC), led by the Department of Transportation (NCDOT) and the Division of Motor Vehicles (NCDMV), in response to the introduction of CAV technology in the marketplace over the next 10 years. The NCDOT and NCDMV directed this project with two primary goals:

- Identify the wide range of questions raised by CAV technology
- Define an approach, or ***Activities Roadmap***, for how North Carolina should prepare for CAV technology

CAV technologies continue to advance toward introduction into public roadway systems; in fact, some passenger vehicle models including Tesla, Mercedes, and Infiniti can be purchased today with a basic level of self-driving driver assistance capability. A wide range of other models have foundational elements such as sensors and adaptive cruise control. More than 10 states now have significant CV pilot programs and are in the planning or implementation stages for CAV programs, projects, and deployments. Almost every major automobile manufacturer has an active AV research and development program, and a variety of third-party aftermarket suppliers are investing significant funds in the development of CAV driving technologies.

Connected vehicles involve both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. Dedicated short-range communication (DSRC) is the primary technology for low-latency, high-speed message exchange between vehicles to warn drivers of safety issues. *Automated* vehicles involve advanced sensors, artificial intelligence algorithms, and on-board computing that enable the vehicle itself to perform some or all driving functions. *Autonomous* vehicles can perform driving functions without a driver. The daily news reports and articles related to advancements in this technology confirm the urgency to prepare.

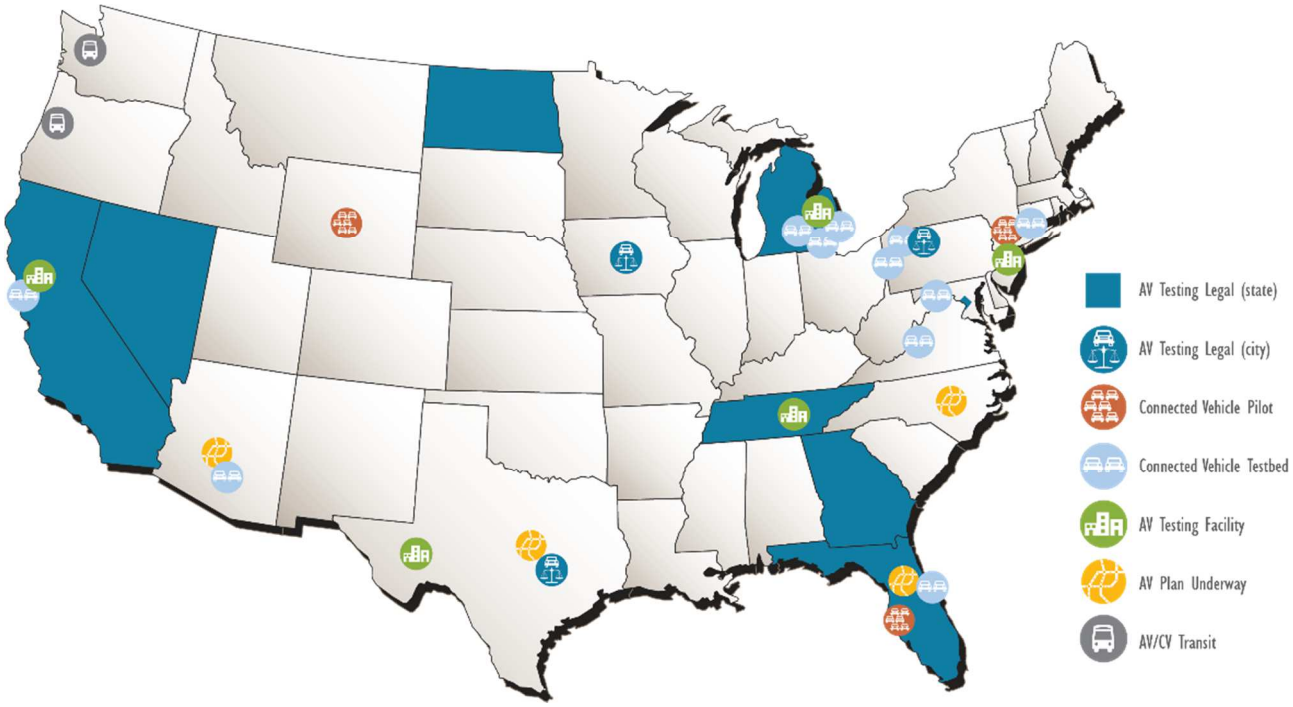

Figure 2. CAV Test Beds, Projects, and Plans Across the Country, March 2016

Table 1 provides an overview of the USDOT Federal Automated Vehicles Policy released in September 2016. The policy defines the roles and responsibilities of the National Highway Traffic Safety Administration (NHTSA), state governments, and CAV manufacturers and system suppliers. The policy also provides several proposed changes to NHTSA authority in response to the artificial-intelligence software and related sensors that provide self-driving capabilities. The full policy and fact sheets can be accessed at the following links. Table 1 identifies the differences in roles and responsibilities of the federal and state governments.

- Federal Automated Vehicles Policy - September 2016
- Automated Vehicle Policy Fact Sheet Overview

- AV Fact Sheet - Vehicle Performance Guidance
- AV Fact Sheet - Model State Policy
- AV Fact Sheet - Current Regulatory Tools
- AV Fact Sheet - Modern Regulatory Tools

Table 1. Federal and State Responsibilities for CAV Readiness

Federal Responsibilities	State Responsibilities
Setting safety standards for new motor vehicles and motor vehicle equipment, including CAV technologies	Licensing (human) drivers and registering motor vehicles in their jurisdictions
Enforcing compliance with safety standards	Enacting and enforcing traffic laws and regulations, including provisions for CAV
Investigating and managing the recall and remedy of non-compliances and safety-related motor vehicle defects on a nationwide basis	Conducting safety inspections, when states choose to do so
Communicating with and educating the public about motor vehicle safety issues	Regulating motor vehicle insurance and liability, including provisions for CAV
When necessary, issuing guidance to achieve national safety goals	

Project Overview

The NCDOT and NCDMV partnered on this project with the primary goal of determining how NC should be positioning to prepare for CAV technology. The project includes coordination with a wide range of stakeholders and education on the state of the industry and best practices related to CAV initiatives. The products of this project include:

Assessment summary of the NC Motor Vehicle and Licensing Codes

Stakeholder workshop to identify key areas of focus for the State in response to CAV technology

Activities Roadmap of suggested near- and medium-term initiatives to be considered by the State in preparation for CAV technology

The project is co-chaired by Kevin Lacy, NC State Traffic Engineer, and Kelly Thomas, NCDMV Commissioner. In addition, the leadership from Steering Committee members presented in **Table 2** represents a wide cross-section of disciplines.

Table 2. Steering Committee Members

Member	Department	Member	Department
Kevin Lacy, Co-Chair	**NCDOT**	Brian Lewis	Teamsters Union
Kelly Thomas, Co-Chair	**NCDMV**	Tim Lucas	NCRB
Jeffrey Barghout	Robocist, Inc.	Chris Lukasina	CAMPO
Ryan Boyce	NCDOT	Bob Mack	NCDOI
Mike Bruff	NCDOT	Neil Mastin	NCDOT
John Congleton	NCDMV	Joe Milazzo	RTA
Reita Coxton-Shanaghan	NCDMV	Bill Moore	SHP
Pam Guptill	NCDMV	Hope Mozingo	NCDMV
David Harkey	HSRC	Lynette Pitt	NCADA
Seth Hollar	NCSU - EcoPRT	Nagui Rouphail, Ph.D.	NCSU
Mary Jennings	NCDOT	Reggie Skinner	NCDMV
Freddy Johnson, Jr.	SHP	Warren Smith	NCDMV
Debbie Jones	NCDMV	Dan Spuller	NCDOT
Anita Keith-Foust	Advocacy	John Tallmadge	TTA
Andy Lelewski	NCTA	Kelly Wells	NCDOT

The process began with outreach to a diverse cross-section of stakeholders. Each stakeholder was invited to a day-long workshop that included an educational component about CAV and break-out sessions centered around three topics—laws and policies, infrastructure, and business. This range of input provided a holistic picture of the opportunities and impacts of CAV within NC.

Stakeholder involvement is integral to CAV readiness, and the workshop is only the first step. Moving forward, an effective cross-section of stakeholders should continue to include multiple state agencies, public agencies, the private sector, the legal and law enforcement community, and representatives of the public. The collaboration with stakeholders will require the continuous support of executive leadership from the participating entities.

Key Terminology

The vocabulary surrounding the CAV industry has evolved over the past few decades, and certain key terminology has become integral to following the advancements related to both connected and autonomous vehicles. The following list provides an overview with brief descriptions for a few of those key terms.

- **Autonomous vehicles** – automated vehicles that can perform driving functions without a driver at any time, using sensors to understand their surroundings and make informed decisions to take action(s)

- **Connected vehicles** – vehicles equipped with advanced technology for communication with other vehicles and roadside infrastructure
- **Self-driving vehicles** – vehicles that have traditional controls such as a steering wheel and braking and throttle pedals that may be used by the driver, but are capable of driving without driver assistance
- **Driverless vehicles** – vehicles that can maneuver within the transportation network without a driver and may not have any traditional controls
- **V2V** (Vehicle-to-Vehicle) – ability for vehicles to communicate wirelessly to each other
- **V2I** (Vehicle-to-Infrastructure) – ability for vehicles to communicate wirelessly to infrastructure deployed along the roadway (and vice-versa)
- **V2X** (Vehicle-to-Everything) – ability for vehicles to communicate wirelessly to any other thing, typically considering pedestrians and cyclists

Combining connected vehicle technology with automation is expected to provide even safer operation that can both warn the driver and automatically make adjustments accordingly.

State of the Industry Review

This section presents a brief review of the state of the industry, including an overview of ongoing activities for both connected and autonomous vehicles. The review includes activities led by USDOT, professional organizations, and states. This overview provides examples of effective actions each of the organizations have conducted to promote the advancement of CAV technologies.

Connected Vehicles

USDOT[1] and the Crash Avoidance Metrics Partnership (CAMP) initiated the first V2V research in December 2006 as part of the Vehicle Infrastructure Integration (VII) initiative. The underlying technology for this initiative is called DSRC (dedicated short-range communication). DSRC is a Wi-Fi technology that provides 360 degrees of coverage from the antenna, although line of sight is required for one vehicle to communicate with another or for a vehicle to communicate to a roadside unit. V2V safety warnings are expected to substantially reduce crashes for incidents involving multiple vehicles. A wide variety of V2I applications are also envisioned and have seen various levels of prototyping, development, and testing over the past 10 years.

The CV concept is broken down into two distinct parts: the roadside units and the on-board vehicle equipment (OBE). The roadside network supports the communication of information between the system through the roadside equipment (RSE) to the OBE and from the OBE back to the system (such as a traffic management center, or TMC). To prove the concept, prototypes of the RSEs, OBEs, and applications have been funded and tested by USDOT and partner agencies including Caltrans, Virginia Department of Transportation (VDOT), New York State Department of Transportation (NYSDOT), Maricopa County (AZ) Department of Transportation (MCDOT), Florida Department of Transportation (FDOT), and others. A handful of private-sector vendors and the automobile original equipment manufacturers (OEMs) also have heavily invested in prototype technology. Besides equipment, message protocols have been developed by the Society of

[1] USDOT – United States Department of Transportation

Automotive Engineers (SAE) to allow OBEs from multiple manufacturers (OEM and aftermarket providers) to interoperate and communicate with RSEs and V2I application services from multiple providers.

The USDOT continues to promote the advancement of connected vehicle technology through the facilitation of standards development, research initiatives, information sharing from test bed projects, and the sponsorship of pilot projects. Progress of each of the programs can be followed on the Joint Program Office (JPO) web site at the links provided. **Figure 3** provides a high-level overview of the JPO's CV Pilot Program Goals.

- Standards: http://www.its.dot.gov/research_archives/connected_vehicle/connected_vehicle_standards.htm
- Human Factors Research: http://www.its.dot.gov/research_archives/connected_vehicle/connected_vehicle_humanfactors.htm
- Core Systems: http://www.its.dot.gov/research_archives/connected_vehicle/connected_vehicle_coresystems.htm
- Certification: http://www.its.dot.gov/research_archives/connected_vehicle/connected_vehicle_cert.htm
- Test Beds: http://www.its.dot.gov/research_archives/testbed/testbed_affiliated.htm
- CV Pilots Deployment Projects: http://www.its.dot.gov/pilots/index.htm

Figure 3. CV Pilot Program Goals (ITS Joint Program Office)

The USDOT CV applications have been grouped into "bundles" as follows:

- V2I safety
- EnableATIS
- Integrated Network Flow Optimization (INFLO)
- FRATIS (Freight Advanced Traveler Information System)
- MMITSS (Multimodal Intelligent Traffic Signal System)
- R.E.S.C.U.M.E. (Response, Emergency Staging and Communications, Uniform Management, and Evacuation)
- Integrated Dynamic Transit Operations (IDTO)

- Applications for the environment: Real-Time Information Synthesis (AERIS) (Adds "eco" to other apps) – note that US Department of Energy has also separately funded eco-driving application research and development
- Road weather
- International border crossings
- Fee payments
- Agency data applications (probe-enabled traffic monitoring)

The CV Safety Pilot Program in Ann Arbor, MI was the focus of USDOT investment in V2V and V2I research and development over 2010-2014.[2] Initially, the Safety Pilot Model Deployment (often referred to as the Safety Pilot) was intended to inform the effectiveness estimates of V2V safety applications using DSRC to reduce crashes and to show how real-world drivers respond to these safety applications in their vehicles. The test included over 3,000 vehicles with embedded vehicle awareness devices, others with integrated safety systems, and others that use aftermarket safety devices to communicate with surrounding vehicles. Twenty-seven roadside units on both freeway and arterial locations provided a limited set of V2I applications. The Safety Pilot has concluded and generally is regarded as a successful demonstration of the viability of DSRC for V2V applications. The data collected during the Safety Pilot provided an indication of functional feasibility of the technology—whether the prototypes and the system *worked*, but not necessarily *how well they worked* to provide cumulative societal benefits. According to NHTSA in 2014, a wide variety of research questions remain to be answered before it mandates DSRC equipment in newly manufactured vehicles.[3] In particular, the security credentialing system for ensuring that V2V messaging is from a trusted source still requires significant attention.[4] The readiness report is focused primarily on V2V applications, where the V2I applications are more directly relevant to state and local agency issues. A similar report was released by the Government Accountability Office (GAO) in 2013.[5]

Since the Safety Pilot, USDOT has launched three major real-world pilot projects in Wyoming; New York City; and Tampa, FL. Among these three pilot locations, over 30 different V2V and V2I applications will be demonstrated and evaluated for real-world effectiveness in improving safety, mobility, and environmental performance metrics.[6] Other affiliate test beds are established in California, Arizona, Virginia, Michigan, Minnesota, Tennessee, and Pennsylvania. In parallel with the pilots, a V2I deployment coalition has been formed between USDOT, ITS America, AASHTO[7], and ITE[8]. Other industry associations such as APTA, SAE, OmniAir, and the Telecommunications Industry Association have active roles in connected vehicle technologies.

[2] http://safetypilot.umtri.umich.edu/index.php?content=video/
[3] http://www.dot.gov/briefing-room/us-department-transportation-issues-advance-notice-proposed-rulemaking-begin
[4] http://www.nhtsa.gov/staticfiles/rulemaking/pdf/V2V/Readiness-of-V2V-Technology-for-Application-812014.pdf
[5] www.gao.gov/assets/660/658709.pdf
[6] http://www.iteris.com/cvria/html/applications/applications.html
[7] AASHTO – American Association of State Highway and Transportation Officials
[8] ITE – Institute of Transportation Engineers

While the major focus of the USDOT CV program has been on DSRC, the USDOT has acknowledged that other communication methods such as cellular are possible (and preferred) for many applications that do not rely on very high-speed message delivery with line-of-sight access to a RSE or another OBE. Particularly in the interim period while the number of RSEs is slowly growing, mobility and environmental applications will likely be more cost-effectively deployed using communications methods other than DSRC, such as 4G and future cellular technology. Many V2I applications have already been successfully demonstrated with technologies other than DSRC, notably traffic signal priority, eco-driving, SPaT[9] broadcasts, freight route planning, performance monitoring, and smart parking. Cost effectiveness of the V2I applications likely will require a combination of both technologies to provide positive return on investment for state and local agencies.

A wide variety of important lessons will be learned and experience gained during the CV pilots (years 2015–2020). The varied levels of readiness for deployment among the application bundles listed above will be identified. Adaptation of the application bundles to varied operational environments (e.g., Linux vs. Windows computing systems) and agency organizations also will be proven. USDOT is preparing a variety of guidance documents for state and local agencies.[10] Notably, the guidance identifies the availability of federal funds from a variety of programs (CMAQ[11], NSIP[12], NHPP[13], and STP[14], among others) for deployment of CV-related systems. CV technologies are on an unquestionable rapid trajectory of growth.

Other Notable and Relevant Connected Vehicle Activities

AASHTO has been active in several activities in preparation for CV technology rollout, particularly for V2I applications. The AASHTO footprint analysis report provides some guidance on activities necessary for infrastructure deployment. The report also estimates costs for rollout across the U.S.[15] A second phase of the AASHTO footprint analysis is underway to study business models and policy actions to facilitate deployment. The NHTSA readiness report complements the AASHTO analysis for cost estimation, focusing on the vehicle side rather than infrastructure side.

A significantly important activity is the connected vehicle pooled fund study group.[16] Eleven state partners with the Federal Highway Administration (FHWA) have sponsored more than 10 projects, including the MMITSS, a suite of DSRC-based applications for transit and freight priority; a ConOps[17] for road weather monitoring with DSRC; and a report on the use of CV data in TMCs.[18] Additional projects include the development of standards for a “basic infrastructure message” and algorithms for use of high-resolution data from connected vehicles in modifying traffic signal operations.

[9] SPaT – Signal Phasing and Time
[10] http://www.its.dot.gov/meetings/pdf/V2I_DeploymentGuidanceDraftv9.pdf
[11] CMAQ – Congestion Mitigation and Air Quality
[12] NSIP – National Streamflow Information Program
[13] NHPP – National Highway Performance Program
[14] STP – Surface Transportation Program
[15] http://stsmo.transportation.org/Documents/CV%20Tech%20Memo%20FINAL_with%20CT.pdf
[16] http://www.cts.virginia.edu/cvpfs_research/
[17] ConOps – Concept of Operations
[18] http://www.cts.virginia.edu/wp-content/uploads/2014/05/Task4._Recommendations_122313_-_FINAL.pdf

Despite the recent hype generated by the Google car, AV technology has been envisioned since the early 1930s. Many experienced professionals in the transportation technology space will recall that in 1992, "intelligent transportation systems" was "intelligent vehicle-highway systems," or IVHS. The automated highway system was a major component of the U.S. IVHS Strategic Plan. In the late 1990s, Caltrans and FHWA demonstrated automated vehicle operation with connectivity to the infrastructure. The IVHS system was envisioned to remove drivers from the driver's seat and improve safety and capacity of the roadways through V2V and V2I communication. Faced with extraordinary costs for deployment and inadequate computing and sensor resources at that time, the Automated Highway System (AHS) concept was shelved for many years, receiving no appreciable research or development funding from USDOT or ancillary agencies.

As computing, machine vision, artificial intelligence, and other sensor technologies (Lidar, radar, IR, etc.) have evolved and matured over the past 20 years, automated and autonomous vehicles are now a reality. More than a decade ago, the Defense Advanced Research Programs Administration (DARPA) started a series of challenges for teams of vehicle manufacturers, universities, and sensor developers.[19] In each iteration of the challenges, a higher percentage of teams' vehicles were successful in completing the test trials, and the sensor suites grew smaller and less obvious. Experimental models from vehicle manufacturers, and even a few production models (such as the Mercedes, Tesla, and Volvo models that will drive themselves in environments that the vehicle deems are acceptable to unassisted operation), now have virtually no readily observable sensors.[20] To provide a glimpse of how this technology has progressed, **Figure 4** demonstrates how the visibility of the equipment required to provide certain levels of automation has progressed from the DARPA challenges in 1995 to the current Tesla Model S and other vehicles that are available on the market today.

Figure 4. Progression of Automated Vehicle Technology from 1995 to 2016

Essentially all OEMs have active research and development programs, and a handful of aftermarket component and system suppliers are in the research and development phase of commercial products. Like any technology, there will be an evolution where the capabilities gradually will become more powerful and able to handle more driving scenarios. Initial offerings, such as those offered by Tesla and others today, are only suitable for very simple driving situations, such as good weather and on stretches of open highway with excellent lane markings, or in extremely congested freeway conditions where speeds are low and lane changing is not necessary.

[19] http://archive.darpa.mil/grandchallenge/
[20] http://www.motoroids.com/news/mercedes-highway-pilot-autonomous-drive-technology-long-distance-trucks/

Recent press and awareness through the recognition and publicity of the Google car motivated the TRB symposium on automated driving in 2012, which has quadrupled in attendance over the last three years.[21] In July 2016, the symposium eclipsed 1,000 attendees. A product of the symposium was the development of the CV/AV research roadmap by NCHRP[22] (project 20-24 (98))[23] to specifically address issues of AV operation relevant to state and local governments. Projects on the roadmap are researched under NCHRP 20-102.[24] Notable issues include the integration of AV systems into long-range plans; design of road markings; impacts on regulations on adoption of AV technologies in transit and freight; harmonization of state laws; and a host of additional topics.

Levels of Automation

The Society of Automotive Engineers (SAE) (**Figure 5[25]**) has defined five levels with slightly more nuanced differences between Levels 2 and 3.[26] NHTSA also has adopted the SAE five levels, as noted in the most current federal policy released in September 2016.[27] Most modern vehicles have some capabilities at Level 1, such as Electronic Stability Control. Level 2 describes vehicles like the Tesla, available today, that allows the autopilot function, but also requires constant vigilance and situational awareness from the driver to take back control when prompted. Level 2 vehicles have no concept of driving along a specified route to a destination.

At Level 3, vehicles can drive from one location to another location with significantly longer warning time (e.g., 20-30 seconds) to alert the driver to resume control of the vehicle. An example trip would be from one freeway on-ramp to a designated freeway off-ramp.

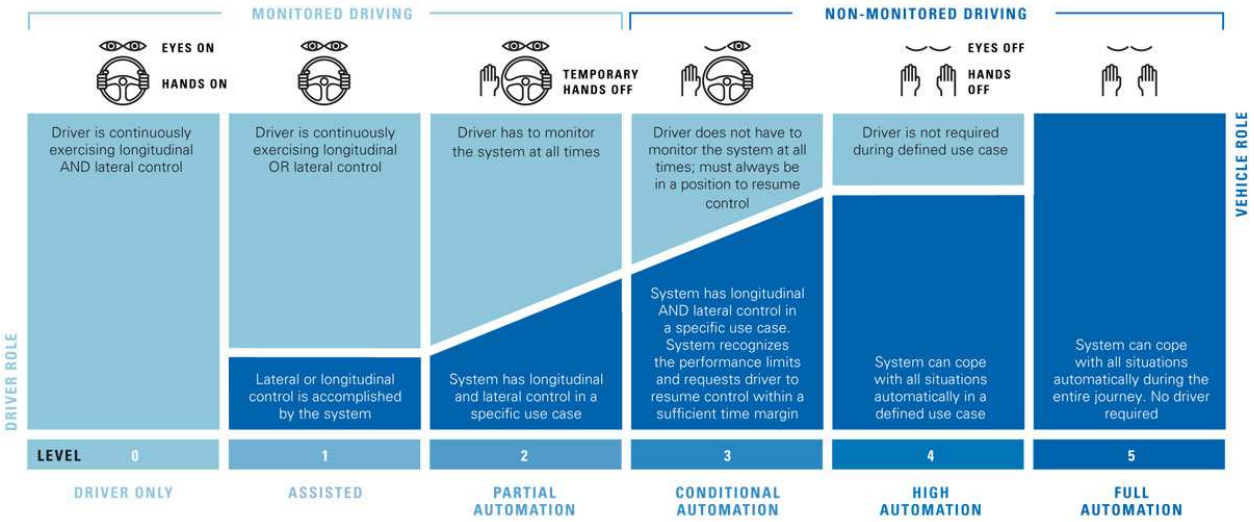

Figure 5. SAE Levels of Automation

[21] http://www.vehicleautomation.org/
[22] NCHRP – National Cooperative Highway Research Program
[23] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3752
[24] http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3824
[25] http://safety.trw.com/wp-content/uploads/2016/01/AutomatedDriving_table_large.jpg
[26] http://standards.sae.org/j3016_201401/
[27] http://www.nhtsa.gov/nhtsa/av/av-policy.html

When operating at Level 4, the vehicle could traverse a traffic network from essentially any origin to any destination that is in its "AV-ready" database and operate without a driver. At Level 5, a vehicle can operate in any driving situation, including in areas that have not been "pre-approved" for automated operation. There is no known vehicle that can provide Level 5 capability today, and despite the well-intentioned and feverish developments of thousands of engineers, scientists, and software developers, such operations are still many years away. Level 4 automation likely will be first available in certain zones where vehicle developers (or vehicle developers in conjunction with infrastructure operators) have sufficiently mapped the available routes and traffic situations to feel comfortable in offering such services for public use.

Most automated vehicles today are being developed to drive themselves by sensing their surroundings. In the original AHS concepts, vehicles relied on lane-keeping with assistance from in-ground magnetic markers. Some current PRT-type systems still use the markers for path following (or at least calibration of path keeping). Most prototypes today must have a highly accurate (in many cases, three-dimensional) map of the route(s) that is pre-loaded on the vehicle. As the vehicle drives the route, active sensors detect changes to the background environment and track fixed and mobile objects (other vehicles, pedestrians, bicycles, falling rocks, etc.). Artificial intelligence software then processes these sensor inputs and adjusts the steering, throttle, and brake to avoid collisions while remaining on the intended path heading toward a destination.

In connected vehicle safety applications, the V2V and V2I communications augment sensor inputs (the same or similar sensors observable by the artificial intelligence) to warn a driver of an impending collision. The human is then tasked with collision avoidance. In an autonomous vehicle, the human is replaced with an artificial intelligence software suite. At least for the foreseeable future, artificial intelligence systems will continue to be no smarter than their programmers and programming techniques to embed logical responses to generic situations using inference rules. Eventually, combining connected and automation technologies will provide even better safety and mobility benefits.

In parallel with the development of automation technology for passenger vehicles for general sale to the public, automation technology typically applied in guideway transit systems is being reimagined for use in mixed-flow facilities. Vehicle developers include Navya, Robosoft, 2GetThere, LocalMotors, and others. These vehicles typically have embedded sensors and no steering wheel.[28] Low-speed transit vehicle operations in mixed environments with pedestrians, cyclists, and regular cars are now possible with limited risk exposure since speeds are rather low. A major contributor to this finding is the CityMobil2 program, where low-speed transit vehicles have been tested in over 12 different countries and operational environments.[29] These

Figure 6. Example of Automated Transit Buses (CityMobil2.eu)

[28] http://en.wikipedia.org/wiki/Navia_(vehicle)
[29] http://www.citymobil2.eu/en/About-CityMobil2/Overview/

vehicles operate at Level 4, but with an extremely limited network of available routes. Most current deployments and pilots have only one linear route.

State and Local Government Activities

Automated vehicle *testing* is now legal in seven states and several cities, and many others have introduced legislation.[30] Testing in most locations still means that someone must be riding in the driver's seat and ready to take over at any time, even if the vehicle is operating at Level 4. Recently, Michigan has extended its investment in the Safety Pilot test bed to include automated vehicles at the University of Michigan Mobility Transformation Center (MTC) MCity.[31] Florida, California, and Texas have announced plans for AV test facilities and pilot projects.[32] Florida has now hosted several automated vehicle summits,[33] in addition to summits hosted by the I-95 Corridor Coalition and other states including Virginia and Texas. As of September 2016, Florida allows Level 4 automated vehicle *operation*.

A significant number of issues need to be addressed before testing becomes legal operation for anyone and production vehicles no longer have steering wheels. The American Association of Motor Vehicle Administration (AAMVA) is working with NHTSA and NCHRP to circumvent the need for the remaining 40+ states to develop their own variants of AV technology law and policy in motor vehicle statutes.[34] In September 2016, USDOT released its Federal Automated Vehicles Policy for testing and deployment of AVs.[35] Some of the largest barriers to Level 4-5 operation likely will be product liability and the influence of the insurance industry. In June 2016, a UK insurer released the first insurance policy to specifically identify automation functionality as an insured feature.[36]

The role of state and local governments as stewards of the nation's transportation facilities will be impacted by issues including parking, road width, urban form, and public transit. The recent RAND report on autonomous vehicles discusses some of the policy issues at a high level.[37] NHTSA has released a report detailing their current activities and intent to remain engaged in the development of testing and certification standards for automation systems.[38] Cybersecurity is a key challenge, since robotic unmanned vehicles offer new avenues for terrorism or mischief.[39] Privacy also is a critical issue relative to DOT policies.[40]

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[30] http://www.usatoday.com/story/news/nation/2013/07/29/states-driverless-cars/2595613/
[31] http://www.mtc.umich.edu/test-facility
[32] http://gomentumstation.net/
[33] http://www.automatedfl.com/
[34] http://www.aamva.org/Autonomous-Vehicle-Best-Practices-Working-Group/
[35] http://www.nhtsa.gov/nhtsa/av/index.html
[36] https://www.theguardian.com/business/2016/jun/07/uk-driverless-car-insurance-policy-adrian-flux
[37] http://www.rand.org/pubs/research_reports/RR443-1.html
[38] www.nhtsa.gov/staticfiles/rulemaking/pdf/Automated_Vehicles_Policy.pdf
[39] http://connectedvehicle.itsa.wikispaces.net/file/view/Connected+Vehicle+Assessment+Cybersecurity+ITSA+FINAL+PUBLICATION2+Jan12014.pdf/500136998/Connected%20Vehicle%20Assessment%20Cybersecurity%20ITSA%20FINAL%20PUBLICATION2%20Jan12014.pdf
[40] http://connectedvehicle.itsa.wikispaces.net/file/view/Connected+Vehicle+Assessment+Cybersecurity+ITSA+FINAL+PUBLICATION2+Jan12014.pdf/500136998/Connected%20Vehicle%20Assessment%20Cybersecurity%20ITSA%20FINAL%20PUBLICATION2%20Jan12014.pdf

Japan ($40M+), the European Union ($150M+), and China (+27M)[41] have launched significant research programs in automation research.[42] Starting next year, the City of Gothenburg, Sweden is planning a major test with Volvo of over 100 Level 3 vehicles.[43] The UK is focusing on testing low-speed shuttles in Greenwich, UK.[44] France, Germany, the Province of Ontario, CA, the Emirate of Dubai, China, India, Australia, Singapore, and a host of other countries have launched initiatives.[45] Automated vehicles are a worldwide phenomenon with a potential market in the trillions of dollars. The paradigm shift to AV is anticipated to have sweeping impacts on quality of life due to potential behavioral transformations to everyday life.

Current Initiatives

A handful of states are ahead of NC in developing AV programs. A lengthy, detailed (yet continuously updated) summary of legislation across the U.S. can be found on Stanford's Cyberlaw webpage.[46]

While there are many states and localities with existing legislation and activities, the best examples to follow to date are Michigan and Florida. As the center of the automotive industry in the United States, Michigan has invested heavily in technology activities to retain their position. According to Michigan representatives in 2015, they have invested or plan to invest over $100M in AV-related activities in the next few years. With strong support from the legislature and the governor, Michigan has established AV test facilities at the University of Michigan MCity, hosted the USDOT Safety Pilot, and established several additional CV-related test beds and an array of MDOT initiatives to develop apps, data feeds, and prototype systems to harness the data from CVs for Transportation Systems Management and Operations (TSM&O).

Michigan has six bills currently under consideration by the legislature as of June 2016 (SB 927, 928, 995, 996, 997, and 998). These bills revise earlier statutes on allowance of AV testing to extend the legal ability of manufacturers to operate AV systems without drivers (notionally called a "SAVE project") and allow riders in AV vehicles (such as consumers of taxi services) to perform normally prohibited actions such as talking on cellular phones and texting. The bills prohibit state or local governments from levying any taxes against SAVE project developers until at least 2022. The bills allow truck platooning and have a variety of liability protections for vehicle manufacturers for AV systems installed, developed, or revised by others. The bills enact penalties including life imprisonment for AV or CV hacking. Bill 995 establishes a *Michigan Council on Future Mobility* to be created within the state transportation department to be the advisory body to the governor, legislature, and other stakeholders. The Council will comprise 11 appointed persons to include representatives from business, policy, research, and technology; one appointed person from insurance; two

[41] http://thinkinghighways.com/chinese-firm-gives-um-27m-for-autonomous-car-research/
[42] http://www.ertrac.org/uploads/documentsearch/id38/ERTRAC_Automated-Driving-2015.pdf
[43] http://international.goteborg.se/smart-cities-and-sustainable-solutions/driveme-self-driving-cars-sustainable-mobility
[44] http://www.digitalgreenwich.com/driverless-cars/
[45] http://www.ertrac.org/uploads/documentsearch/id38/ERTRAC_Automated-Driving-2015.pdf
[46] http://cyberlaw.stanford.edu/wiki/index.php/Automated_Driving:_Legislative_and_Regulatory_Action

state senators (non-voting); two state representatives (non-voting); the secretary of state; the director of the MDOT; the director of the state police; and a governor's representative.[47]

Florida began its AV preparatory actions in 2013 and had enacted legislation allowing AV testing in 2012. The State DOT, led by the Department of Planning and Traffic Statistics, began planning activities by establishing three working groups—Modal Applications, Infrastructure, and Policy. The three groups have a wide range of representation of almost all departments of State government, consumer and special interest advocacy groups, insurance, law enforcement, and all facets of transportation, including sea and space ports as well as transit. The three working groups published white papers in 2015.[48]

The white papers address a range of recommendations across the three focus areas. The program was funded initially with less than $1M and is now a $5M program of continuing activities to develop research projects on AV policy and future transportation system impacts, deployment of pilots testing CV-enabled freight, ADAS systems for State DOT fleet vehicles, and legislative changes. There are no pending bills in the Florida system, but the enacted legislation is quite comprehensive and allows a variety of AV-related testing and operation similar to the bills introduced in 2016 by Michigan, including the allowance of AV operation without a driver in the driver's seat, the requirement to include consideration of AV technology in long-range transportation plans, and the permission of driver-assisted truck platooning (notably repealing laws against manual truck following at "less than safe" distances). The Florida legislation on AV is embedded within larger changes to other transportation-related issues. A good summary of their AV legal actions can be found on the House of Representatives Final Bill Analysis[49].

The Florida program (like Michigan and other lead states) has been active in outreach and education, both within and outside of the state. The Florida program set up exhibit booths in 2013-2015 at popular engineering and technical conferences both to promote Florida as a willing partner in technology introduction and to learn and stay current with technology advances worldwide.

Laws and Regulations

The legal impacts related to CAV technology are expected to require changes across laws and regulations, tort liability, insurance requirements, and enforcement. The statute review conducted for this project highlighted those elements that will require further analysis and provide the foundation for where the stakeholders should focus. As additional research and discussions are conducted, it is important to address the impacts on each of these areas.

Changes and revisions to the Motor Vehicle Code (MVC) will drive the impacts related to tort liability, insurance requirements, and enforcement. It is critical that these changes are diligent to protect the safety of the public while maintaining a certain level of flexibility that allows innovation and business growth for NC. Safety should remain paramount in these discussions.

The review of General Statutes Chapter 20 (Motor Vehicles) and Chapter 58 (Insurance) is provided in the Appendix. The summary tables include the page number within each chapter, the article and section number,

[47] https://www.legislature.mi.gov/documents/2015-2016/billanalysis/Senate/htm/2015-SFA-0995-S.htm
[48] http://www.automatedfl.com/our-efforts/stakeholder-working-groups/
[49] https://www.flsenate.gov/Session/Bill/2016/7027/Analyses/h7027z1.TPS.PDF

the section title, the levels of automation that could affect the identified statute, and the suggested focus of the discussion. Proposed revisions to the wording or changes to the code are not provided; instead, recommendations are presented to guide the relevant working group with a starting point for analysis. Where feasible, additional discussion questions are provided to aid the facilitator.

Moving forward, NC should integrate lessons learned from other states. Examples of successful and failed legislation are maintained and easily accessible for reference on the National Conference of State Legislation (NCSL) web site (http://www.ncsl.org/research/transportation/autonomous-vehicles-legislation.aspx). In addition, AAMVA, NHTSA, and AASHTO (through the 20-102 research plan) have active efforts to track these developments and guide further advancements of model policy and legislation. NC should combine the review provided with these ongoing efforts to promote the most successful revisions to the MVC.

Comments provided focus on elements of the statutes that may require revisions to permit the advancement of CAV technologies within NC. Some definitions may require an iterative review as the technology progresses through certain levels of automation.

The list below summarizes the topic areas that were identified for assessment within Chapter 20.

- Driver's license designation and issuances
- Registration and titles
- Vehicle attributes (steering wheel, windshield, brakes, etc.)
- Safety standards
- Vehicle operations
- Enforcement
- Tort liability

The list below summarizes the topic areas that were identified for assessment within Chapter 58.

- Issuance of insurance
- NC Rate Bureau
- Insurance rates
- Moving traffic violations
- Specific definitions within the code

As vehicles with higher levels of automation are introduced, the decision relating to tort liability—where one person causes damage, injury, or harm to another person—will continue to remain a focus. In addition, tort liability will be closely related to the definition of the driver or the system that is responsible for the operation of the vehicle.

Along with the introduction of CAV technologies, certain forecasts are predicting an increase in shared ownership of vehicles. Whether travelers maintain single or shared ownership, insurance requirements will likely need modifications to respond to this cultural shift. Also, as technology improves and automated vehicles may allow the transport of disabled or younger riders, current insurance requirements will require changes to allow the operation of vehicles without a licensed driver.

Lastly, changes in each of the three areas above will place additional requirements on the enforcement community. As more levels of automation are introduced, the mix of vehicles operating within the fleet of passenger, transit, and commercial vehicles will increase the complexity of enforcement. Changing laws, regulations, tort, and insurance requirements also will require continuous training for enforcement personnel to stay informed of the most current policies. Clear delineation of insurance requirements and fault also are critical to the safety and enforcement of automated vehicle operations. Representation from enforcement agencies must be included in the discussions around these potential and adopted changes.

Activities Roadmap Development Process

The development of the Activities Roadmap included a three-pronged approach of information gathering and stakeholder involvement. This effort was guided by the Steering Committee and involved stakeholders representing a broad range of agencies. The initial Steering Committee meeting established a foundational list of high-priority issues the State should be discussing. In addition, the committee recommended stakeholders that should be invited to participate in the activities roadmap development.

1. National and International CAV Activities Documentation

A high-level overview of the state of the industry and current initiatives from across the country and internationally were provided to the Steering Committee and stakeholders. A summary of this overview is presented in the State of the Industry Review section.

2. Analysis of General Statutes Chapter 20 (Motor Vehicles) and Chapter 58 (Insurance)

The project team performed an in-depth review of the General Statutes Chapter 20 (Motor Vehicles) and Chapter 58 (Insurance) to identify areas that should receive additional scrutiny with respect to CAV technology. A more in-depth documentation of the review is provided in the Appendix. An overview of the assessment is presented in the Laws and Regulations section.

3. Cross-Cutting Stakeholder Workshop

The CAV workshop was conducted in February 2016 in Raleigh, NC. During the full-day workshop, stakeholders discussed high-priority issues and actions for the State focusing on three major goals:

1. Identify opportunities and challenges for NC to benefit from CAV technology
2. Establish high-priority focus areas for the State
3. Establish a forum for information sharing across stakeholder organizations and State agencies

Figure 7. Stakeholder Workshop

The participants self-selected into one of three focus groups:

- **Laws and Policies**
- **Infrastructure**
- **Business**

Each of the three groups discussed the following common subtopics:

1. Opportunities
2. Challenges
3. Actions
4. Desired outcomes
5. Unintended consequences
6. Who will be affected and how
7. Partners
8. Existing efforts and resources

The feedback from the workshop was summarized into initiatives and activities that will serve as the foundation for the activities roadmap and guide the State in moving forward. It is expected that this first iteration of the activities roadmap will expand into additional steps and sub-activities as the working groups begin to dive into the initial actions, as new stakeholders and partners are integrated, and as funding and other resources are identified. An in-depth summary of the workshop input is provided in the Appendix.

Table 3 presents agencies and corresponding representatives that participated in the workshop.

Table 3. Workshop Attendees by Agency

State Agencies	Local Agencies	Businesses	Other
Gov Highway Safety *Don Nail* **NC Advocate for Justice** *Lynette Pitt* **NC Chamber** *Jake Cashion* **NCDOI** *Bob Mack* **NCDOT** *Mike Bruff* *Alex Hollbrook* *Kevin Lacy* *Helen Landi* *Kelly Wells* *Brian Wert* **NCDMV** *John Congleton* *Debbie Jones* *Hope Mozingo* *Robert Sawyer* *Fred Schmidt* *Jim Semmens* *Warren Smith* *Eddwin Surita* *Kelly Thomas* *Dan Whittacre*	**Charlotte DOT** *Charles Abel* *Scott Putnam* *Debbie Smith* **City of Durham** *Jaqueline Wagstaff* **GoTriangle** *John Tallmadge*	**Goldberg Segalla** *Brady Yntema* **Pinto Coats Kyre & Bowers, PLLC** *Deb Bowers* **Regional Transportation Alliance** *Michael Haley* *Joe Milazzo* **Robocist** *Jeff Barghout* **SAS** *Eric Hunley*	**Advocate for the Blind and Visually Impaired** *Anita Keith-Foust* **NCSU EcoPRT** *Marshall Brain* *Seth Hollar* **UNC Charlotte** *Edd Hauser* **UNC Highway Safety Research Center (HSRC)** *David Harkey* *Stephanie Harrell*

State Agencies	Local Agencies	Businesses	Other
NC Rate Bureau *Keri Johnson* *Tim Lucas* *Karen Ott* **NC State Highway Patrol** *Major Joseph Cotton* *Bill Moore*			

Workshop attendees identified additional stakeholder agencies and potential participants to be included in the advancement of the activities roadmap. Those agencies and contacts are shown **Table 4.**

Table 4. Additional Potential Project Participants

State Agencies	Local Agencies	Businesses	Other
NC Advocate for Justice *Todd Barlow* *Mike Pross* *D. Hardison Wood* **NCDOT** *Debbie Collins* *Burt Tasiaco* **NCDMV** *Ryan Boyce* *Reggie Skinner* *Steve Watkins* **NC Office of the Governor** *Ryan Minto* **NC State Highway Patrol** *Freddie Johnson, Jr.* **NC Turnpike Authority** *Andy Lelewski* *Dan Spuller*	**Charlotte Area Transit** *John Lewis*	**Daimler** *Thomas Buss* **MGC Law** *Jessica Tyndall* **NC Association for Defense Attorneys** *Chris Denton* **Regional Transportation Alliance** *Natalie Griffith*	**Tesla Automotive** *Randy Haywood*

The initial stakeholder workshop indicated there is significant interest to invest in a proactive approach to moving the State forward with respect to CAV technology. With careful planning, active stakeholder engagement, and focused education efforts to key constituents, NC can be poised to leverage CAV technologies to benefit a broad range of objectives, including both safety and mobility for the users and business development that supports job and economic growth in the state.

Initiatives

The input garnered from the stakeholders was distilled into an Activities Roadmap centered around seven key ***initiatives*** for CAV readiness.

A. Group Structure and Organization
B. Political Leadership Engagement
C. Changes to Laws and Motor Vehicle Codes
D. Long-Range Transportation Plans
E. Mobility and Access Improvements
F. Pilot Projects and Research
G. Outreach/In-Reach Strategy

Within each initiative, one or more focused ***activities*** were identified. The activities include more specific tasks with measurable deliverables or outcomes that support advancement of the initiative. The outcomes include administrative actions, revisions to general statues, facilitation of workshops or outreach events, and focused recommendation reports.

Each activity is presented in the following section with a brief description and additional details regarding the working group(s) involved, an assigned owner, a rough-order-of-magnitude (ROM) schedule, and a ROM budget. Where appropriate, dependencies with other activities or stakeholders are identified, whether it is within the same initiative or across initiatives. Additionally, a summary of these initiatives and activities is presented in **Table 6**.

The successful execution of this Activities Roadmap depends primarily on the first two activities: ***the development of an Executive Leadership Team (ELT) and CAV Program Manager to champion the program and the identified activities.***

The establishment of ***working groups*** is critical to the success of the CAV Activities Roadmap. These working groups will coordinate closely with each other, the ELT, and CAV Program Manager (see Activity A-1) to accomplish the goals identified with the activities roadmap. The roles of the working groups are:

- To take ownership of activities as identified within each initiative
- To coordinate with the CAV program manager and the ELT on activity progress
- To coordinate with other working groups on activities with overlap
- To maintain a knowledge base of the CAV Activities Roadmap through membership and leadership transitions

The three proposed working groups are described in **Table 5.**

Table 5. Overview of Working Groups

Working Group	Primary Responsibility
Laws and Policies	Identify possible changes or additions to the laws, regulations, and policies
Infrastructure	Reevaluate the planning and design of transportation facilities and systems (e.g., vehicle fleets, pavement markings, signing, etc.)
Business	Facilitate partnerships and technology development with third parties from the private sector and universities

Table 6. Activities Roadmap

	Working Group	Activity Owner	Schedule	Budget
A. Group Structure and Organization				
A-1: Develop CAV Oversight Structure		NCDOT	< 1 month	Internal
A-2: Identify CAV Program Manager		ELT	< 2 months	Internal
A-3: Develop Business Plan		ELT, CAV PM	< 4 months	Internal
B. Political Leadership Engagement				
B-1: Present Activities Roadmap to Leadership (including political groups)		CAV PM	3 months from Activities Roadmap approval	Internal
B-2: Present Findings and Updates to Leadership (including political groups)		CAV PM	Biannually	Internal
B-3: Present Findings and Updates to Major Business and Industry Associations		CAV PM	Biannually	Internal
C. Changes to Laws and Motor Vehicle Code				
C-1: Modifications to Laws and MVC for AV Testing		NCDMV	1 year	Internal
C-2: Modifications to Laws and MVC for AV Operations		NCDMV	2 years	Internal
C-3: Engage AAMVA/NHTSA AV Model Policy Group		NCDMV	1 year	Internal
C-4: Conduct an Insurance Expo Workshop		NCDOI	< 6 months	$50K
C-5: Define Advanced Driver Education Programs		NCDMV	1 year	Internal
D. Long-Range Transportation Plans				
D-1: Monitor and Participate in LRTP Research		NCDOT TPB	1 year	$100K
D-2: Review and Revise NCDOT 2040 Plan		NCDOT TPB	< 6 months	$100K (review); $300K (revision)
D-3: Develop Guidance for MPOs' 2040 Plans		NCDOT TPB	< 6 months after NCDOT 2040 Plan	$200K

	Working Group	Activity Owner	Schedule	Budget
E. Mobility and Access Improvements				
E-1: Modify Laws and Regulations regarding Holistic Transportation Services		NCDOT with NCHHS	2 years after AV testing legislation	Internal effort
E-2: Conduct Workshop Focused on Opportunities for Disabled Traveler Services		Disadvantaged Sub-Committee Chair	< 1 year	$50K
E-3: Develop Partnerships with Department of VA, Hospitals, Advocacy Groups, and Transit/Paratransit Operators for Funding		Disadvantaged Sub-Committee Chair	< 6 months (sub-committee); < 1 year (grants apps)	$100K ($10K per grant app)
F. Pilot Projects and Research				
F-1: Conduct Workshop on Potential Opportunities		CAV PM	< 6 months	$25K
F-2: Join CV Pooled Fund Study		CAV PM	< 6 months	$50K per year
F-3: Develop Statewide Consortium for CAV Research		CAV PM, Business Working Group Chair	TBD (> 1 year)	TBD
F-4: Engage NASCAR		CAV PM	TBD (> 2 years)	$15M+
G. Outreach/In-Reach Strategy				
G-1: Develop an Outreach/In-Reach Strategy		CAV PM	< 6 months from start of regulatory actions	$100K
G-2: Conduct Webinars for Activities Roadmap Intro		CAV PM	< 6 months from initiation	$25K
G-3: NCAV.org for the Public		CAV PM	< 6 months from initiation	$25K
G-4: NCAV.org Content Expansion		CAV PM	< 6 months from initiation	$50K
G-5: Participation in National Organizations and Conferences		CAV PM	Ongoing	$15K
G-6: Highlight the Ability of Toll Roads to Leverage CV Technology		CAV PM	Within 1 year	Internal effort

A. Group Structure and Organization

This initiative is foundational to the activities roadmap. The quantity and range of questions and opportunities identified are far too many to be addressed by a single person or single agency. It is recommended that NC establish an organizational structure that includes an oversight committee supported by working groups and sub-committees that can take ownership of individual activities. This defined organizational structure will provide consistency for ownership, communication, and accountability for progress against the defined activities roadmap objectives.

	Activity
***Activity owner**: Steering Committee, to establish the ELT* ***Goal:** CAV Oversight Structure in place* ***Schedule**: Within 1 month, starting immediately* ***Budget**: Internal effort, ~1 person-year*	A-1: Develop a CAV Oversight Structure Establish an organizational structure as presented in **Figure 7** and **Figure 8**. A top-down leadership model is proposed with oversight from an executive leadership team (ELT) and a CAV program manager. The details related to the management and the composition of the ELT should be defined by the agencies represented. Since CAV technology affects more facets than just transportation, the committee should include members from all facets of State and local government, plus representation from other groups such as business and trade organizations, special interest groups, and advocacy groups. The proposed structure supports the distribution of responsibilities to those stakeholders who are best to undertake each initiative or activity. The CAV program manager is strongly recommended to lead and facilitate the different working groups and coordination with the ELT. The establishment of ***working groups*** is a critical first step to the success of the CAV Activities Roadmap. These working groups will coordinate closely with each other, the ELT, and the CAV Program Manager to accomplish the targets identified with the activities roadmap. the recommended working groups to be established are legal, infrastructure, and business. Each working group should include representation from a variety of agencies, such as NCDOT, commerce, the governor's office, universities, and other agencies. The resources and effort required can easily grow, and distribution of workload using contracted support staff to minimize overload and burnout of working group members should be considered.

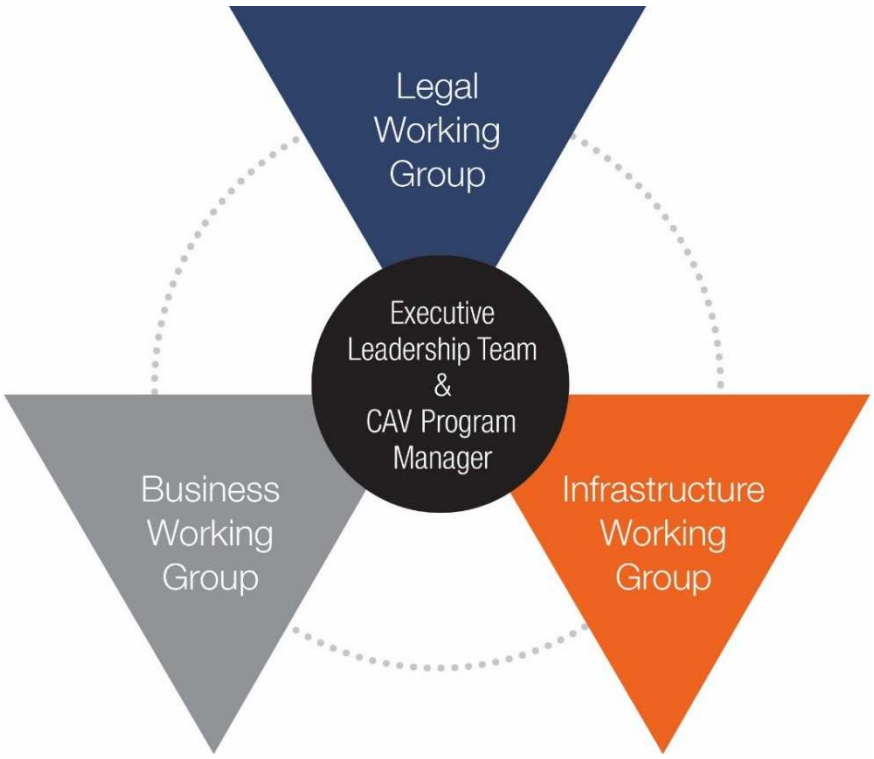

Figure 8. Recommended CAV Oversight Structure

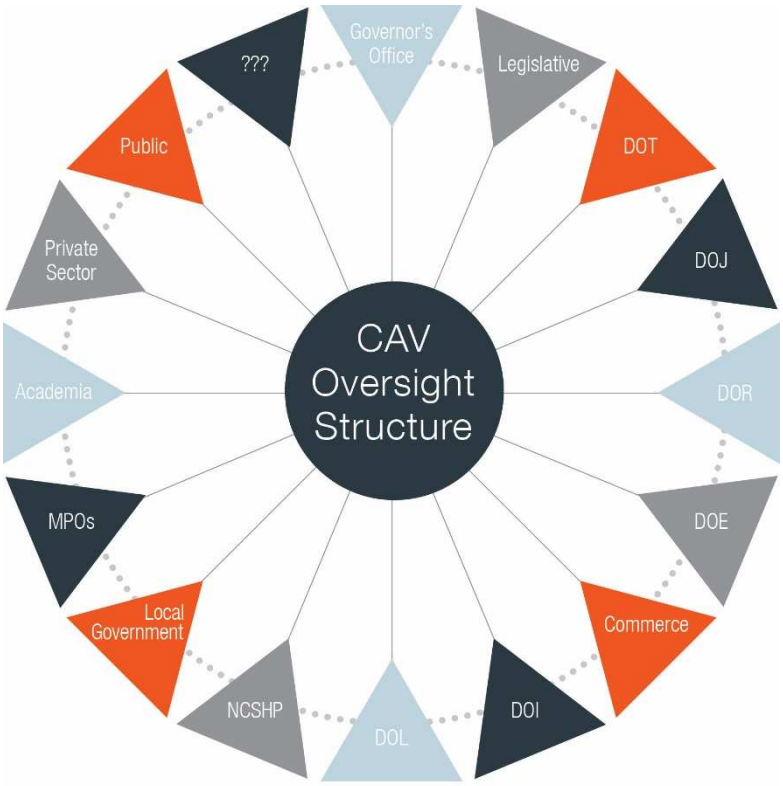

Figure 9. NC CAV Representation and Coordination

	Activity
***Activity owner**: ELT* ***Goal:** CAV Program Manager in place* ***Schedule**: Within 2 months, starting immediately* ***Budget**: Internal effort, ~1 person-year*	A-2: Identify a CAV Program Manager The identification of a CAV Program Manager is recommended to serve as the "ringleader" to provide continuous focus and energy on the initiatives and activities. This role would coordinate with the ELT and working groups. This person should have a passion for CAV technologies and the benefits of NC's role within the growth of this technology. They should become a spokesperson and champion for all the initiatives on this activities roadmap, represent the State in conferences and the media, and be a leader in the organization and structure of future workshops. The CAV Program Manager should have the authority to manage resources related to CAV, including a defined budget and contracts or agreements with developers, vendors, or consultants to advance the interests of the State. *Virginia, Florida, Michigan, and Nevada DOTs have designated program managers for their defined CAV programs.*
***Activity owner**: ELT and CAV Program Manager* ***Goal:** Establish a business plan* ***Schedule**: Within 4 months* ***Budget**: Internal effort, ~1 person-year* ***Other stakeholders**: Committee working groups*	A-3: Develop a Business Plan Once the CAV Oversight Structure has been established, it is recommended that the group derive a business plan based on the foundation of this activities roadmap. The business plan should describe the what, the who, the how, and the when for the objectives of NC's CAV program. This plan will define the platform for the CAV Oversight Structure and the CAV program. It should provide prioritized goals, the expected outcomes, and performance measures that allow the stakeholders to monitor progress and effectively report that progress to the executive management of the invested agencies.

B. Political Leadership Engagement

There is significant interest at the legislative level in NC to advance these efforts. Political support is necessary to garner the resources to oversee and implement a new program. In addition, the CAV Program Manager will need to coordinate closely with the political leadership regarding any recommended modifications to the laws and regulations in the Motor Vehicle Code (MVC) Chapters 20 and 58.

	Activity
	B-1: Present Activities Roadmap to Leadership (including political groups)
***Activity owner**: CAV Program Manager* ***Goal:** Educate political groups* ***Schedule**: 3 months from activities roadmap approval* ***Budget**: Internal effort, ~2 person-months* ***Other stakeholders**: ELT*	It will be important to establish buy-in and support from the appropriate political groups. This will involve education and outreach on the direction and progress of the CAV program. The NCDOT and NCDMV should present their initial findings, proposed group structure, and business plan to the Board of Transportation, League of Municipalities, Governor's Office, and other State leaders to gain momentum and support for key elements within the Activities Roadmap.
	B-2: Present Findings and Updates on Activities to the Appropriate Political Groups
***Activity owner**: CAV Program Manager* ***Goal:** Progress updates to political groups* ***Schedule**: Biannual updates to the Board and related groups* ***Budget**: Internal effort, ~2 person-months* ***Other stakeholders**: ELT*	The CAV Program Manager will need to maintain ongoing communication with the identified political groups. This could involve recurring status reports and updates when key milestones are achieved.
	B-3: Present Findings and Updates on Activities to Major Business and Industry Associations
***Activity owner**: CAV Program Manager* ***Goal:** Progress updates to business and industry* ***Schedule**: Biannual updates to the major business and industry associations* ***Budget**: Internal effort, ~2 person-months* ***Other stakeholders**: ELT*	After launching the program and gaining political support, obtaining collaboration with major businesses and industries in NC is an important step. Associations could include the NC Chamber, the NC Technology Association, Regional Transportation Alliance (RTA), and others. As demonstrated by the City of Columbus in their recent Smart City Challenge success, private industry will collaborate with state and local governments with funding contributions when they see direct benefits.

C. Changes to Laws and Motor Vehicle Codes

It will be critical to begin this initiative as soon as possible. Changes to certain laws and regulations in the MVC Chapters 20 and 58 may be necessary to permit AV testing in the State of North Carolina. The initial review of the MVC is attached as an appendix to this report and identifies a wide range of areas that should be further evaluated. Example revisions of the MVC include certain definitions, licensing rules, registration rules, insurance requirements, and liability assignments.

	Activity
***Activity owner**: NCDMV, needs a defined champion* ***Goal:** Revise laws to allow AV testing* ***Schedule**: 1 year starting immediately* ***Budget**: Internal effort, ~1 person-year*	C-1: Modify Laws and Motor Vehicle Codes for AV Testing NC must assess the MVC review provided to identify laws that will need modification to permit private and public agencies to pursue testing of AV on publicly maintained roadways. One consideration includes whether the laws will require a human inside the vehicle. Early versions of legislation introduced in some states tended to contain strong language requiring the presence of a capable operator to be on board at all times. Newer rules and regulations are aiming to be less restrictive in response to the advancements of technology development within the vehicle.
***Activity owner**: NCDMV, same champion as for AV testing rules activity* ***Goal:** Revise laws to allow AV operations* ***Schedule**: 2 years starting immediately, concurrent with AV testing rules* ***Budget**: Internal effort, ~1 person-year*	C-2: Modify Laws and Motor Vehicle Codes for AV Operations The next decision for NC is to determine recommendations for revisions to existing laws to permit private and public agencies and individuals to *operate* AVs on publicly maintained roadways. This analysis should consider vehicle operations related to both revenue service and personal use. These provisionary laws and regulations may be attractive in nature (i.e., to bring business to the state, such as tax rebates or credits, insurance premium reductions, or other cost-sharing measures). Working groups involved in this activity should reference the recently released Federal Automated Vehicle Policy (www.transportation.gov/av) and any future updates to that policy.

Activity	
 ***Activity owner**: NCDMV, same champion as for AV operation rules activity* ***Goal:** Participation with AAMVA/NHTSA* ***Schedule**: 1 year starting immediately* ***Budget**: Internal effort, ~1 person-year* ***Other stakeholders**: Governor's Office of Legislative and Fiscal Research*	**C-3: Engage with AAMVA/NHTSA AV Model Policy Group** NC should integrate lessons learned from other states. Examples of successful and failed legislation are easily accessible for reference on the National Conference of State Legislation (NCSL) web site (http://www.ncsl.org/research/transportation/autonomous-vehicles-legislation.aspx). In addition, AAMVA, NHTSA, and AASHTO (through the 20-102 research plan) have active efforts to track these developments and guide further advancements of model policy and legislation. NC should engage AAMVA/NHTSA and participate fully in the model legislation process. This task would require a dedicated staff member (or members) and travel funds to attend all relevant AAMVA/NHTSA meetings. An adjunct activity or sub-activity could be to engage surrounding states in a multi-state collaboration to harmonize rules and regulations regionally per the model policies.
 ***Activity owner**: NC Department of Insurance* ***Goal:** Facilitate an insurance expo* ***Schedule:** Within 6 months* ***Budget**: $50K, 2 person-months internal effort* ***Other stakeholders**: NCDMV, Governor's Office of Legislative and Fiscal Research*	**C-4: Conduct an Insurance Expo Stakeholder Workshop** The NC insurance industry should be engaged as part of the process of development of legislation and changes to the MVC. A workshop as part of the Insurance Expo for Independent Agents is recommended. As part of the workshop coordination, dedicated resources and a champion should be identified for the entire process, from event development through the finalization of the workshop.
 ***Activity owner**: NCDMV, needs a defined champion* ***Goal:** Establish advance driver education programs* ***Schedule**: 1 year starting immediately* ***Budget**: Internal effort, ~1 person-year*	**C-5: Define Advanced Driver Education Programs** As AV technology progresses, NCDMV will need to develop more advanced educational programs. These programs should include a focus on the use of automation technologies in the vehicle and the continued responsibility of the driver for the safe operation of the vehicle. As the vehicle fleet transitions to more vehicles with advanced technologies, courses will require modifications and should be focused on both new and renewing drivers. This program will require changes to the educational and testing environment for the obtainment of a commercial driver's license (CDL).

D. Long-Range Transportation Plans

CAV technologies will have significant impacts on traveler behavior. Current estimates of Level 4 (hands-free, feet-free operation from origin to destination) technology introduction into the passenger vehicle market indicate around the year 2025. There are a range of possible scenarios that could evolve, including a mix of shared-ownership, no-ownership, and status-quo. Regional planning models and tools use regional travel demand models that forecast surface travel and land-use models that simulate household locations and attributes. Metropolitan planning organizations (MPOs) maintain travel demand models specific to their regions and use them to develop long-range transportation plans (LRTPs) and evaluate major projects for transportation improvement programs (TIPs).

Currently, these travel demand models do not have any significant capacity to represent CAV alternatives and their effect on travel behavior and vehicle ownership. The broad community of transportation professionals expects that many attributes of land use, vehicle ownership, and travel behavior will change when Level 3, 4, and 5 vehicle capabilities are commonplace in both passenger cars and in transit. Assessing these impacts currently is the subject of research by USDOT, AASHTO/NCHRP, universities, and model developers. It is recommended that NC maintain knowledge on the advances and changes in the approach to LRTP development. The introduction and adoption of CAV into the communities potentially will have major impacts on how future projects are evaluated, designed, and implemented.

	Activity
 ***Activity owner**: NCDOT Transportation Planning Branch, needs a defined champion* ***Goal**: Be active in LRTP research* ***Schedule**: 1 year starting immediately (participate in research); reviewing results and developing a NC response would start within 1 year and last 6 months* ***Budget**: $100K, ~3 person-months internal effort* ***Other stakeholders**: Regional MPO directors*	D-1: Monitor and Participate in LRTP Research NCDOT should take an active role in participating in LRTP research by USDOT/AASHTO by volunteering to use a North Carolina MPO's current plan as a case study. In addition, NCDOT could review the results of the research products and develop an NC-specific response to the recommendations and research activities. It also will be important to invite representation from the MPOs to participate in this research effort.

	Activity
 ***Activity owner**: NCDOT Transportation Planning Branch, needs a defined champion (same champion as previous activity)* ***Goal:** Integrate CAV in 2040 Plan* ***Schedule**: 6 months starting immediately* ***Budget**: $100K (review plan), ~3 person-months internal effort; $300K (revise plan)*	D-2: Review and Revise the NCDOT 2040 Plan The 2040 plan published in 2012 has no mention of alternative vehicle ownership or other modalities related to CAV technology introduction. Review and analysis of this plan and development of recommendations related to current LRTP research is a natural first step. Coordination of NC plans with regional state partners, respective to CAV technologies, may be considered. This revision also may consider broader needs to align the State LRTP with ITS architectures as defined in 23 CPR part 940.
 ***Activity owner**: NCDOT Transportation Planning Branch, needs a defined champion (same champion as previous activity)* ***Goal**: Training Materials for MPOs* ***Schedule**: Within 6 months after previous activity* ***Budget**: $200K, ~3 person-months internal effort* ***Other stakeholders**: Regional MPO directors*	D-3: Develop Guidance for NC MPOs in Revising Regional 2040 Plans NCDOT should build upon their lessons learned and products from the 2040 plan update to develop recommendations for MPOs within the state. This guidance would also integrate the USDOT guidance and results of AASHTO/NCHRP recommendations and apply it to the state-specific processes.

E. Mobility and Access Improvements

NC has significant populations of disabled and disadvantaged travelers[50] who are unable to operate or own a vehicle. This limited mobility impacts their ability to travel without a dependency on someone or something else. This dependency includes a reliance on either transit mobile options or third-party assistance for making trips. These travelers represent a very wide range of users, including those who are physically disabled (e.g., blind, deaf, wheelchair-bound), the elderly, veterans, those living in rural areas, low-income households, children, and those with language barriers.

CAV technology provides the potential to extend services to these populations through technological breakthroughs accommodating disabilities and physical challenges, reductions in cost of services such as paratransit, improved response and travel times, and greater accessibility of transportation in general (accessibility, availability, affordability, and acceptability). It may be many years before these technologies are readily available to the larger population if no actions are taken to stimulate industry to act. North Carolina could take a leading position in the U.S. in promoting the development and implementation of such services, as no state has done so to date.

	Activity
	E-1: Modify Laws and Regulations regarding Holistic Transportation Services
***Activity owner**: NCDMV partnered with NCHHS, needs a defined champion* ***Goal**: Revise statutes to allow more holistic paratransit services enabled with CAV technology* ***Schedule**: 2 years starting immediately after AV testing legislation is in place* ***Budget**: Internal effort, ~1 person-year*	With or without CAV technology features, paratransit rules and regulations are restrictive to specific types of trips. They sometimes discourage trip chaining or make it impossible due to the funding sources used to support an individual trip. NC could improve paratransit service and pave the way for automated vehicles in certain types of paratransit by reducing the red tape associated with use of the service.

[50] https://connect.ncdot.gov/projects/planning/RNAProjDocs/2013-12%20Final%20Report.pdf

	Activity
	E-2: Conduct a Focused Workshop on Opportunities for Disabled Traveler Services through AV Operation
***Activity owner**: Disabled Traveler Sub-Committee chair* ***Goal:** Identify additional activities* ***Schedule**: Within 1 year* ***Budget**: $50K, ~3 person-months*	Services specific to disabled travelers and the opportunities that CAV can provide warrant a focused workshop. There are multiple advocacy groups that should be invited to expand the feedback and provide a broader range of input into how NC can promote CAV to benefit those individuals. One element of CAV is the independence that CAV can provide physically challenged North Carolinians to use autonomous vehicles for more responsive door-to-door service. The workshop would result in a set of findings and additional activities to add to the activities roadmap or actions to coordinate those identified issues with other activities within the CAV Activities Roadmap.
	E-3: Develop Partnerships with the Department of Veterans Affairs (VA), Hospitals, Advocacy Groups, and Transit/Paratransit Operators for Grant Funding
***Activity owner**: Disabled Traveler Sub-Committee chair, partnered with Pilot Programs Sub-Committee Chair* ***Goal:** Submit grant applications to fund initiatives for transit services* ***Schedule**: Development of subcommittee membership within 6 months; initial grant applications within 1 year* ***Budget**: $100K ($10K per grant application), ~1 person-year*	Pilot projects for disabled traveler services using CAV technology are possible even with today's technology, but they require significant investment. As part of the development of a subcommittee on services for the disabled, the subcommittee should take ownership of the pursuit of grant funding through the FTA, USDOT Accessible Transportation Technologies Research Institute (ATTRI), Department of Energy (DOE), and other health and human services programs. A worthwhile goal could be to have three grant applications in place within 1 year, 10 grant applications within 3 years, and two secured projects among those applications.

F. Pilot Projects and Research

The best way to gain experience in CAV technology deployment is through pilot programs. The goal of pilot deployments should focus on gaining insights into potential benefits, understanding how the technologies work, and identifying gaps that could be created with the implementation of the technology. NCDOT can work with partners to develop projects on the "bleeding edge" and develop or provide test beds for certain types of CAV technology.

	Activity
 ***Activity owner:*** *CAV Program Manager* ***Goal:*** *Identify potential pilot site and test bed project* ***Schedule:*** *Within 6 months* ***Budget:*** *~$25K, ~1 person-month internal effort*	F-1: Conduct a Workshop on Potential Sites and Opportunities During the workshop, participants noted the need to brainstorm potential sites and real near-term pilot deployment concepts. The CAV Program Manager should coordinate a workshop for a sub-group of the stakeholders to discuss potential real-world pilots of technologies, including both CV and AV applications and tests. Potential venues could include military bases; hospital campuses; universities; State-owned properties; Global TransPark; NASCAR facilities; Panamax seaport; urban areas; and first-mile, last-mile transit connections. The workshop should result in a prioritized list of potential venues and demonstration pilots.
 ***Activity owner:*** *CAV Program Manager* ***Goal:*** *Become a member of the Pooled Fund Study* ***Schedule:*** *Within 6 months of start of development of regulatory actions and other actions on activities roadmap* ***Budget:*** *~$50K per year, ~1 person-month internal effort per year*	F-2: Join the Connected Vehicle Pooled Fund Study (CVPFS) The CVPFS is a group of like-minded state and local DOTs that have pooled moneys together to fund research of common interest (including Utah, California, Arizona, Virginia, and Michigan). Some past projects have included the impact of CV technologies on TMC operations, algorithms for intelligent traffic controls with CV data, and multimodal signal operations with CV technology. Current projects include the development of a Basic Infrastructure Message to be broadcast from agency roadside units, among others. At a very low point of entry (~$50K per year), results are amplified across the participants. States also enjoy improved peer-to-peer information sharing and early access to USDOT and related research results and information.

	Activity
	F-3: Develop a Statewide University and Industry Consortium on CAV Research
Activity owner: *CAV Program Manager, partnered with the Business Working Group Chair* ***Goal:*** *Establish a CAV Research Consortium* ***Schedule:*** *TBD; likely more than 1 year* ***Budget:*** *TBD; ~3 person-months internal effort*	Just 10 years ago, Insight Racing from North Carolina State University competed in the DARPA Grand Challenge.[51] The University of North Carolina at Chapel Hill recently hosted a symposium on AV issues. EcoPRT is being developed at NC State. Other university resources across the state have interest in CV and AV technologies. The State could promote a collaborative cross-university consortium to further CAV technology, policy, and infrastructure research in NC. Some seed funding would be necessary to energize the research efforts and further collaboration in an NC-centric effort. Identify private funding sources from local NC businesses along with national and international businesses with a strong presence in NC to contribute to the consortium.
	F-4: Engage NASCAR to Collaborate on AV Racing
Activity owner: *CAV Program Manager* ***Goal:*** *Host a NASCAR Grand Challenge* ***Schedule:*** *TBD; likely more than 2 years* ***Budget:*** *~$15M+, ~4 person-years internal effort*	As the home of NASCAR and the NASCAR Hall of Fame, NC is the center of automobile racing in the U.S. While Google and NASCAR teamed up a few years ago for an April Fool's joke announcing a Google autonomous racecar, real AV racing could bring a significant spotlight to the state. The first AV race day was held in California in mid-2016. If the State wanted to do something different, AV racing (initially, time trials, leading up to head-to-head races on a NASCAR track) would put the state literally on the map of AV activities worldwide. AV developers would locate in NC to develop race-ready versions of their commercial offerings. Head-to-head racing of AVs versus professional drivers, or AVs versus AVs, could have commercial potential (i.e., sell tickets) and demonstrate AV capabilities in the most stressful and safety-critical settings. An NC "grand challenge" prize could be offered to winners in different classes, much like the DARPA grand challenges, which saw teams invest significant internal funds to compete for much less than a compensatory prize. AV racing is a "go big or go home" activity for the State.

[51] http://www.insightracing.org/images/Jul26VIRBT/pages/IMGA0623_JPG.htm

G. Outreach/In-Reach Strategy

Most of the public has now heard of the Google car and related AV technologies through the popular media. Connected vehicle technologies have not penetrated the popular media with the same level of hype. Typically, there is some confusion between AV and CV technologies. As part of the NC strategy to make it legal to test and eventually operate AVs on NC roads, the public needs to be informed of the implications. There are many misconceptions about the timeline of technology introduction, and questions about liability, personal safety, and ethics are common. Outreach and education on the technology and the Activities Roadmap should target other divisions within NCDOT, other State departments, local governments, universities, and businesses. In addition, educational efforts on CAV technology and initiatives in NC should be developed for the public. Each effort should be developed around the appropriate audience and message to be delivered.

	Activity
***Activity owner**: CAV Program Manager* ***Goal:** Outreach and in-reach strategy* ***Schedule**: Within 6 months of start of development of regulatory actions and other actions on activities roadmap* ***Budget**: $100K, ~3 person-months internal effort* ***Other stakeholders**: Regional MPO directors*	G-1: Develop an Outreach and In-Reach Strategy NCDOT should develop an outreach and in-reach strategy to convey the content and progress related to the activities roadmap. The outreach strategy should identify media events, e-publications, additions to NCDOT and related web sites (ncav.org), "town halls," attendance and presence at relevant national and regional conferences, and other common public relations actions. The in-reach strategy should identify webinars, department-specific briefings, e-publications, workshop series, and other common in-reach activities that foster collaboration and coordination among departments and related agencies.
***Activity owner**: CAV Program Manager* ***Goal:** In-reach on Activities Roadmap* ***Schedule**: Within 6 months of activities roadmap action initiation* ***Budget**: $25K, ~3 person-months internal effort*	G-2: Conduct Webinars to Introduce the Activities Roadmap Once the activities roadmap is established, NCDOT should hold a series of in-reach webinars to introduce the activities roadmap across NCDOT divisions and geographic regions.

 ***Activity owner**: CAV Program Manager* ***Goal:** NCAV.org update* ***Schedule**: Within 6 months of activities roadmap action initiation* ***Budget**: $25K, ~3 person-months internal effort*	G-3: Develop Sections on ncav.org regarding the Activities Roadmap for the Public NCDOT should refine the ncav.org web site to reflect the activities roadmap. The web site should be organized by initiative and be used to highlight the progress. Content should be developed for public consumption as opposed to technical documentation used for internal education.
 ***Activity owner**: CAV Program Manager* ***Goal:** Maintenance of NCAV.org* ***Schedule**: As activities are completed* ***Budget**: $50K, ~3 person-months internal effort*	G-4: Expand Content on ncav.org and Internal Web Sites as Activities are Completed A continuous effort should be made to keep the ncav.org web site current with progress of the activities roadmap.
 ***Activity owner**: CAV Program Manager* ***Goal:** Continuous participation in professional organizations and national conferences* ***Schedule**: Ongoing* ***Budget**: $15K annually*	G-5: Participation in Professional Organizations and National Conferences NC's participation and involvement on the national level is paramount to staying informed on the progress of CAV technology roll-out. This involvement allows NC to stay aware of progress before and as it is happening as opposed to after. The working groups should identify the professional organizations and the conferences where involvement supports and promotes each activity. Once identified, the working groups should establish a strategy that identifies the resources that allow consistent attendance and involvement in the relative committees, conferences, and professional organizations. A potential sub-activity could be the sponsorship of a booth at a national or regional conference that promotes the NC activities related to CAV technology.
 ***Activity owner**: CAV Program Manager* ***Goal:** Attract CV technology developers to test on toll facilities* ***Schedule**: Within 1 year* ***Budget**: Internal*	G-6: Assess the Ability of Toll Roads to Leverage CV Technology NCDOT and NCTA should assess the potential opportunities that could leverage the toll infrastructure to test and implement CV technologies. CV technology is continuing to evolve, but use of the toll facilities could promote CV advancement and attract equipment manufacturers to the state.

Appendix: Foundational Stakeholder Feedback

The stakeholder feedback from the workshop is summarized as follows. The information below are not recommendations, but purely participant comments during the three breakout groups.

Laws and Policies

1. Opportunities

Participants noted that identifying business-friendly laws that allow AV operation and provide economic incentives for CAV developers to test in NC could provide significant economic development for the State. Licenses and the associated hassles with obtaining, maintaining, approving, and managing them could be eliminated if driverless cars were the norm in NC. Participants also noted that CV technologies do not appear to need legislative or policy changes, so the focus of the NC AV program should be on AV technologies.

2. Challenges

Participants were particularly proficient in identifying challenges with laws and regulations related to AV operations. The discussion points ranged from high-level policy considerations to minutiae of specific situational concerns. Some of the many discussion topics are listed here.

Driver's education is already a challenge in NC, and reducing the basic skill level of drivers who are usually being driven by an AV could be a huge risk. Drivers will be expected to "take control" in the most *serious* of driving situations, yet have little to no experience in driving under many *basic* scenarios. Laws and policies may need to reflect the need for drivers to still maintain high levels of proficiency in manual driving, or driver training will need to be radically different and include specific training for "handoff" issues between automated and manual driving. Currently, most vehicles in NC older than a certain age must receive yearly inspections. With AV technology, how will inspections need to be updated or modified to ensure the technology is still working as expected?

Drivers will be expected to "take control" in the most serious of driving situations, yet have little to no experience in driving under many basic scenarios.

Some classes of users may have to have special restrictions to certain modes of operation. Similarly, if NC has specific rules for licensure of AV operation, will reciprocity with other states be allowable? Laws and regulations may be needed to restrict certain types of goods delivery via autonomous vehicle, such as alcohol or medicine. The State will need to determine what actions will be allowable by drivers under certain levels of automation (impairment, cell phone use, texting, reading, and sleeping, among others).

Law and regulations will certainly need to address crimes committed by autonomous vehicles. Other challenges mentioned include hacking, data protection, data privacy, and government access to in-vehicle data feeds as well as use of AV in school buses, farm vehicles, motorcycles, hazardous materials vehicles, and law enforcement vehicles. Participants discussed at length issues related to AV use on law enforcement vehicles and the need to perhaps have law enforcement and emergency services vehicles "opt out" of AV

features. This could prevent scofflaws from disabling a police vehicle's AV features via remote hacking, allowing the suspect to escape pursuit. On the other hand, participants discussed the potential capability for a law enforcement officer (or some centralized control function) to remotely hack a suspect vehicle that may be "out of control" to prevent injuries, death, or property damage. Some participants wondered how laws and regulations would address the issues related to mixed levels of functionality where some vehicles are Level 2 and some are Level 3 or 4. There may be limited potential for a law enforcement officer to determine that a particular driver is violating the functionality of his AV by performing certain actions (e.g., sleeping). Similarly, it was discussed by participants that it is a challenge to simply determine if using an AV feature when it is not designed to accommodate that type of activity must be *prevented* by a law or regulation, or whether liability torts will naturally address such issues.

The final serious issue identified by the participants was liability and insurance provisions. The participants suggested that an insurance summit with national insurance providers would be helpful for the State to determine a course of action. Review of what other states have already done was suggested strongly as a next step.

3. Actions

The workshop participants agreed that initial actions by the State must be led by the implementation of changes to the Motor Vehicle Code, licensure, and insurance statutes (section 20 and 58). All other actions would flow down from regulatory actions permitting testing and eventual operation of AVs. Several participants noted that the State should follow best practices already taken by other states instead of reinventing the wheel with new regulations. It was discussed, however, that the State should not repeat some potential missteps by other leading states that have been criticized by some AV developers, such as requiring substantial bonds, extensive reporting, or overly restrictive regulatory protocols. In this regard, the State should volunteer to be part of the AAMVA/NHTSA activity to develop model policy and legislation. The regulations, once enacted, should then be reviewed no less frequently than annually as the technology evolves. The participants agreed that the State needs a standing committee on AV issues to take ownership of the necessary actions. The formulation of this committee and its membership should be pursued immediately. Finally, the group discussed the need for public education and public outreach as a parallel activity to the development of the changes to the regulations. Providing services for disadvantaged travelers, particularly the blind, was mentioned as an important area of focus for the State.

The participants agreed that the State needs a standing committee on AV issues to take ownership of the necessary actions.

4. Desired Outcomes

The participants agreed that the promise of AV operation is reduction in fatalities and property damage by reducing crashes caused by human drivers. Improvements to fuel economy, consumer convenience, and mobility for the disadvantaged were also mentioned as important desired outcomes of AV operations in NC.

5. Unintended Consequences

The group discussed a wide range of potential consequences, with the most prevalent being the product liability issues that will be hotly debated when an AV is found to be at fault for serious injuries or fatalities. Risk homeostasis is a human condition that is very difficult to predict. In the world of traffic safety, measures implemented intended to improve safety often have no desired effects because humans adjust their risk taking to compensate for the additional level of perceived safety in doing so (e.g., driving faster and making riskier maneuvers because they are wearing a seatbelt and the lanes are wider). It may likely be the case that replacing human drivers with automated functions will result in humans taking more risks, assuming their AV capabilities far exceed the vehicle's actual capabilities. Participants also offered that, in general, the introduction of more capable AV systems would lead to less and less capable human drivers who would be expected by the AV system to take control in the most challenging driving conditions. This is quite a paradox, particularly with respect to new drivers such as teens and immigrants from countries with low penetration rates of automobile use, less defined traffic safety regulations, and/or more varied behaviors than are currently practiced by drivers in NC or the United States.

Participants also mentioned additional potential consequences such as reduction of gas tax revenues due to higher vehicle efficiency and fewer miles traveled, insurance business reductions, software hacking and general issues of software reliability, procedures and processed for updates or upgrades, and affordability of personal vehicles for the general population (i.e., more and more people may become AV-transit or taxi "captives;" some may not mind, but many may find this troubling and limiting of their personal freedoms).

6. Who Will be Affected and How

The participants largely agreed that the societal benefits potentially outweigh the unintended consequences. Insurance rates may be drastically reduced, freeing up consumer dollars for other uses; disadvantaged travelers will enjoy substantially more freedom of travel, convenience, and efficiency; and reduction in fatalities and injuries will increase the quality of life for thousands and thousands of people, raise productivity, decrease traffic congestion, and reduce the other burdens on society of traffic crashes, including vast economic and emotional impacts. New markets may be opened by AV operations, such as reselling/repackaging of data or new land development/construction redevelopment projects to redesign the built environment. NC should take actions in the Laws and Policies section above to try to take advantage of these new opportunities and bring new revenues and economic development to the state.

New markets may be opened by AV operations, such as reselling/repackaging of data or new land development/construction redevelopment projects to redesign the built environment.

7. Partners

Participants noted that additional partners would necessarily include transit agencies, which were not represented in the initial group of stakeholders (note: several transit agencies were invited, but could not attend). Other partners mentioned included AAA, trucking associations, local law enforcement agencies

(State Patrol was the only enforcement agency represented at this initial workshop), Google (Durham fiber), FMCSA (Federal Motor Carrier Safety Administration), CVSA (Commercial Vehicle Safety Alliance), local insurance companies, research centers, elderly advocacy groups, veteran advocacy groups, and the Metrolina Association for the Blind. Participants noted that cities and MPOs across the state should be more strongly represented in the stakeholder group. Participants also noted that perhaps NC could reach out to surrounding states to promote interoperability across state lines and harmonization of laws and policies to facilitate smooth introduction in the region.

8. Existing Efforts and Resources

Participants noted that there is keen interest from the Governor's office to push this initiative forward. The initiative should engage partners in legislative and fiscal research (the Governor's General Transport, IT Oversight, and Insurance Oversight committees) to develop a State strategy related to investment based on the findings of this initiative. As discussed earlier, the key action was noted to be the establishment of a Standing Committee on AV for the State.

Business

1. Opportunities

Participants acknowledged that NC will likely be a "fast follower" as it may be too late to become an early adopter with respect to autonomous vehicles. There are unknown opportunities within the business development surrounding AV. Each day introduces new technologies and breakthroughs, so NC must remain agile and quickly responsive as stakeholders learn the "things we don't know that we don't know."

NC is a diverse state and can easily facilitate business development that keeps all services in-house, including everything from technology through manufacturing. NC can leverage the dense population of universities to support research and development. In addition, we can leverage the accessibility of resources within the state through existing tech hubs. There will be a new wave of development associated with AV, including a wide range of new apps in response to the paradigm shift of people using their cars as decision-making tools for everyday life. The tremendous technology shift will introduce a certain job loss within certain sectors, but strategic efforts to remain a fast follower will allow NC to establish new jobs in new sectors.

NC is a diverse state and can easily facilitate business development that keeps all services in-house, including everything from technology through manufacturing.

Participants suggested the use of our rural areas to support the needs of manufacturing through cottage industries such as companies focused on a growing market of biking apparel. It was suggested that stakeholders invest in building upon the existing resources of NASCAR to develop a strong partnership with other public and private sector agencies. Lastly, NC has a substantial communications infrastructure in place today that can support fast growth. Similar to existing requirements for developers to contribute to

transportation infrastructure, future developments could expand the definition of the transportation infrastructure to include communications infrastructure to support the growing data needs.

2. Challenges

Participants identified some inherent challenges to business development around AV technology that would could occur with respect to generational and geographic gaps in willingness to accept the technology. In addition, there will be psychological challenges as users adjust to a transitioning fleet, some with AV features and some without (and never to be added). With fully autonomous vehicles, it could be frustrating to acknowledge empty cars in traffic. In addition, vehicles that obey all driving regulations—such as coming to a full stop at stop signs and strictly adhering to all speed limits—will likely frustrate surrounding human drivers. These frustrations, based on perceptions and observations, could introduce unique challenges (e.g., "robot road rage") to business development opportunities.

New business models for funding include a use tax based on VMT or time-of-day congestion charging and new or higher taxes to support the shift of infrastructure demand.

Some challenges will arise related to how AV will change other industries. Level 4 vehicles performing errands for a user will influence packaging, store fronts, and socializing among customers. It will require a new level of trust in specific services, such as school buses, emergency services, and elder care. Participants also discussed the environment of the mid-term condition, where users will experience a mixed fleet. Businesses will need to accommodate the transition and shift as it occurs to support all customers. In addition, the design of infrastructure, communities, access roads, parking, and facilities all will need to accommodate the mixed fleet.

The job market will need to respond to disruptions and layoffs as specific skill sets and job responsibilities are no longer required. Businesses will face the challenge of identifying methods to fill employment gaps, such as truck drivers, before they occur. Participants also acknowledged that this technology may shape how the infrastructure is funded, operated, and maintained. The gas tax is already experiencing limitations. New business models for funding include theories founded on a use tax based on VMT or time-of-day congestion charging and new or higher taxes to support the shift of infrastructure demand.

Other challenges discussed included issues around the security of data and vehicle operations. A wide range of new challenges and questions involved who can access data (law enforcement, marketing divisions of businesses, public agencies). In addition, who will own and manage the large volumes of data now being created? Similar to the opportunities discussed, there is a spectrum of information that "we don't know that we don't know."

3. Actions

Participants introduced focused actions, including outreach to the business community to involve them in the conversation as early as feasible. In addition, education of the general public and local governments will be

important as NC experiences this technology shift. To support quality partnerships in the business community, participants suggested support through the endorsement of the Governor of the selected initiatives on the AV roadmap. In addition, endorsements from key stakeholders in both the private and public sectors will be instrumental in demonstrating NC's coordinated effort to support the growth of AV in the state.

4. Desired Outcomes

Participants stated that the primary outcomes the business initiatives can support include increasing revenues in NC through job creation and market growth. Additionally, playing a key role in AV technology will strengthen universities as research hubs. Lastly, participating in the ongoing conversation regarding AV could support the identification and implementation of better methods for funding transportation infrastructure and modes.

5. Unintended Consequences

Participants acknowledged that the technology shift could be disruptive, and possibly destructive, to specific business sectors such as the insurance industry, judicial system (i.e., traffic court), and emergency services (i.e., traffic related injuries), to name a few. Additionally, it will be important to monitor how this technology will change land development related to where people choose to live and work.

The disadvantaged community will be afforded new mobility and access that have previously been limited.

6. Who Will be Affected and How

From a business perspective, all facets of NC's population will be impacted, and it is important to mitigate those impacts and convert them into positive opportunities. Consumers will alter the way they shop and purchase goods, which could change the way the commercial vehicle fleet provides deliveries. Developers will need to respond to a new live and work paradigm that people could be afforded through the use of AV. The disadvantaged community will be afforded new mobility and access that has previously been limited.

7. Partners

To foster an effective environment within NC that can attract new business and support existing business sectors as they transition, it will be important to coordinate a large cross-section of partners. This will involve a range of citizens including millennials, the elderly, and the disadvantaged. From the transportation community, transit and ride sharing companies (Uber/Lyft/Zipcar), freight, and state and local transportation agencies must play a key role. The business community should be integrated through groups such as the Regional Transportation Alliance (RTA) and the Urban Land Institute (ULI). Participants stated that utility providers such as Duke Energy should be involved. Lastly, universities were identified as a key partner to support research and development.

8. Existing Efforts and Resources

The conversation is relatively new for a large cross-section of NC, so participants stated that everyone involved should focus on keeping the conversation going. To determine the direction for NC, effort should be made to establish liaisons with key partners and get everyone involved in the conversation. The current resource needs to perform outreach and education are vast and will require further recruitment of motivated partners and funding sources for such activities.

Infrastructure

1. Opportunities

Participants discussed numerous opportunities that can provide a range of benefits. AV technology could require less infrastructure as a whole. Smaller vehicles would require less roadway space and reduce parking demand, freeing up property in downtown areas for greenspace. In addition, downtown congestion could be reduced through the use of edge parking facilities. AV valet parking could happen in the near term in garages that are AV-friendly. Car sharing could bring down costs for the individual user and also reduce congestion in downtown areas. Public agencies can design with considerations for AV within ITS infrastructure, such as broadcast of signal phase and timing (SPaT) so AVs know automatically whether the traffic light is red, yellow, or green.

Transit services could include smaller, on-demand transit vehicles that provide service on selectable transit routes.

Participants discussed a change in the approach for planning and designing for a transitioning fleet. Transit services could include smaller, on-demand transit vehicles that provide service on selectable transit routes. Fleet management allows transit agencies to coordinate movement for a streamlined travel experience. In the long term, an extensive market penetration could introduce the need for less infrastructure such as pavement markings and signing, as well as the associated maintenance of traffic controls and warnings focused on human operators.

Participants provided specific examples of opportunities related to upcoming projects or initiatives. The I-77 HOT lanes project and tolling project could include incentives for CAV. This could include additional infrastructure in that lane to manage cooperative adaptive cruise control and potentially test mileage-based tolling or service fees. The military is currently testing and implementing multiple AV efforts and could become a key partner for the State. Ft. Bragg is already launching efforts to test AV shuttles as a demonstration on a closed network. Other military efforts are using AV technology for platooning of supply convoys and to transport wounded warriors away from combat.

Participants noted that cities and MPOs across the state should be more strongly represented in the stakeholder group.

Partnering with the private sector could introduce new opportunities related to infrastructure. Some partners could allow testing of newer technologies on private property, such as business campuses. In addition, private sector companies could focus on the refinement of algorithms used by vehicles in an effort to maximize safety and efficiency.

2. Challenges

With a transitioning fleet of vehicles, it is difficult to not be reactive with the infrastructure to support newer technologies. Agencies identified the challenge of determining how to maintain and implement signs and pavement markings to support CAV. Agencies are challenged with continuously debating whether it is acceptable to be less predictable, or if they should strive to be more predictable. As an example, do we still need rules that pedestrians must cross at crosswalks, or will vehicles be so capable as to detect them anywhere, eliminating the need for crosswalks and pedestrian buttons at signalized intersections? Regardless, pedestrians remain a significant challenge in the CAV environment.

NCDOT should work with the State's senior leadership and lawmakers to establish standing committees within the General Assembly to focus on NC's initiatives moving forward.

Agencies are already challenged with limited budgets. This will become more challenging as they work to support the technological transition. During this transition, comparative analysis for large capital investments with the unknowns of AV also presents a challenge. Participants presented the example of decisions on a new light rail implementation compared with the unknown options of potentially less expensive and farther reaching transit solutions in the future. Perception also introduces a challenge. Taking transit as a solo rider could be intimidating, and driving in traffic with empty vehicles can be confusing for the general population to understand the overall societal benefits. Education of the public lawmakers and partner agencies will likely be a daunting task.

Discovering what motivates cities will be a challenge. How can local governments leverage these newer technologies to support their future initiatives?

3. Actions

Participants confirmed there are some actions they can take on now and others that will require extensive resources to be successful. Endorsement from the Governor will support and attract additional partners to the conversation. In the short term, it is important to identify who should be targeted (RTA, MPOs, municipal governments) to promote the AV initiative. Participants noted that assembling a larger cross-section of stakeholders into a larger workshop would be a valid next step to continue the conversation. The State

Partnering with the private sector could introduce new opportunities related to infrastructure. Some partners could allow testing of newer technologies on private property, such as business campuses.

should build on existing relationships to create an industrial coalition and assemble the right stakeholders who can advance the effort.

As public agencies move forward, there are certain activities they will need to apply on a continuous basis. It will be important to keep AV in mind during the design of upcoming projects. In addition, integration of these emerging issues into long-range plans will support the conversation moving to the forefront. Lastly, NCDOT should work with the State's senior leadership and lawmakers to establish standing committees within the General Assembly to focus on NC's initiatives.

Specific actions also were listed by the participants. Benefits could be realized by identifying incentives for private properties to allow testing of AV. Additionally, development of a potential test project of autonomous operation for transit vehicles would be a huge step forward. Possibly the proposed bus on shoulder operation in the Triangle could be an option. This may require legislation changes such as early exemptions to allow for testing of public vehicles on the public right-of-way.

4. Desired Outcomes

The desired outcomes all support an improved transportation network within NC. Specific outcomes include the identification of test projects. These could attract industry and would grow the state's economy by securing the role of NC in CAV technology growth. Participants want to promote the adoption of AV and create an environment for AV in NC. It is important to a large cross-section of the population to promote a transportation network that provides accessibility, lower costs, and improved safety to the end user.

> Partnerships with the military efforts can be supported through outreach with the military bases, but also through groups such as Veterans' Affairs and Wounded Warriors.

Mobility and safety of the transportation infrastructure could be supported by leveraging the assets within the existing infrastructure to promote the growth of CAV. Agencies should move from a construction mindset to an operations/management mindset for transportation systems. AV was viewed to be a supporting element in identifying and supporting the growth of transportation as a service through options for a seamless and demand-responsive trip.

5. Unintended Consequences

Participants realized that perceptions are going to be a significant consequence requiring focused and aggressive education to a large range of audiences. Job disruption will occur, and all partners should strive to stay ahead of the impact. Lastly, there will be a shift in traffic management strategies that may require reactive changes from transportation management agencies.

6. Who Will be Affected and How

Participants believed the biggest impacts will be experienced by local public agencies as they strive to shift their roles and responsibilities relative to infrastructure. This will likely often feel reactive despite efforts to stay ahead of the challenges. In addition, the consumers and users of the transportation infrastructure will be

affected, and this will be dependent upon their willingness to adopt the technology shift as well as the affordability of AV options.

7. Partners

NC is fortunate to have a wealth of potential partners. It will be important to reach out to those partners and bring them to the conversation early. Transportation agencies such as local agencies, MPOs, transit agencies, FHWA, and the I-95 Corridor Coalition are key for information sharing and discussions around managing public assets. It will be important to continually educate the consumers and users of the infrastructure, including focused conversations with advocacy groups such as AARP and the Metrolina Association for the Blind. Partnerships with the military efforts can be supported through outreach with the military bases and through groups such as Veterans' Affairs and Wounded Warriors.

> The military is currently testing and implementing multiple AV efforts and could become a key partner for the State. Ft. Bragg is already launching efforts to test AV shuttles as a demonstration on a closed network.

Relationships with the private community include organizations such as AAA, which is already involved on a national level. The freight community will play a key role as well as data and IT companies looking to ensure secure and proper data management. The driving community—including taxi, transit, and ride sharing initiatives (e.g., Uber and Lyft)—will likely also be strong partners.

8. Existing Efforts and Resources

Participants identified several initiatives that currently are underway. The ecoPRT effort is looking to demo at NC State in the near future. EcoPRT are autonomous pods that can operate on a fixed guideway or on a dedicated roadway. The military has several initiatives in various stages of testing and implementation. In an effort to stay close to the curve, NC should stay abreast of initiatives from other states, national committees, and working groups that are currently active. NC representatives should attend conferences and educational programs through organizations such as the Association for Unmanned Vehicle Systems International (AUVSI).

> The ecoPRT effort is looking to demo at NC State in the near future.

Appendix: Review of Existing Statutes

The project team performed a review of the General Statutes Chapter 20 (Motor Vehicles) and Chapter 58 (Insurance). The summary tables provided include the page number within the chapter, the article and section number, the section title, levels of automation where the comments should be considered, and the suggested focus of the discussion. Specific changes to the code are not provided; instead, recommendations are presented to guide the relevant working group with a starting point for analysis. Where feasible, additional discussion questions are provided to aid the facilitator in guiding the discussion.

Comments provided focus on elements of the statutes that may require revisions in response to the advancement of autonomous vehicle technologies. Recommendations are included to revisit specific definitions through each iteration of changes in technology.

Chapter 20 includes the identification of sections referencing the following:

- Driver's license designation and issuances
- Registration and titles
- Vehicle attributes (steering wheel, windshield, brakes, etc.)
- Safety standards
- Vehicle operations
- Enforcement
- Liability

Chapter 58 includes the identification of sections referencing the following:

- Issuance of insurance
- NC Rate Bureau
- Insurance rates
- Moving traffic violations
- Specific definitions within the code

Addendum

During the final review period, stakeholders provided input into modifications to both the stakeholder involvement and the structure of the working groups. Those comments along with their resolution or action needed are captured in **Table 7**. Two comments are tabled for discussion during the first activity which will define the oversight and working group structure. Additional support for these comments is captured in UNC HSRC's Comments on the Draft Report, dated November 8, 2016.

Table 7. Stakeholder Comments and Resolution

Stakeholder	Page/Section	Comment	*Resolution*
Todd Barlow (10/26/2016)	Page 4, Table 2	Revise Lynette Pitt's agency NC Association for Defense Attorneys. Include Hardison Wood to represent NCAJ.	*Done. Lynette's agency revised to NCADA; Hardison is included in the Addendum (Working Group nominations)*
Warren Smith (11/1/2016)	Page 4, Table 2	Eric Bellamy is replacing Warren Smith (NCDMV)	*Done. Warren is noted as part of the Steering Committee to capture his participation in the development of this report.* *Eric is included in the Addendum (Working Group nominations)*
Ryan Boyce (11/7/2016)	Page 4, Table 2	Need to change agency from DMV to DOT	*Done*
	Page 4, Table 2	Change Mary Jernigan to 'Jennings'	*Done*
Jeff Barghout (11/8/2016)	General	Update Jeff's company name from "Nexus EMC" to "Robocist, Inc"	*Done*
Stephanie Harrell/ David Harkey (11/8/2016)	Page 4, Table 2	Revise agency for David Harkey from "SHRC" to "HSRC"	*Done*
	Page 21, Table 6	W.R.T.: **A: Group Structure and Organization**, a research working group is suggested, thus creating four working groups	*Tabled.*

Stakeholder	Page/Section	Comment	*Resolution*
		W.R.T.: **F: Pilot Projects and Research**, Activity F-3 is recommended to be split into two activities. One for universities (non-profit) and one for businesses (for-profit)	*Tabled.*
Working Group Nominations	General	Nick Talarico, TSL Inc (nrtalarico@tsl-inc.com)	
		Hardison Woods, NCAJ (dhw@hardisonwood.com)	
		Eric Bellamy, NCDMV (edbellamy@ncdot.gov)	

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
1-13	20-4.01	Definitions.	3 and 4	(23) Motor Vehicle. Consider if the definition should be revised to accommodate automated vehicle opertion. Redefine *(25) Operator* and possibly define a specific term for *vehicle operator* Define *automated vehicle* as part of *(27) passenger vehicles* Define *automated mode* Define *automated technology* Redefine *(19) manufacturer* and/or *(20) manufacturer's certificate* to account for automated technology manufacturers; include under description of *(49) vehicle* to include AV technology existence/make/model Redefine *(7) Driver* and *(25) Operator* to address autonomous vehicle operator definition (computer?) Define "For hire autonomous passenger vehicles" under (27) Passenger Vehicles	G.S. 20-138.1 Should *(32) Public Vehicular Area* be redefined in some way to define the areas that AV can operate? Are there any limitations of use of public roads? Do we define automated vehicle (allowing driver override; has automated mode and driver mode) and fully autonomous vehicle (no driver override How is "operator" defined in autonomous vehicles? In Nevada, people in autonomous vehicles are deemed not to be operating a motor vehicle for the purposes of the law. In Washington, D.C., AV requires a human driver "prepared to take control of the AV at any moment."
20	20-7.(a)	Issuance and renewal of drivers licenses.	3 and 4	Possibly add another description for *automated vehicles* under Class C Consider additional text to describe testing for those who wish to operate an AV, but are not commercial drivers. Consider adding endorsement for AV. *(a) License Required. - To drive a motor vehicle on a highway…* - Need to discuss the implications of AV and the license requirements. Should this include an exemption from driver's license law if the driver/operator is defined as a computer?	Level 3: Should there be a special license that allows the operation of an AV? Should there be a special vehicle classification for automated vehicles? Should people who are operating or testing automated vehicles be issued a special license classification from the DMV? Are Class B and Class C license holders allowed to operate an automated Class B/Class C vehicles? Will commercial automated vehicles be allowed? Should there be a special vehicle classification for automated vehicles? Level 4: Does a person in a fully autonomous vehicle need a driver's license of some form? If the driver/operator is a computer, then the manufacturer of the computer would have to make sure the computer is "licensed" to drive, which would be governed under rules for vehicle manufacturers?
23	20-7.(c1)	Insurance	3 and 4	Determine if operators of automated vehicles will have unique insurance requirements.	Does the owner need insurance? Or does the AV manufacturer?
32	20-8.	Persons exempt from license.	4	Determine if any person in an autonomous vehicle that does not operate the vehicle is considered a passenger and is exempt	Does this need to be stated explicitly? Technically they are passengers, not driver/operators. These sections concerning licensing all say "persons." Should there be a section specifically talking about on-board computer systems?
38	20-11.	Issuance of… drivers license to person who is less than 18 years old	4	Determine if additional language is required in relation to a learner's permit and provisional drivers license.	Can those under 18 "operate" an autonomous vehicle?
58	20-16.2. and 20-16.3	Implied consent to chemical analysis/Alcohol screening tests…	4	Will laws and regulations related to impaired driving impacted by the use of AV?	Are fully autonomous vehicle passengers exempt? Does there need to be a change in the statute for impaired drivers in automated mode?
89	20-20.1	Limited driving privilege for certain revocations.	3	Should this be revised relative to limited driving privilege according to the scope of privilege using automated mode on a vehicle?	Should drivers who have had their licenses revoked for whatever reason be allowed to operate an automated vehicle?
128	20-37.13	Commercial drivers license qualification standards	3	Need to discuss the potential need for provisions that qualify a person to operate an automated commercial vehicle.	
132	20-37.16(c)	Classifications and endorsements	3 and 4	Considerations include: an endorsement symbol and description for automated vehicles; qualification provisions for a driver to be allowed to operate AV – applicants may be required to demonstrate knowledge on AV operation and driver takeover	
152	20-52.(a)(2)	Application for registration and certificate of title	3 and 4	Consider the inclusion of text specific to whether the vehicle has automated technology installed and what make/model of technology is installed.	

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
152	20-52.(a)(4)	Application for registration and certificate of title	3 and 4	Should registration for a vehicle include the name of the AV technology manufacturer and installer; and date of installation? Should insurance details include the AV technology information? Should registration for vehicle be updated when the AV technology is removed or altered?	A statement that the owner is an eligible risk for insurance coverage as defined in G.S. 58-37-1(4a). G.S.58-37-1(4a). See what the insurance requirements are and if they need to be changed for operators of AV.
154	20-53.1.(a)	Specially constructed vehicle certificate of title and registration	3 and 4	Should the Title and registration for an AV have special denotation (e.g. "Autonomous/Automated Vehicle")? Should the vehicle certificate of title and registration include a special denotation if the vehicle is altered by a 3rd party (not the original vehicle manufacturer) to be alternately automated and fully controlled?	
164	20-61	Owner dismantling or wrecking vehicle to return evidence of	3 and 4	Should the DMV be notified and subsequent records be update if the AV technology is removed? Should this occur in a minimum number of days?	
165	20-63.(b)	Registration plates…	4	Consider the designation of a plate issued for an autonomous vehicle to include the designation of the word *autonomous* or similar?	Do we want special denotations on license plates or on the car itself for AV?
177	20-64	Transfer of registration plates to another	3 and 4	This section stipulates that plates can be assigned to another vehicle of *a like vehicle category.* Include documentation for the AV technology type and install date.	
179	20-66.(j)	Renewal of vehicle registration	3 and 4	Consider the additional of language specific to AV technology inspection and registration renewals.	Should there be a safety inspection for AV technologies overseen by the State?
180	20-70.	Division to be notified when another engine is installed or body changed	3 and 4	Similarly, Division should be notified if automated vehicle technology retrofit is installed	
189	20-79.	Dealer license plates	3 and 4	Include special provisions for cars with AV technology that are being test driven at dealers	
199	20-79.2	Transporter plates.	3 and 4	Consider the impact for the issuance of transporter plates on AV.	Should AV test vehicles use transporter plates?
261	20-87.	Passenger vehicle registration fees.	4	Are revisions needed for the fee structure to accommodate for AV and AV operating as for hire vehicles?	
274	20-107.	Injuring or tampering with vehicle.	3 and 4	Consider language that explicitly addresses someone tampering AV technology.	Would hacking autonomous technology be a misdemeanor or felony?
282/434	20-114./20-188.	Duty of officers; manner of enforcement./Duties of Highway Patrol.	3 and 4	Add that officers may adopt safety standards and performance requirements to ensure safe operation and testing to AV on public roads. (Like California?) Officers may also need new operating procedures for highway patrol.	
286	20-116.	Size of vehicles and loads	3 and 4	Will the size of vehicles and loads change relative to AV operations.	Are there any AV vehicle size/load limits? Would this be different than the current size/load limits?
305	20-121.1.	Operation of a low-speed vehicle on certain roadways.	3	Add low speed AV vehicle operation and testing Should have a similar section for allowable AV technology and any related restrictions A vehicle with Av technology shall be equipped with … (all mechanisms needed to allow a driver to take over control in accordance with all...)	
307	20.123.1.	Steering mechanism.	3 and 4	Add that vehicles with automated mode can be driver-overridden with the steering mechanism.	The steering mechanism of every self-propelled motor vehicle operated on the highway shall be maintained in good working order, sufficient to enable the operator to control the vehicle's movements and to maneuver it safely.
308	20-124.	Brakes.	3 and 4	Should this address the ability of a driver to override AV mode to apply brakes?	
311	20-127.	Windows and windshield wipers.	4	Will the restrictions and safety requirements related to windshields and wipers change for the operation of an AV?	Code of Federal Regulations, Title 49, Part 393, Window of a vehicle that is operated on a public street or highway is subject to these provisions Level 4: Would these window laws/requirements be different if the passengers do not need to see outside the vehicle?
323	20-135.4.	Certain automobile safety standards.	3 and 4	Need to confirm these align with changing AV technologies and do not restrict or limit the application of certain safety features that do comply with federal standards.	

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
325	20-137.3.	Unlawful use of a mobile phone by persons under 18 years of age.	3 and 4	Under (d) Exceptions, will restrictions be changed to allow the use of mobile phones if the car is in automated mode.	Level 3: if "the driver is expected to be available for occasional control, but with sufficiently comfortable transition time," would this allow texting and driving if the vehicle warns the driver to pay attention?
326	20-137.4.	Unlawful use of a mobile phone.	3 and 4	Under (d) Exceptions, will restrictions be changed to allow the use of mobile phones if the car is in automated mode.	Level 3: if "the driver is expected to be available for occasional control, but with sufficiently comfortable transition time," would this allow texting and driving if the vehicle warns the driver to pay attention?
326	20-137.4A.	Unlawful use of mobile telephone for text messaging or electronic mail.	3 and 4	Under (d) Exceptions, will restrictions be changed to allow the use of mobile phones for texting if the car is in automated mode.	Level 3: if "the driver is expected to be available for occasional control, but with sufficiently comfortable transition time," would this allow texting and driving if the vehicle warns the driver to pay attention?
331	20-138.1.	Impaired driving.	4	Would impaired driving laws be different for autonomous vehicles?	
331	20-138.2.	Impaired driving in commercial vehicle.	4	Would impaired driving laws be different for commercial autonomous vehicles?	
332	20-138.2A.	Operating a commercial vehicle after consuming alcohol.	4	Would impaired driving laws be different for commercial autonomous vehicles?	
332	20-138.2C.	Possession of alcoholic beverages while operating a commercial motor vehicle.	4	Would alcohol possession laws be different for commercial autonomous vehicles?	
336	20-138.7.	Transporting an open container of alcoholic beverage.	4	Would open container laws be different for autonomous vehicles?	
351	20-141.4.	Felony and misdemeanor death by vehicle; felony serious injury by vehicle…	3 and 4	If a vehicle is in automated mode and causes death, who is responsible – the operator or the autonomous technology manufacturer?	
358	20-146.2.	Rush hour traffic lanes authorized.	3 and 4	This section may require revisions if AV specific lane use is introduced for application in NC.	Would we want to either allow for the designation of an autonomous vehicle lane or roadway and/or include vehicles operating in automated mode avoid the HOV lane restrictions?
360	20-152.	Following too closely.	3 and 4	Vehicles on automated mode may follow closer, especially in a platoon of AV. Will this text require revision to allow for AV platoon operations?	
361	20-153.	Turning at intersections	3 and 4	Potentially require demarcations denoting that the vehicle is an AV, vehicle is a test vehicle, or other such designations.	
374	20-166.1.	Reports and investigations required in event of accident.	3 and 4	Determine if additional documentation should be required when a crash involves an AV that is testing. (proof of insurance for the AV manufacturer)	
377	20-169.	Powers of local authorities.	3 and 4	Will local authorities have the power or authority to prohibit the use of autonomous vehicles or automated technology on public roads?	
380-384	Part 10C	Operation of All-Terrain Vehicles	3 and 4	Possibly add Part 10D (unrelated to 10C) *Operation of Automated Vehicles* and explicitly state restrictions and rules for the technology and operator.	
406	20-183.3.	Scope of safety inspection and emissions inspection.	3 and 4	Add safety inspection of automated mode technology	Should the safety inspection fee be increased? Or another fee altogether? (20-183.7 page 413) Should these fees be distributed to an AV fund/account?

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
407	20-183.4.	License required to perform safety inspection; qualifications for license.	3 and 4	Need to expand the safety inspection license test to include instructions on how to test technology	
409	20-183.4C.	When a vehicle must be inspected; 10-day trip permit.	3 and 4	Vehicles retrofitted with automated technology must be inspected	
416	20-183.7B.	Acts that are Type I, II, or III safety violations	3 and 4	Include failure to inspect AV technology as one of the safety violations.	
427-428	20-183.13. Article IV	Compact enacted into law; form of Compact - Vehicle Equipment Safety Compact	3 and 4	No changes needed. Simply identification or relevant text. The Commission shall have power to: (b) Recommend and encourage the undertaking of research and testing in any aspect of equipment or related matters when, in its judgment, appropriate or sufficient research or testing has not been undertaken. (c) Contract for such equipment research and testing as one or more governmental agencies may agree to have contracted for by the Commission, provided that such governmental agency or agencies shall make available the funds necessary for such research and testing. (d) Recommend to the party states changes in law or policy with emphasis on uniformity of laws and administrative rules, regulations or codes which would promote effective governmental action or coordination in the prevention of equipment-related highway accidents or the mitigation of equipment-related highway safety problems.	How to direct the Vehicle Equipment Safety Commission to pursue research and testing on safe operation/testing of AV on NC public roads?
446	20-279.1.	Definitions	3 and 4	Need to clarify the responsibilities of the manufacturer in responding to damages caused by vehicle/technology.	
449	20-279.6	Further exceptions to requirement of security.	4	Should this state that it does not apply to people in an AV (not legally operating the vehicle)?	
454-455	20-279.19.-20.	Certificate of Insurance as proof	3 and 4	Add a section for automated vehicle technology manufacturer insurance as proof; include liability clarification that limits liability of original vehicle manufacturer on which a 3rd party installed automated system	
455	20-279.21	"Motor vehicle liability policy" defined.		Liability needs to be addressed, in terms of the transfer of liability from the original vehicle manufacturer to the manufacturer and/or installer of the AV equipment.	If the autonomous vehicle manufacturer is liable for crashes caused while in automated mode, how is the line drawn if the person in the vehicle takes control? How much coverage should the manufacturer have?
473	Article 10; 20-280	Financial Responsibility of Taxicab Operators	3 and 4	Need to determine how to address *taxicabs* with automated mode and how responsibility will be addressed.	Will taxicabs be allowed to use AV? Are AV taxis subject to different insurance rules? Would autonomous vehicle "taxis," autonomous cars for hire, still be considered taxis?
474	Article 11; 20-281.	Liability Insurance Required of Persons Engaged in Renting Motor Vehicles	4	Need to determine how to address *renting of motor vehicles* with automated mode and how responsibility will be addressed.	Will vehicle rental companies be allowed to rent AV?
476	20-286.	Definitions. (relating to renting motor vehicles)	3 and 4	Distinguish between the original vehicle manufacturer and the 3rd party that installs AV technology. Define *autonomous vehicle* Define *autonomous vehicle manufacturer*	

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
111	58-7-15(19)			"Motor vehicle or aircraft insurance" - Is this adequate for AV/CV technology operations? "…resulting from the ownership, maintenance or use of such liability."	
515	58-35-1	Definitions.	3 and 4	Possibly add a separate section dedicated to insurance premium financing specific to automated vehicles.	
515	58-35-10	Exceptions to license requirements	3 and 4	Possibly add an exception for instances where the OEM undertakes the insurance premium.	If the burden of insurance is shifted from the owner to the OEM how will this impact exceptions to the current laws.
515-516	58-35-15	Issuance or refusal of license; bond; duration of license; renewal; one office per license; display of license; notice of change of location.	3 and 4	*The Commissioner may require a bond not to exceed twenty-five thousand dollars ($25,000)* - need to discuss the implication of the bond and if it needs to be raised or lowered for automated vehicle insurers.	If the bond is increased a significant amount this may be a limiting factor for some insurers to engage in business, with that being said what would be an appropriate bond amount to protect the insurers and the insureds?
521	58-35-60	Prohibited provisions in insurance premium finance agreements	3 and 4	Suggest including a provision for not excluding automated vehicles or vehicles with automated capabilities.	
525 - 527	58-36-1	North Carolina Rate Bureau created.	3 and 4	The Rate Bureau has the potential to have significant adjustments over the longer term in rate calculations due to the likely decrease in crashes mitigated by autonomous features. *for liability insurance for such motor vehicles, automobile medical payments insurance, uninsured motorists coverage and other insurance coverages written in connection with the sale of such liability insurance* - with respect to all listed coverages here consider adding coverage for autonomous vehicles. *for liability insurance for such motor vehicles, automobile medical payments insurance, uninsured and underinsured motorists coverage and other insurance coverages written in connection with the sale of such liability insurance;* - consider adding a provision for insurance if you are hit by an autonomous vehicle. Similar to uninsured motorists coverage, autonomous coverage may be a new addition. *This subdivision does not apply to motor vehicles operated under certificates of authority from the Utilities Commission, the Interstate Commerce Commission, or their successor agencies, where insurance or other proof of financial responsibility is required by law or by regulations specifically applicable to such certificated vehicles.* - Consider modifying or adding a sentence to include autonomous vehicles under this exception if so desired. *it shall prepare a separate exhibit for the experience years in question showing the combined earnings realized from the investment of such reserves on policies written in this State.* - consider having the insurers report on the earnings from autonomous versus non-autonomous policies. Possibly include another clause in this section which addresses the need for different methods of rate calculations for autonomous versus non-autonomous vehicles.	Consider the impact to premiums if insurance companies are paying out less due to a decrease in crashes that can be attributed to autonomous vehicle features.
527	58-36-3	Limitation of scope; motorcycle endorsements allowed; Department of Insurance report.	3 and 4	It should be encouraged that this section not include an exception for autonomous vehicles and or vehicles with autonomous features.	
531	58-36-5	Membership as a prerequisite for writing insurance; governing committee; rules and regulations; expenses.	3 and 4	Recommend adding a sub-committee to the Bureau to be responsible for overseeing the proper incorporation of autonomous vehicles into their policies. The sub-committee should have a sunset provision after such a time it is no longer needed.	

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
532	58-36-10	Method of rate making; factors considered.	3 and 4	Rate making must consider and make provision for the difference between autonomous and non autonomous vehicles. Given the initial low proportion of autonomous versus non-autonomous vehicles there may be limited data available to demonstrate a statistically significant impact of autonomous features. The time periods for assessment in this section should re-evaluated on a recurring basis to ensure that they are appropriate. *Risks may be grouped by classifications and lines of insurance for establishment of rates, loss costs, and base premiums* - It is recommended that there be clear delineation of classification to determine rates for autonomous versus non autonomous vehicles in this section.	
533-536	58-36-15	Filing loss costs, rates, plans with Commissioner; public inspection of filings.	3 and 4	*paragraph (h) should include a provision for distinguishing between and reporting on autonomous and non-autonomous vehicles. A distinction should be made between these two vehicle types to better set rates appropriate to the safety features of the various types of vehicles.* The Bureau or Commissioner should give prior notice to the insurers to begin collecting and reporting statistics on autonomous vehicles.	
539	58-36-30	Deviations.	3 and 4	Consider adding a deviation (e) which is worded similarly to deviation (d) to allow for a deviation in a rate for autonomous versus non-autonomous vehicles.	
540	58-36-40	Existing rates, rating systems, territories, classifications and policy forms.	3 and 4	Consider amending the existing rate provision for rates in use on Sept 1, 1977 as these would not be applicable with the adoption of more autonomous vehicles to the overall vehicle fleet.	
540	58-36-41	Development of policy endorsement for exclusive use of original equipment manufactured crash parts.	3 and 4	This provision should be extended to the use of OEM autonomous systems, software, sensors, etc. Also the autonomous systems must be certified after repair to be in full working order.	
540	58-36-43	Optional program enhancements authorized not altering coverage under Rate Bureau jurisdiction.	3 and 4	Optional enhancements could potentially include coverage if your autonomous vehicle systems are subject to a malicious hack.	
542-543	58-36-65	Classifications and Safe Driver Incentive Plan for nonfleet private passenger motor vehicle insurance.	3 and 4	(a) (4) This section should be updated to include new classifications for level 3 and level 4 autonomous vehicles. *(a) (b) The Bureau shall file, subject to review, modification, and promulgation by the Commissioner, a Safe Driver Incentive Plan ("Plan")* - Consider redefining the contents for *Driving record* The Commissioner should be authorized to structure plans to provide for discounts below the rate otherwise charged for autonomous vehicles. Recommend including language to state that whenever any policy loses any autonomous vehicle the insured shall be informed of a rate change. *(e) Records of convictions for moving traffic violations to be considered under this section shall be obtained at least annually from the Division of Motor Vehicles and applied by the Bureau's member companies in accordance with rules to be established by the Bureau.* - Further discussion is necessary to identify whom may be at-fault for an autonomous vehicle and how this would impact ones moving violation record. *(h) If an insured disputes his insurer's determination that the operator of an insured* - redefine the term operator in this sentence.	

Indexing			Level	Stakeholder Discussions	
Page Number	Article / Section	Section Title	Level of Vehicle Automation	Suggested Focus	Discussion Questions
545-547	58-36-75	At-fault accidents and certain moving traffic violations under the Safe Driver Incentive Plan.	3 and 4	Redefine "at-fault" with respect to autonomous vehicles versus non-autonomous vehicles. Redefine and clarify "conviction" and "infraction" as it applies to the driver and the autonomous vehicle. A new and separate sub classification plan should be included in this section for autonomous vehicles. Redefine to whom an 'insurance point' is assessed to if an autonomous vehicle fails to yield to a pedestrian. *(h) The North Carolina Rate Bureau shall assign one insurance point under the Safe Driver Incentive Plan for persons who fail to yield to a pedestrian under* - Specify who a 'person' is in this statement.	
549	58-36-90	Prohibitions on using credit scoring to rate noncommercial private passenger motor vehicle and residential property insurance; exceptions	3 and 4	In paragraph (4) redefine "Noncommercial private passenger motor vehicle" and "private passenger motor vehicle" in relation to autonomous vehicles.	
550	58-36-95	Use of nonoriginal crash repair parts	3 and 4	This section should be updated to include provisions to state that autonomous vehicle systems, components, sensors , etc. critical to the autonomous functioning shall be replaced with OEM parts and certified after installation.	
557	58-37-1	Definitions		(4) and (4a) "Eligible risk" - consider if the definition should be expanded to address autonomous vehicles or autonomous vehicle manufacturers	
558	58-37-1	Definitions		(7) "Motor vehicle insurance" - consider redefining "…arising out of the ownership, operation, maintenance or use of a motor vehicle…". Does this sufficiently address AV technologies?	
558	58-37-1	Definitions		(8) "Person" - consider if the definition should be revised relative to AV technology (AV or AV manufacturer). "…natural person, firm, partnership, association, trust, limited liability company, firm, corporation, government, or governmental agency."	
597	58-40-10	Other definitions		(1) "Private passenger motor vehicle" - confirm the definition will not require revisions to accommodate AV/CV	