EVTC

Electric Vehicle Transportation Center

Automated and Connected Vehicle Implications and Analysis

David Block
Richard Raustad
Electric Vehicle Transportation Center
Florida Solar Energy Center
1679 Clearlake Road
Cocoa, FL 32922-5703
block@fsec.ucf.edu

Submitted as:
Final Research Project Report
EVTC Project 22 – Automated and Connected Vehicle Implications and Analysis

Submitted to:

Ms. Denise Dunn
Research and Innovative Technology Administration
1200 New Jersey Avenue, SE
Washington, DC 20590
E-mail: denise.dunn@dot.gov

Contract Number: DTRT13-G-UTC51
EVTC Report Number: FSEC-CR-2065-17

May 2017

University of Central Florida

Acknowledgements

This report is a final research report for Automated and Connected Vehicle Implications and Analysis project of the Electric Vehicle Transportation Center (EVTC) at the University of Central Florida (UCF). The Electric Vehicle Transportation Center is a University Transportation Center funded by the Research and Innovative Technology Administration of the U.S. Department of Transportation. The EVTC is a research and education center whose projects prepare the U.S. transportation system for the influx of electric vehicles into a sustainable transportation network and investigate the opportunity these vehicles present to enhance electric grid modernization efforts. The EVTC is led by UCF's Florida Solar Energy Center partners from UCF’s Departments of Electrical Engineering and Computer Science and Civil, Environmental and Construction Engineering, the University of Hawaii, and Tuskegee University.

The objective of the Automated and Connected Vehicle Implications and Analysis project was to evaluate the usage and implementation of automated and connected vehicles (AV/CV) through case studies with the results being applied to determine appropriate vehicle applications and how electric vehicles (EVs) will participate in this new transportation future. The work was conducted by David Block and Richard Raustad of the Florida Solar Energy Center.

Final Research Project Report

Automated and Connected Vehicle Implications and Analysis

David Block
Richard Raustad
Electric Vehicle Transportation Center (EVTC)
May 2017

1.0 Abstract

Automated and connected vehicles (ACV) and, in particular, autonomous vehicles have captured the interest of the public, industry and transportation authorities. ACVs can significantly reduce accidents, fuel consumption, pollution and the costs of congestion which in turn will offer a fundamental change to the future U.S. transportation network. The objective of this project was to evaluate ACV technologies, activities, laws and policies that are now in place or proposed and to assess future ACV usage. The assessment also evaluates the highest level of automated vehicles called autonomous or self-driving vehicles and includes how electric vehicles (EVs) will participate in the future ACV transportation system. The results show that the three areas of largest activities are: (1) Autonomous vehicle development and demonstration, (2) Connected vehicle and their application to safety improvements, and (3) The interaction between autonomous and electric vehicles. The future dollar value in ACV technologies is huge with multi-billion dollar investments being made by auto manufacturers, ride sharing companies and technological innovators all seeking to establish their positions. Due to the electro-mechanical nature of the ACV technology, electric propulsion will likely dominate future transportation. This is due to regulatory reasons (no urban emissions) and other attributes of EVs (having fewer moving parts, reduced maintenance, and capability to be configured to drive, steer, brake and recharge by wire).

2.0 Introduction

This report represents the final project report for the EVTC's Automated and Connected Vehicle Implications and Analysis project and contains new and updated information from the previous project report listed below:

1. Block, D., Kettles, D., Harrison, J. (2016). Automated, Autonomous and Connected Vehicle Technology Assessment (FSEC Rep. No. FSEC-CR-2020-16) Cocoa, FL: Florida Solar Energy Center.

At the federal level, the U.S. Department of Transportation (US DOT), in September 2016, issued its policy for automated vehicles which set an approach to providing safety assurance and facilitating innovation through four key parts; vehicle performance, state policy, regulatory tools, and new tools and authorities [1]. In the fall of 2016, the US DOT and the Federal Highway Administration also set the vision of eliminating fatalities and serious injuries on the nation's roadways [2]. Other new actions at the federal level are being addressed by the new administration, but these actions are not yet published.

A recent published paper [3] entitled "The Autonomous Vehicle Revolution—Fostering Innovation with Smart Regulation" has been published by the Center for the Study of the Presidency & Congress (CSPC). This paper was developed in order to address the policies and make recommendations with regard to ACV technologies. The work by CSPC convened off-the-record round-tables in Washington, D.C.; San Francisco, CA; and Seattle, WA with the goal of beginning a dialogue between the government and private sectors and identifying solutions to potential problems. This publication presents political and regulatory factors, the roles of Congress and the federal government and selected state level regulations and policies. The paper also lists 10 recommendations and discusses planning for the future.

3.0 Research Results

As noted in Report 1 above, the activities related to automated, autonomous and connected vehicles (ACV) and their use can be divided into two areas - one being the technology research and development done by scientists and engineers from the automakers, universities and information technologists (IT) and the other being the actions by federal, state and local governments whose actions in R&D, laws, policies and demonstrations are needed and required to implement these technologies.

3.1 Definitions and Classifications

The definitions for automated, autonomous and connected vehicles are as follows:

- Automated vehicles utilize some level of convenience or safety-critical control functions that occur without direct driver input. In defining automated vehicles there are two basic delineations - automated as defined in the previous sentence and autonomous which is defined as a driverless or self-driving vehicle.
- Connected vehicles (CV) employ vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications to provide real-time warnings to driver or autonomous control system to help avoid crashes and increase vehicle efficiency. Information can also include traffic signal status, traffic congestion and pedestrian and construction warnings, as well as impending severe weather events. CV technologies can allow non-vehicular systems such as the traffic signal control system to react to real-time information from the vehicle.

Equipping vehicles with ACV technologies will significantly reduce crashes, energy consumption, pollution and traffic congestion. These vehicle types will require some dedicated infrastructure development, however, most of the technology required will be embedded in the vehicle itself and interactions with existing communication networks (i.e., cellular, satellite, etc.).

An ACV classification is based on six different levels (ranging from none to fully automated systems) published in 2014 by SAE International [4]. This classification system is based on the amount of driver intervention and attentiveness required, and not on the vehicle capabilities, however, these two are closely related. The SAE standard has now replaced the National Highway Traffic Safety Administration (NHTSA) classification system as of September 2016.

SAE automated vehicle classifications are:

- Level 0: Automated system has no vehicle control, but may issue warnings.
- Level 1: Driver must be ready to take control at any time. Automated system may include features such as Adaptive Cruise Control (ACC), Parking Assistance with automated steering, and Lane Keeping Assistance (LKA) Type II in any combination.
- Level 2: The driver is obliged to detect objects and events and respond if the automated system fails to respond properly. The automated system executes accelerating, braking, and steering. The automated system can deactivate immediately upon takeover by the driver.
- Level 3: Within known, limited environments (such as freeways), the driver can safely turn their attention away from driving tasks, but must still be prepared to take control when needed.
- Level 4: The automated system can control the vehicle in all but a few environments such as severe weather. The driver must enable the automated system only when it is safe to do so. When enabled, driver attention is not required.
- Level 5: Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive and make its own decisions.

At the present time almost all vehicles have some type of automated functions. Examples are: anti-locking brakes, lane departure warning, blind spot monitoring, back-up cameras and sensing, automatic collision notification, intelligent or automatic parking assist, night vision with object detection, adaptive cruise control, adaptive headlights and forward collision warning. The classification functions at the levels of 0, 1 and 2 require a human driver to perform all or part of the vehicle operation. The classifications at the levels of 3 and 4 require the driver to monitor the driving environment and level 5 is the completely autonomous mode with no driver assistance.

OEM examples include the auto pilot technology introduced by Tesla Motor Co in October 2015 and the selling of Level 2 vehicles by Cadillac, BMW and Mercedes-Benz in 2017. Level 5, full self-driving automation vehicles have been demonstrated by many auto companies and organizations that include Google, Carnegie Mellon University, Mercedes-Benz, GM, Nissan, Audi, and Uber, to name a few.

3.2 Autonomous Vehicles

Autonomous or "self-driving" vehicles are defined as "Other than setting the destination and starting the system, no human intervention is required. The automatic system can drive to any location where it is legal to drive to and make its own decisions." There is no required driver and the vehicles may not have a steering wheel.

Autonomous vehicles sense their surroundings with techniques such as radar, LIDAR, GPS, odometry and computer vision. Advanced control systems interpret sensory information to identify appropriate navigation paths, as well as obstacles and relevant signage. By definition, autonomous vehicles are capable of updating their maps based on sensory input, allowing the vehicles to keep track of their position even when conditions change or when they enter uncharted environments. Autonomous cars will have control systems that are capable of analyzing sensory data to distinguish between different cars on the road. A graphic of such a vehicle is shown in Figure 1 [5].

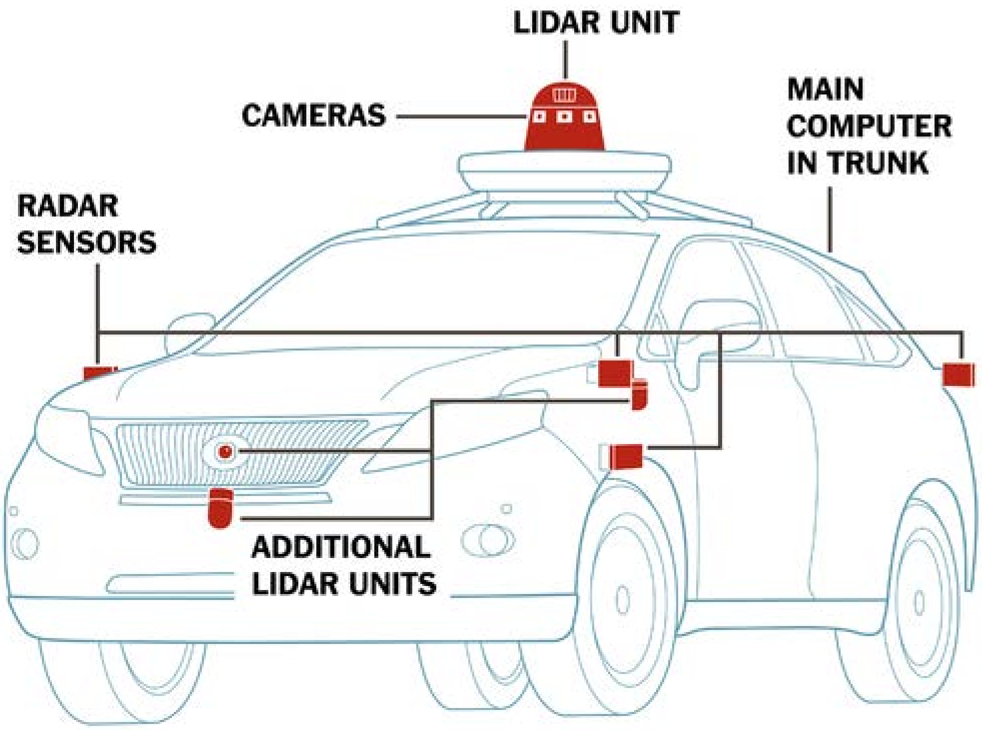

Figure 1. Examples of Autonomous Vehicle Control Systems [5]

How autonomous vehicles will look in the future is still being debated. A self-driving vehicle could eliminate the steering wheel while personal vehicles will most likely remain the same. However, the future will likely see a fleet of self-driving and shared vehicles filling the streets of towns and cities.

As stated in Report 1, driverless or autonomous vehicles will usher in a revolution in both safety and fuel efficiency. A study has found the potential for a reduction of up to 90 percent in driving fatalities by using self-driving cars is due to the fact that computers are so much better drivers than error-and distraction-prone humans. In the U.S. alone, this would equate to about 30,000 lives saved each year and up to $190 billion in annual savings from healthcare costs associated with accidents. This translates to 10 million lives saved globally each decade [6]. Autonomous vehicle technology has the potential to make the US DOT and the FHWA vision to eliminate fatalities within 30 years a reality.

In the energy area, driverless cars and car-sharing services could save up to 90 percent of the fuel currently consumed, mainly through “right-sizing” the vehicle required for each task [7]. For example, if a person needs a quick ride five miles from town, a single-person self-driving EV would pick that passenger up and take him or her to the desired destination. If a family needs an electric SUV for a beach excursion, that could be provided. By right-sizing each vehicle for each trip, the needless transportation of tons of steel would be dramatically reduced from today's highly wasteful default driving situation. In addition, driverless cars can be actively driven for far more hours in the day through car-share services like Uber and Lyft, further increasing the efficiency of the entire transportation system [8].

The advantages of autonomous vehicles are many; however, there are challenges and obstacles to be overcome. For example, items such as who is liable for accident damage; IT software reliability and compromise; laws and regulations for use; loss of drivers ability to control the auto; drivers being inexperienced if manual driving is required; the elimination of jobs (e.g., taxi drivers); privacy and ethical issues in an unavoidable crash or the ability of systems to operate in extreme weather conditions such as ice or snow are known challenges. In fact, tests have already been conducted that show autonomous vehicles have the same difficulties as humans do on snow or ice [9]. There is also the issue of public acceptance of the vehicle being controlled by a machine instead of a human. A recent Washington Post article did a story "Will the public accept the fatal mistakes of self-driving cars?" This article presents information on the public's negative impression of a machines thinking for them [10].

How close are we to self-driving cars? The news is filled with stories. Noteworthy ones are:

1. Tesla has deployed its autopilot technology over the cellular phone network for self-driving on highways and familiar roads beginning in October 2015.
2. Uber placed self-driving cars in the downtown area of Pittsburg, PA in September 2016. The cars are Uber modified Ford Fusion hybrids outfitted with more than 20 cameras, seven lasers, a spinning 360-degree laser-based detection system and over 1000 aftermarket parts to drive the vehicle.
3. Ford plans to build self-driving cars within 5 years.
4. Ride-sharing companies are moving rapidly to self-driving and EVs for a variety of reasons.
5. A driverless bus has been operating in Helsinki, Finland (November 2016).

3.3 Electric Vehicles and ACV

The technological development and public interest in two major automobile innovations – EVs and ACVs -- have progressed and emerged in an almost parallel time fashion [11]. Do they need each other? The answer is no, but almost all future predictions point to their integration. Lux Research makes this case based on six good reasons as follows [11]:

- Technology-focused early vehicle purchasers want both innovations in the same car -- Automotive innovations are expensive, and they come to premium cars first. As these innovations eventually trickle down and become more affordable, the initial pairing demanded by early purchasers will carry on through to the mass market, as well.
- It is easier to implement autonomous features on EVs -- Because of sensors and advanced computing hardware and software, self-driving cars require more from a car's electrical subsystem, and ICE engines still largely use 12 V electrical systems, running off a single

lead-acid battery. EV battery packs allow for large voltages and increased energy stored giving more options to ACV vehicles**.** It is also simpler to control an electric motor and battery pack than an internal combustion engine, with its thousands of moving parts and complex cabling (for example, “drive by wire” technology is a more natural fit for EVs).

- Wireless charging integrates seamlessly with autonomy -- A self-driving ICE car will have a hard time filling itself with gasoline. Wireless charging, does away with this issue. **A**n autonomous car can drive to an open parking spot, align itself properly, and self-charge using wireless charging. Wireless charging is also more efficient as a function of alignment – and self-driving cars will be able to park themselves optimally, every time, to ensure the highest possible wireless charging efficiency. Finally, EVs enable “opportunistic charging”; rather than waiting until the battery pack is nearly depleted, an EV can charge itself when it is between driving duties.
- More efficient self-driving extends range, which mitigates EV range anxiety -- Early studies indicate that self-driving technology may improve driving efficiency by 5% to 10%, thanks to smoother braking and acceleration, as well as more logical coasting and regenerative braking.
- Both technologies will mature at about the same time.
- Both technologies have high probabilities of being mandated by governments -- As EVs become more affordable and more mainstream, the idea of governments allowing OEMs to sell ICE-powered cars will be seen as increasingly irresponsible. A number of governments around the world are already debating about when to ban the sale of ICE-powered cars. That will not happen for a while, but the time will come when the ICE could be regulated out of existence. Similarly, once driver assist features conclusively prove that they are much safer than human drivers, governments will mandate that they become standard equipment, just like they did with airbags, anti-lock brakes, electronic stability control, and other innovations. These issues could force the coexistence of both technologies.

3.4 Connected Vehicles

Connected vehicles use any of a number of different communication technologies to wirelessly communicate with the driver, other cars on the road (V2V), roadside infrastructure (V2I), and with bikes, pedestrians or others (V2X). CV technology can improve vehicle safety, improve vehicle efficiency, improve commuting times and greatly reduce crashes. This technology will also reduce the need for new infrastructure (less vehicles on the road), improve energy efficiency by more efficient driving, reduce travel times, provide lighter, more fuel-efficient vehicles and create more efficient infrastructure that will reduce energy consumption and expand opportunities for vehicle ownership by allowing multiple owners to share a self-driving vehicle.

With regard to wireless communication, almost all cars after 2010 have in-dash communication systems with a touch-screen offering items such as music/audio, navigation, roadside assistance, parking apps and engine control and diagnostics. On EV vehicles, phone apps offer battery charge status and charging station location and distance. For safety and automation, the connectivity should be bi-directional which means communication between vehicles and with the infrastructure and with the communication in both directions.

For these communications, the final standards are yet to be established. In one effort, the US DOT in a joint research effort with SAE is setting V2V and V2I communication standards, such as using a 5 GHz frequency for transmission. This 5G specification is not completed. However, car companies are moving forward which means compatibility issues may arise. For example, the 2017 Cadillac CTS will use a dedicated short-range communications (DSRC) for a hazard warning systems for up to about 1000 ft., but the Cadillac system will not recognize a similar system on a BMW or Mercedes-Benz car which use cellular networks [12].

How this bi-directional communication system will occur is still unknown. The three systems – DSRC, cellular based or satellite based -- all have pluses and minuses. Using direct communication between vehicles, the short-range systems are not slowed down by having to communicate with a cellular or satellite base stations and they could be rolled out without any major infrastructure investments. In the case of cellular systems, they may not work in the large parts of rural America that does not have cellular service. Other challenges are issues with security, privacy, data analytics, and aggregation due to the abundance of data associated with the vehicles. And, the increased technical complexity of vehicles makes them more prone to "bugs" and other system malfunctions that can effectively immobilize an ACV.

For the wireless 5G system, designers point out that it can include direct vehicle-to-vehicle communication that do not depend on a separate cell network. The 5G network could be up to twice as fast as dedicated short-range communications devices and the 5G is a forward-looking platform that could be used to handle demanding, high-bandwidth applications like transmitting a video feed from a car's onboard camera to the internet to collect information about road conditions. There is also a critical need for the communication system to have up-to-date navigational maps which can place the vehicle's exact position within a few yards [13].

3.5 Laws, Policies and Governmental Actions

One of the most important aspects of ACV technology development is the enactment of laws and policies and research supported by the federal, state and local governments. This section looks at laws, policies and actions that have been enacted beginning with the federal actions followed by the states. Note is made that almost all of the enacted laws and policies refer to autonomous vehicles and do not specifically mention automated or connected vehicles. In addition, the intent of the U.S. laws, policies and actions are to promote the use of safer vehicles by the public as quickly as possible without hindering technology development.

3.5.1 Federal Actions

U.S. Department of Transportation (US DOT) -- The US DOT has been the lead federal agency in charge of the development of ACV polices. The DOT actions are summarized as follows:

- National Highway Traffic Safety Administration's (NHTSA) produced its Preliminary Statement of Policy on Autonomous Vehicles in May 2013.
- In September 2016, the US DOT issued its policy for automated vehicles. This policy sets an approach to providing safety assurance and facilitating innovation through four key

parts. Vehicle performance guidance uses a 15-point Safety Assessment to set clear expectations for manufacturers developing and deploying automated vehicle technologies. Model state policy delineates the Federal and State roles for the regulation of highly automated vehicle technologies as part of an effort to build a consistent national framework of laws to govern self-driving vehicles. Finally, the policy outlines options for the further use of current federal authorities to expedite the safe introduction of highly automated vehicles into the marketplace, as well as discusses new tools and authorities the federal government may need as the technology evolves and is deployed more widely. The full policy and additional materials can be found at www.transportation.gov/AV.

- Awards of $42 million, in September 2015, to three Wave 1 participants in the Connected Vehicle Pilot Deployment Program. The three Wave 1 sites are using connected vehicle technologies to improve safe and efficient truck movement along I-80 in southern Wyoming, using vehicle-to-vehicle (V2V) and intersection communications to improve vehicle flow and pedestrian safety in high-priority corridors in New York City and deploying multiple safety and mobility applications on and in proximity to reversible freeway lanes in Tampa, Florida.
- Initiating and funding the Smart Cities Challenge project in which the winning city of Columbus, OH will receive up to $40 million from US DOT and up to $10 million from Paul G. Allen's Vulcan Inc. to supplement the $90 million that the city has already raised from other private partners to carry out a Smart City plan. The Smart City Challenge will integrate the ACV into a city transportation system and will provide the critical needed test case for the technologies.
- The Smart City Challenge has also initiated several non-federal Smart City programs, such as Smart Cities Innovation Challenge, Smart Cities Startup Challenge and Smart Cities Conference and Expo. See: Smart Cities Connect Conference and Expo connect@techconnect.org.
- In the fall of 2016, the US DOT and the Federal Highway Administration set a 30 year vision of eliminating fatalities and serious injuries on the nation's roadways [2].
- Announced, on January 22, 2017, the selection of 10 designated "proving ground" test pilot sites for autonomous vehicles, which are intended to play host to the rapid in-depth testing of the technology. The 10 selections are mostly unsurprising, as most have been the site of autonomous vehicle testing for some time now. They are: City of Pittsburgh and the Thomas D Larson Pennsylvania Transportation Institute, Texas AV Proving Grounds Partnership, US Army Aberdeen Test Center, American Center for Mobility (ACM) at Willow Run, Contra Costa Transportation Authority (CCTA) & GoMentum Station, San Diego Association of Governments, Iowa City Area Development Group, University of Wisconsin-Madison, Central Florida Automated Vehicle Partners and North Carolina Turnpike Authority.

U. S. Department of Energy -- The U. S. Department of Energy (DOE) has numerous programs directed at EVs and to a lesser extent to ACV technologies. The EV programs have the goals of cutting battery costs from $500/kWh down to $125/kWh, increasing energy density from 50 Wh/L to 400 Wh/L, eliminating almost 30% of vehicle weight through light-weight materials, and reducing the cost of electric drive systems from $40/kW to $8/kW. The DOE EV program is now in its 5th year and progress has been made in all of the stated goals [14, 15].

In the ACV area, DOE has funded 3 projects that all look at modelling of potential energy savings from ACVs. These programs are operated under Argonne National Lab and the University of Michigan.

In addition, DOE's Advanced Research Projects Agency-Energy (ARPA-E), in November 2016, announced $32 million in funding for 10 innovative projects as part of its newest program: Next-Generation Energy Technologies for Connected and Autonomous On-Road Vehicles (NEXTCAR) [16]. As today's vehicles become creators and consumers of more and more data, there is a transformative opportunity to put this new information to the additional use of saving energy in our road transportation system by "co-optimizing" the interactions between vehicle dynamic controls, like accelerator and braking input, and powertrain controls that manage engines, motors and transmissions. NEXTCAR technologies offer efficiency-boosting solutions like smarter cruise control and vehicle speed harmonization, or energy-saving options for approaching and departing from traffic signals. By integrating these systems with data from emerging ACV technologies, vehicles will be able to predict future driving conditions and events like changing lane or the interacting with other vehicles merging from multiple intersections. The goal of NEXTCAR program is to develop technologies that will improve the energy efficiency of future connected and automated vehicles by at least 20 percent beyond other planned vehicle efficiency improvements.

3.5.2 State Legislative Actions

Each year, the number of states considering legislation related to autonomous vehicles has gradually increased [17]. The following are the present statistics:

- States have continuously introduced legislation. In 2017, 33 states introduced legislation, in 2016, 20 states introduced legislation, in 2015, 16 states introduced legislation, up from 12 states in 2014, nine states and D.C. in 2013, and six states in 2012.
- Since 2012, at least 41 states and D.C. have considered legislation related to autonomous vehicles.
- Thirteen states—Alabama, Arkansas, California, Florida, Louisiana, Michigan, New York, Nevada, North Dakota, Pennsylvania, Tennessee, Utah and Virginia—and Washington D.C. have passed legislation related to autonomous vehicles.
- Governors in Arizona and Massachusetts issued executive orders related to autonomous vehicles.

The state map of autonomous legislation acts follows.

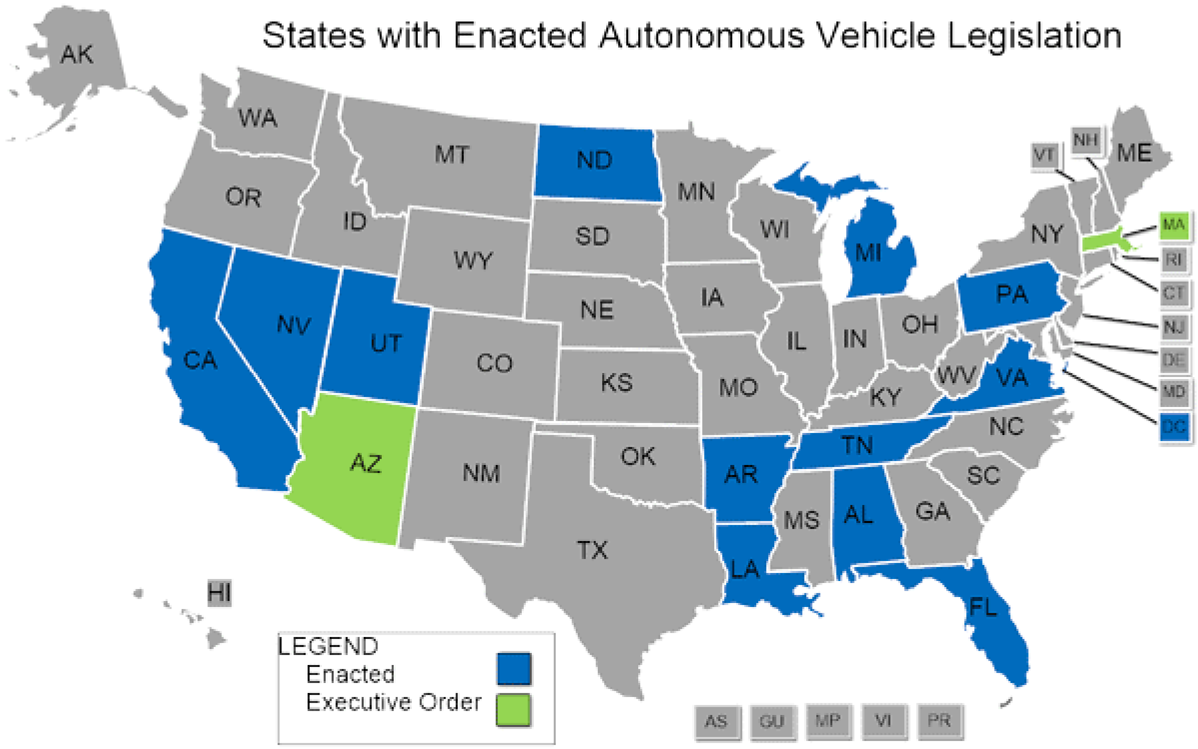

Figure 2. States with Enacted Autonomous Vehicle Legislation
From: National Conference of State Legislatures [15]

The actions of these thirteen states and D.C. are summarized as follows [17]:

- Alabama established a Joint Legislative Committee to study self-driving cars.
- Arizona's Governor signed an executive order in late August 2015 directing various agencies to "undertake any necessary steps to support the testing and operation of self-driving vehicles on public roads within Arizona." He also ordered the enabling of pilot programs at selected universities and developed rules to be followed by the programs. The order established a Self-Driving Vehicle Oversight Committee within the governor's office.
- Arkansas regulates the testing of vehicles with autonomous technology and vehicles equipped with driver-assistive truck platooning systems.
- California legislation defined "autonomous technology," "autonomous vehicle," and "operator". It requires rulemaking; permits current operation under certain conditions; imposes additional oversight on the operation of vehicles without a human in the driver's seat; and requires that the "manufacturer of the autonomous technology installed on a vehicle shall provide a written disclosure to the purchaser of an autonomous vehicle that describes what information is collected by the autonomous technology equipped on the vehicle. It authorizes the Contra Costa Transportation Authority to conduct a pilot project for the testing of autonomous vehicles that are not equipped with a steering wheel, a brake pedal, an accelerator, or an operator inside the vehicle.
- Florida was the second state to adopt legislation allowing for automated vehicle testing on public roadways (in 2012). Florida Statue 316.86 addresses the testing of automated

vehicles, financial responsibility and includes exemption from liability for a manufacturer when a third party converts a vehicle. It also has a law for autonomous vehicle title certificates and the Legislature mandated a study of a driver-assistive truck platooning project.

- Louisiana has defined autonomous technology for purposes of the Highway Regulatory Act.
- Massachusetts Governor signed an executive order in October 2016, "To Promote the Testing and Deployment of Highly Automated Driving Technologies."
- Michigan has defined "automated technology," "automated vehicle," "automated mode," and "upfitter," and expressly permits testing of automated vehicles by certain parties under certain conditions. Michigan has also defined "operator", addressed liability of the original manufacturer of a vehicle on which a third party has installed an automated system and directed the state DOT with the Secretary of State to submit a report. As noted in [3], the Michigan law has an overly strict definition of "manufacturer" that appears to lock all but major automobile manufacturers out of the autonomous vehicle and ride sharing market. Major companies such as Apple, Google, Lyft, and Uber have all expressed their concerns about the legislation, which requires that companies operating autonomous vehicles in Michigan be an automobile manufacture, defined by selling vehicles that meet Federal Motor Vehicle Safety Standards.
- Nevada was the first state to authorize the operation of autonomous vehicles in 2011. Nevada has defined "autonomous vehicle" and directed state DMV to adopt rules for license endorsement and for operation, including insurance, safety standards, and testing.
- North Dakota has established a legislative management study of automated vehicles.
- New York allows autonomous vehicle tests and demonstrations, specifies requirements for operation, defines autonomous vehicle technology and dynamic driving task and requires a report on testing and demonstration.
- Pennsylvania funded the use of $40 million for intelligent transportation system applications.
- Tennessee legislation prohibits local governments from prohibiting the use of a vehicle solely on the basis of it being equipped with autonomous technology if the vehicle otherwise complies with applicable safety regulations, defines "autonomous technology" as technology "that has the capability to drive a motor vehicle without the active physical control or monitoring by a human operator."
- Utah has authorized the state DOT to conduct a connected vehicle testing program. Requires a study for autonomous vehicles that evaluates appropriate safety features, regulatory strategies and develops recommendations.
- Virginia's governor announced in early June 2015 a partnership allowing research and development for autonomous vehicles to take place in the state with "Virginia Automated Corridors."
- Washington D.C. has defined "autonomous vehicle," required a human driver be "prepared to take control of the autonomous vehicle at any moment," restricted conversion to recent vehicles, and addresses liability of the original manufacturer of a converted vehicle. Passed Congressional review (April 2013).

3.5.3 Case Study of Florida Department of Transportation (FDOT) AV/CV Program

Because of its active program, the Florida Department of Transportation (FDOT) is used as a case study for ACV projects at the state level. The FDOT program was presented in detail in Report 1 and it will be summarized and updated here.

The FDOT plan for the deployment of AV/CV technologies on Florida's public roadways has been established through its Florida Automated Vehicles (FAV) initiative. The FAV initiative deploys pilot projects to establish Florida as a leader by leading by example and in being an early adopter of the technology. The FAV will create the framework for implementation by engaging stakeholders, by developing research and pilot projects, and by creating awareness of the technologies and how they support FDOT's vision statement.

The major activities are [18]:

- Using Stakeholder Working Groups to provide recommendations on policies and legal issues, infrastructure development and modal applications,
- Funding university based research projects for over 10 years,
- Conducting a connected vehicle for freight mobility project,
- Assessing advanced driver assistance systems through a Tampa Bay area program,
- Conducting a Florida Public Transit Association emerging technologies survey,
- Conducting a $17 million U.S. DOT Connected Vehicle Pilot Deployment Program by the Tampa Hillsborough Expressway Authority,
- Conducting yearly Autonomous and Connected Vehicle Conferences, and
- Recognizing Autonomous Vehicle Roadway Test Beds in the Tampa Bay region and at Florida Polytechnic University.

4.0 Conclusions

This report has presented an assessment and evaluation of the technologies, actions and the laws and policies that are in place for automated and connected vehicles. The combination of automation and connectivity can significantly reduce crashes, energy consumption, pollution and the costs of congestion which in turn will offer a fundamental change to the U.S. transportation network and system. The results show that autonomous vehicles are receiving the most attention from the general public and the government agencies. The report has also shown that electric vehicle stakeholders will be a major participant and partner in the new ACV transportation system. And, the future is bright with multi-billion dollar investments being made by auto manufacturers, ride sharing companies and technological innovators who are all looking for positions in the new vehicle future.

5.0 Impacts/Benefits

The application of automated and connected vehicles (ACV) can fundamentally change the U.S. transportation network by reducing crashes, energy consumption, pollution and the costs of congestion. This project evaluated present ACV usage through case studies and has set the stage for planners to use these results to determine how ACVs and EVs will participate in this emerging transportation system. Planners, engineers and innovators working in both the ACV and EV areas must develop meaningful partnerships that bridge the two technologies and facilitate their inevitable integration in the future. These partnerships will bridge the divide, since inevitably the two technologies will merge, resulting in something greater than the sum of the parts.

6.0 References

1. U.S. Department of Transportation, National Highway traffic Safety Administration, "Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety," September 2016.
2. U.S. Department of Transportation, Federal Highway Administration, "Toward Zero Deaths," https://safety.fhwa.dot.gov/tzd/, 2016.
3. Center for the Study of the Presidency & Congress; The Autonomous Vehicle Revolution—Fostering Innovation with Smart Regulation, March 2017.
4. Levels of Driving Automation defined in new SAE International Standard J3016," SAE International, "Automated Driving, January 2014.
5. Gates, G., et. al., "When Cars Drive Themselves," New York Times, December 14, 2016.
6. Lafrance, A., "Self-Driving Cars Could Save 300,000 Lives per Decade in America: Automation on the roads could be the great public-health achievement of the 21st century," The Atlantic, September 29, 2015.
7. Hunt, T., "The Solar Singularity Is Getting Closer," GTM, Green Tech Media, January 6, 2016.
8. Zimmer, J., "The Third Transportation Revolution, Lyft's Vision for the Next Ten Years and Beyond," The Road Ahead, September 2016.
9. Gareffa, P., "Ford, Google Self-Driving Cars Tackle Challenges of Snow and Rain," Edmunds.com, January 12, 2016.
10. Overly, S., "Will the public accept the fatal mistakes of self-driving cars?" The Washington Post, March 1, 2017.
11. Laslau, C. "Six Reasons Why Electric Vehicles and Autonomous Vehicles Will Inevitable Merge," Lux Research, September 2016.
12. Quain, J., "Cars Will Talk to One Another. Exactly How Is Less Certain", New York Times, March 9, 2017.
13. Boudette, N., "Building a Road Map for the Self-Driving Car," New York Times, March 2, 2017.
14. Block, D., Brooker, P., 2016, "2015 Electric Vehicle Market Summary and Barriers," FSEC-CR-2027-16, Cocoa, FL, Florida Solar Energy Center.
15. U.S. Department of Energy, "EV everywhere Grand Challenge road to success," DOE/EE-1024, January 2014.
16. Energy.gov, "Department of Energy Announces 10 New Projects to Improve Connected and Automated Vehicle Efficiency," November 2016.
17. National Conference of State Legislatures, Autonomous Vehicles, Self-Driving Vehicles Enacted Legislation, February 2017.
18. The Florida Automated Vehicles Initiative, 2016 Design Training Expo, Florida Automated Vehicles, June 14, 2016.