11.0 EMERGING TECHNOLOGIES

New and emerging technologies have the potential to drastically reshape the region's transportation system. Alternative fuel and autonomous vehicles have the potential to reduce greenhouse gas emissions and health threats, improve traffic flow on our highways, and increase safety for drivers and vulnerable road users. However, if deployed prematurely or utilized incorrectly, they also present new hazards that we need to be prepared to address. Additionally, advancements in technologies for large vehicles, including buses and trucks, and increasing access to assisted or powered micro-mobility all will have an impact on the region. Though these technologies may not be ready for mass adoption as of the publishing of this report, it is possible that any or all of them may dramatically reshape getting around the Greater Naugatuck Valley.

In recent years, many automobile manufacturers began to offer a range of driver assistance devices that help drivers avoid collisions. The key feature of these systems is the driver remains in control. The evolution of technology to operate a vehicle and take control from the driver is accelerating. Fully automated cars and trucks are currently in widescale testing around the country and are likely to be widespread between now and 2045. Several of these technologies allow for autonomous driving on highways today, and current beta testing software can attempt to navigate complex urban streets as well. At the same time, wireless communication is increasing the ability to exchange information between vehicles and with roadside devices. As inter-vehicle communication advances, drivers will become better informed about their surroundings and the position of nearby vehicles.

The goals of these technologies are to make travel safer and reduce the number of crashes. They also have the potential of reducing congestion by at least 35%, according to research from the University of Cambridge[1]. There will likely also be impacts to the amount of parking needed, the total number of vehicles on the road, and, potentially, the amount of energy used by those vehicles.

[1] https://www.sciencedaily.com/releases/2019/05/190519191641.htm

11.1 INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

ITS refers to using advanced technologies to better manage and operate transportation systems. It is defined as: *"the application of advanced sensor, computer, electronics, and communication technologies and management strategies—in an integrated manner—to improve the safety and efficiency of the surface transportation system".* These advanced systems include computer hardware or software, traffic control devices, communications links, and remote detectors. The intent is to realize a more seamless transportation system with reduced delays and conflicts and increased systems integration, interoperability, and communication. *ITS* projects need to be consistent with the *National ITS Architecture* and must satisfy a defined set of user services defined by FHWA.

The National ITS Architecture defines eight broad service areas:

- Advanced Traffic Management Systems (ATMS):

  These systems include: CCTV cameras, computerized traffic signal systems, dynamic message signs, highway advisory radio, and traffic incident management systems.

- Advanced Public Transportation Systems (APTS):

  These systems include: Computer aided dispatch (CAD), automatic vehicle location (AVL), automated payment systems, transit signal priority, and fare technology.

- Advanced Traveler Information Systems (ATIS):

  These systems include: Traveler information websites, 511 travel information call centers.

- Emergency Management (EM):

  These systems include: Service patrols, infrastructure protection, and disaster response and recovery.

- Maintenance and Construction Management (CM):

  These systems include: Vehicle and equipment GPS, route deployment, road weather information systems (RWIS), work zone management and safety management.

- Archived Data Management (ADM):

  These systems include: Data warehouses and *ITS* databases.

- Commercial Vehicle Operations (CVO):

  These systems include: Roadside enforcement, automated roadside safety inspection, weigh-in-motion technology, vehicle electronic clearance, and on-board safety and security monitoring.

- Advanced Vehicle Safety Systems (AVSS):

  These systems include: Intersection, longitudinal and lateral collision avoidance, vehicle safety monitoring, automated vehicle operations, and vision enhancement systems.

Through the application of *ITS*, travel conditions can be determined more quickly, traffic controls can automatically respond to changing traffic conditions, and real-time information can be disseminated. In order to realize these benefits, ITS must be fully incorporated into the surface transportation network and work together to deliver transportation services. In other words, *ITS* must be "mainstreamed" into the overall transportation planning and project development processes that exist in the state and region. To accomplish this mainstreaming, the development and deployment of *ITS* actions must be advanced through the existing transportation planning process in the region.

The *National ITS Architecture* provides a common structure for the design of intelligent transportation systems and a framework around which multiple design approaches can be developed, each one specifically tailored to meet the individual needs of the user, while maintaining the benefits of a common architecture. It is a mature product that reflects the contributions of a broad cross-section of the *ITS* community (transportation practitioners, systems engineers, system developers, technology specialists, consultants, etc.). The architecture is functionally oriented, not technology specific. It defines what needs to be done (functions) as opposed to how it will be done (technology). In this way, the architecture can remain valid and current even as technology changes.

The architecture defines the following elements:

- The functions – gather traffic information or request a route – that are required for *ITS*.
- The physical entities, or subsystems, where these functions reside – the field, roadside, or vehicle.
- The information flows and data flows that connect these functions and physical subsystems together into an integrated system.

The intent of developing and deploying intelligent transportation systems is to realize a more seamless transportation system with reduced traveler delays, quicker response to highway incidents, better traveler information, enhanced and more efficient transit operations, and improved safety and reduced number of crashes. Integration of these services and seamless communication among operators offers the opportunity of increased traveler efficiency and better management of transportation resources.

In the Naugatuck Valley planning region, *ITS* projects conform to the state architecture and focus on three broad areas:

- Freeway Incident Management: The CTDOT operates 24-hour incident management centers in Bridgeport and Newington. The program includes monitoring of traffic and detection of incidents along I-95, I-91, I-691 and I-84. The program should be expanded to include coverage along Route 8 through the region. The project would include the installation of video cameras along the highway and speed detectors to monitoring operations and identify incidents. Including Route 8 in the state's incident management system will reduce response time when an incident occurs and reduce congestion and delay caused by an incident.

- Enhanced Highway Corridor Operations: The proposed program would integrate existing and planned traffic control devices to enhance and coordinate arterial traffic control systems. The intent will be to monitor traffic operations and institute timing changes in response to traffic conditions in real time. The system may also provide transit signal priority.

- Real Time Traveler Information System: The proposed system would provide information to transit travelers on vehicle location, schedule adherence, and delays. The project would install interactive information kiosks and dynamic message signs at the region's commuter rail stations. Advancements in vehicle location tracking have allowed similar systems to be implemented on bus systems throughout the country. In many cases, this information can be delivered directly to a user's smartphone through transit agency apps.

11.2 AUTONOMOUS VEHICLES

Autonomous vehicles, or AVs, refer to vehicles that have been mounted with a variety of sensors, cameras, and other sensing devices to allow the vehicle to operate with varying combinations of autonomy and driver control. The deployment of AVs is increasing in popularity and many communities are considering or are operating AVs. However, since they rely on the ability of sensors and cameras to detect and recognize the road environment, weather, poor road condition and lines of sight have impacted AVs capabilities to move safely and consistent with driver expectations.

The transition from driver control to vehicle control has been defined by six levels of automation by the Society of Automotive Engineers (SAE), ranging from no automation (Level 0) to full automation (Level 5):

SAE Levels of Automation	
Level 0	The human driver does all the driving
Level 1	An advanced driver assistance system (ADAS) on the vehicle can sometimes assist the human driver with either steering or braking/accelerating, but not both simultaneously.
Level 2	An advanced driver assistance system (ADAS) on the vehicle can itself actually control both steering and braking/accelerating simultaneously under some circumstances. The human driver must continue to pay full attention ("monitor the driving environment") at all times and perform the rest of the driving task.
Level 3	An Automated Driving System (ADS) on the vehicle can itself perform all aspects of the driving task under some circumstances. In those circumstances, the human driver must be ready to take back control at any time when the ADS requests the human driver to do so. In all other circumstances, the human driver performs the driving task.
Level 4	An Automated Driving System (ADS) on the vehicle can itself perform all driving tasks and monitor the driving environment – essentially, do all the driving – in certain circumstances. The human need not pay attention in those circumstances.
Level 5	An Automated Driving System (ADS) on the vehicle can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving.

Table 1 SAE Levels of Automation Source: National Highway Safety Traffic Safety Administration, https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety#issue-road-self-driving

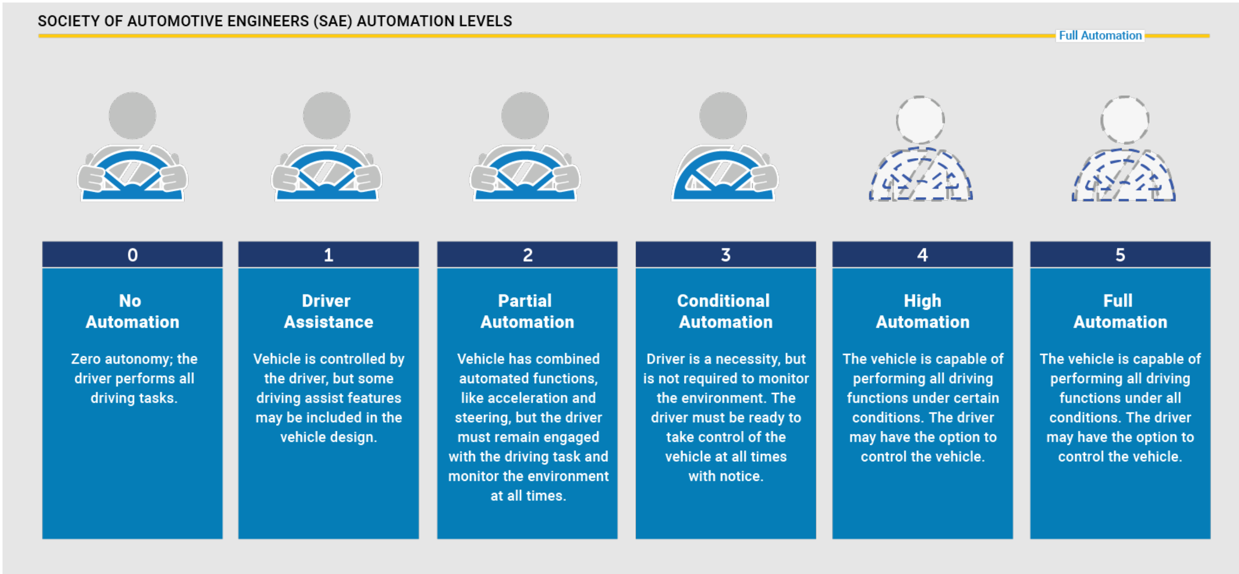

Figure 1 SAE Levels of Automation Source: https://www.mdpi.com/1424-8220/21/16/5397/html

While AV technology is advancing, acceptance of US drivers will be critical to deployment. A recent survey by the American Automobile Association (AAA, December 2017) indicated 54% of US drivers would be afraid to ride in a fully automated vehicle. This is down from the 63% and 78% marks for the same question from earlier surveys. Acceptance has come a long way, but there is still significant increases public support needed. The AAA survey also determined that safety and reliability are the greatest concern about AVs. Education will be critical to increasing AV acceptance. Notably, Covid-19 did not alter the acceptance of AVs significantly. Motorists, passengers, and those sharing the road with an autonomous vehicle must be confident that the technology works and is not prone to errors. To achieve the level of trustworthiness required for acceptance, there must be truth in advertising – the sensors must work according to manufacturer claims and manufacturers must be transparent with shortcomings or failures of their systems.

Currently, AV technology is being developed along two separate paths:

- Private ownership
- Shared mobility

The approach based on private vehicle ownership is being driven by the auto industry. These companies are developing and offering driver assistance equipment as options on generally higher end vehicles. Examples include:

- Crossing traffic warning rear and front
- Night vision
- Lateral parking aid

- Distance information
- Land departure warning
- Wrong way assist
- Lane changing warning
- Approach control warning with braking function
- Speed limit and No Pass information
- Parking assistant – Sensors to detect front and rear collisions while parking and remote control parking
- Steering and lane control assistant
- Active cruise control with Stop & Go function
- Rear collision prevention

These features are intended to aid the driver and assume that the driver remains in control.

Figure 2 AV owned and used by Uber® Source: https://www.nbcnews.com/business/autos/brave-new-world-why-when-we-ll-go-drivers-passengers-n785876

The other AV development and deployment path involves technology companies and “ride hailing companies” (also referred to as Transportation Network Companies or TNCs). Technology companies, such as Google, and TNCs, such as Uber and Lyft, are working towards developing driverless vehicles that enhance their businesses. Instead of a private person owning the AV, a company owns a fleet of AVs that are shared by many. They would provide on-demand service. Several companies are striving to achieve levels 4 and 5 automation for their services which would decrease the need for many individuals to own personal vehicles as AVs become more widespread within ride service businesses.

Regardless of which path AV advancement and deployment follows there will be significant changes within the on-street transportation system. There are numerous benefits to AV technology, most importantly when it comes to traffic safety. Roughly 95% of serious crashes (NHTSA) are due to human error. Driver assistance features that warn drivers about the vehicles position relative to other vehicles have the potential to greatly reduce human error from the crash equation and, thereby, greatly reducing the number and severity of vehicle collisions.

Other cited benefits include Enhanced mobility where increased deployment of fully automated vehicles will provide new mobility options to persons that are unable to drive, either due to age or disability. Economic benefits are significant because vehicle crashes cost billions of dollars in economic activity, productivity, loss of life and decreased quality of life due to injuries. Decreased congestion due to vehicles with high levels of autonomy operating in closer proximity at higher speeds, which helps reduce impedance and congestion.

Conversely, the potential exists for negative consequences from the proliferation of AVs. While reduced congestion is perceived as a possible benefit, deployment of large AV fleets can add more vehicles to our roads, increasing vehicle miles traveled (VMT) and, as a result, increasing traffic congestion, especially in urban/downtown areas. An additional concern of AVs is the potential impact on transit services. As AVs deployed by Transit Network Companies (TNCs, i.e. Uber, Lyft, etc.) become common, bus ridership may decline. The TNC AV fleet would provide on-demand, point-to-point service, as opposed to fixed-route service offered by public transit. Riders would no longer be captive to a bus schedule, long headway and set route. In this scenario, one bus would be replaced by multiple vehicles with disperse boarding and alighting stops, potentially having a significant impact on urban congestion.

However, in the future public transit and TNCs may be able to partner for mutual benefit. The AV fleets could help solve the “first mile/last mile” problem and fill gaps in regular bus service, especially on weekends and late-night hours. The applicability also extends to trucks and home deliveries as goods get distributed throughout a network as they head towards their destination.

Advancements in autonomous technology could result in driverless buses that could help reduce costs to operate services or encourage smaller transit vehicles, operated more frequently. In addition to more frequent service, autonomous buses can have their schedules modified to account for shifts in passenger demand dynamically changing their routes and frequency. This technology can be applied to both local bus routes and bus rapid transit systems between urban areas on dedicated bus lanes. Both forms of transit will lead to increased capacity and efficiency due to autonomous vehicles.

The potential impact on land use decisions is also uncertain currently. The deployment of fully automated vehicles may spur interest in denser, mixed use urban centers where a substantial portion of the fleet will be shared. Or, because of the increase in mobility and ability to perform other activities instead of driving, interest in development in auto-dependent suburban areas may increase.

Many cities and states, including Connecticut, have begun testing autonomous technologies on their roadways. Some of these pilots are testing multi-passenger vehicles or shuttles, while others are requesting vendor proposals to demonstrate the capabilities of individual vehicles. These projects are aiming to prove that the technology can reliably work while also identifying potential threats to successful implementation. One such threat, identified in several studies around the country, is the need for streets to remain in a state of good repair, most importantly ensuring that pavement markings, signage, and traffic signals are all clearly readable and working correctly.

Route 8 over the Tingue Dam, Seymour

11.3 CONNECTED VEHICLES

Connected vehicles, or CVs, rely on wireless communications between vehicles or to and from a vehicle and roadside infrastructure. The communication links provide valuable and timely information to the vehicle regarding the position of other vehicles as well as the status of road devices, such as traffic signals, or roadway conditions. Whereas an AV operates in isolation from other vehicles using its internal sensors, CVs communicate with nearby vehicles and infrastructure.

When discussing connected vehicle technologies, how the vehicles communicate with the world around them is fundamental. Vehicle communications fall under five categories:

- *Vehicle-to-Vehicle* – V2V
- *Vehicle-to-Cloud* – V2C
- *Vehicle-to-Infrastructure* – V2I
- *Vehicle-to-Anything* – V2X
- *Vehicle-to-Pedestrian* – V2P

When connected to other vehicles, the communications are referred to as *"Vehicle-to-Vehicle"* or V2V. This type of connectivity works whenever similarly equipped vehicles encounter one another and is currently being experimented on highways throughout the nation. An advantage of V2V technologies is that they can be implemented with no change to the current roadway.

Vehicle-to-Cloud or V2C involves the transmission of information from a vehicle to a cloud-based server that then communicates the information to another vehicle. *Coordinated Adaptive Cruise Control* (CACC) offers a good example of a V2C technology. A majority of AV testing around the world utilize V2C to ensure the data transferred to and from the AV is secure. This system involves two or more vehicles connected to a cloud-based server and allows the vehicles to find each other on the highway and connect in route. The CACC technologies then help the vehicles synchronize their speeds to create a platoon. The lead vehicle broadcasts its actions to all trailing vehicles using V2V communications. Similarly, trailing vehicles broadcast their information to the other vehicles in the platoon.

Communications with roadside devices is referred to as *"Vehicle-to-Infrastructure"* or V2I. These systems require roadside units be installed to work. The flow of information is bi-directional and is typically handled by *Dedicated Short Range Communication* (DSRC) frequency. DSRC is a broadcast mode on a dedicated frequency or channel. The range is short, typically about 900 feet, but provides fast and reliable communications with minimal delay. DSRC can be deployed relatively easily; it is a mature, proven, and stable technology. However, the installation of devices to receive and transmit information to and from the vehicle is the responsibility of auto manufacturers and state and local agencies are responsible for installing the roadside infrastructure. An example of V2I systems that is being deployed and tested involves communications between vehicles and traffic signal systems. The status of the signal is transmitted to vehicles and allows the vehicle to adjust speed as it approaches the intersection. The intent is to reduce the number of complete stops and improve the traffic flow along the interconnected corridor. Roadside infrastructure can also be installed that provide weather and road condition reports. This permits the vehicle to adjust its movement accordingly.

Wireless communications, currently via 5G, are also being developed that rely on smartphone apps to connect roadside units and on-board units to pedestrians; *Vehicle-to-Pedestrian* or V2P communication. It is a non-broadcast mode with unlimited range, with communications processed through a server. These systems can inform vehicles of the pedestrian's presence and location, as well as transmit a request to activate the pedestrian phase and signal as the pedestrian approaches the intersection.

Figure 3 Demonstration of connected vehicle technology Source: https://www.itsinternational.com/feature/frequency-changes-threaten-vehicle-safety-applications

As with AVs, the primary goal of CV deployment is improved road safety and driver behavior:

- V2V Safety Applications:
  - Communicating Radar Cruise Control
  - Forward Collision Warning
  - Emergency Electronic Brake Light
  - Blind Spot Warning
  - Lane Change Warning/Assist
  - Intersection Movement Assist
  - Vehicle Turning Right in Front of Bus Warning
- V2I Safety Applications:
  - Traffic Signal Change Advisory
  - Right Turn Collision Caution
  - Red Light Violation Warning
  - Speed Compliance
  - Curve Speed Compliance
  - Speed Compliance in Work Zone
  - Oversize Vehicle Compliance – Prohibited Facilities (Parkways); Over Height warning
  - Pedestrian in Crosswalk
  - Pedestrian Signal
  - Emergency Communications and Evacuation Information

In the coming decades, the increase in vehicles connected to each other and roadside units should help contribute to improved efficiency on existing highways, allowing vehicles to better take advantage of the available space. Inter-vehicle communication will help fill gaps in the road and allow cars to seamlessly merge and maintain relative speeds and spacing.

The principal challenges facing CV deployment are:

- Market penetration – need to get devices installed in vehicles.
- Security – need to encrypt systems to prevent cyber vulnerabilities.
- Privacy – need to scrub data to eliminate identity and personal information.
- Mainstream acceptance and public perception.
- Budget for implementing and maintaining roadside infrastructure.

The integration of AV and CV systems and technologies has the potential to enhance the performance of both. Communication of data from roadside infrastructure to an AV would permit the vehicle to operate more efficiently as it would not have to rely solely on on-board sensors. The use of CV technology would transmit information about surrounding vehicles, location, and road environment, and has the potential to ameliorate weather, poor road maintenance, and lines of sight problems that impede the operation of AVs.

11.4 CONNECTED AND AUTONOMOUS TRUCKS

While the prospects for widespread acceptance of connected and autonomous vehicle technologies and systems loom large on the horizon of transportation planning, the potential implication these systems could have on motor carrier freight transportation is enormous. The trucking industry is a $700 billion industry and truck borne freight has the potential to be revolutionized by the introduction of connected and autonomous trucks.

Currently, there is a shortage of both truck drivers and truck parking. Trucks going to pick up shipments and driving them to their destination require breaks for drivers for 30 minutes as well as rest stops after their shift so the driver can sleep. This required activity is currently creating truck parking shortages across the country. Autonomous trucks can provide a long term solution to this problem. Additionally, High fuel costs (about 24% of operating expenses), vehicle repair and maintenance (about 9% of operating expenses), in addition to wages and benefits (about 43% of operating expenses) contribute to the trucking industry's low profit margin in research performed in 2018 by American Transportation Research Institute.

These market forces and environmental concerns make the industry a prime candidate for any advanced technology that can improve operations and performance and reduce costs. Demonstrated benefits include:

- Safety – reduce the frequency and severity of commercial vehicle crashes.
- Fuel savings – reduced air drag and wind resistance from platooned vehicles improves fuel efficiencies about 10.0% for the rear vehicle and 4.5% for the front vehicle.
- Air quality – reduced fuel consumptions reduced diesel emissions. The potential for electric or alternative fuel trucks can have an even greater impact on air quality while also reducing pollution from fossil fuel extraction and refining.
- Mobility – improved information for drivers and fleet managers will increase freight throughput and efficiency.

As an intermediate step to fully automated commercial vehicles, many companies are working to deploy level 1 and 2 automation in the freight industry. These technologies rely on the driver remaining in control of the vehicle with cameras (video optics), sensors (RADAR and LIDAR) and communications (DSRC and wireless 4G or 5G) equipment to allow information to be broadcast to and from the vehicles. These technologies generally provide for the vehicles to be connected but also afford a certain level of automation.

- Active Safety Systems

  Currently, active monitoring systems are being installed in many commercial vehicles to improve safety and reduce the severity of crashes. Examples of systems:

- Electronic stability control to control speed and traction over curves and poor weather conditions.
    - Forward collision avoidance and warning, with automated braking system – RADAR systems can sense and identify obstacles farther in front of a vehicle than the driver and can automated braking systems can respond and react faster than the driver.
    - Adaptive cruise control – automatically adjusts speed to maintain distance from a vehicle in front of the truck.
    - Lane change assist – sensors identify the presence of vehicles in the adjacent lane and warn the driver.
    - Lane keeping system – sensors help maintain the vehicle within the travel lane.

- Automated Driving Systems (ADS)

  Over the next 20 years, full automation of both heavy duty and light weight vehicles will be a reality. Proponents claim that self-driving trucks will be safer and less costly to operate. While currently private companies are working on ADS units, standardization of communications, backed by new regulations or regulatory buy-in, is required to realize widespread deployment.

  Several companies such as Daimler Trucks, Watch Plus, Waymo, and TuSimple are performing level 4 autonomous vehicle testing with trucks. Some of these tests occurred on highways with no actual driver behind the wheel to intervene. Testing is occurring in more predictable environments, often at locations with clearer skies and no ice and snow. These tests have been occurring for several years and widespread commercial deployment is inevitable.

- Truck Platoons

  Connected and autonomous trucks can closely coordinate their movements to platoon over long stretches of highway. Currently available systems control truck platoons via DSRC communications. With the driver manually steering the truck, the lead vehicle controls longitudinal movement of the platoon via the throttle and brakes. The systems can be disengaged from the trailing vehicles at any time and video is provided to the trailing trucks to allow drivers to see what the lead driver sees. Truck platoons operate

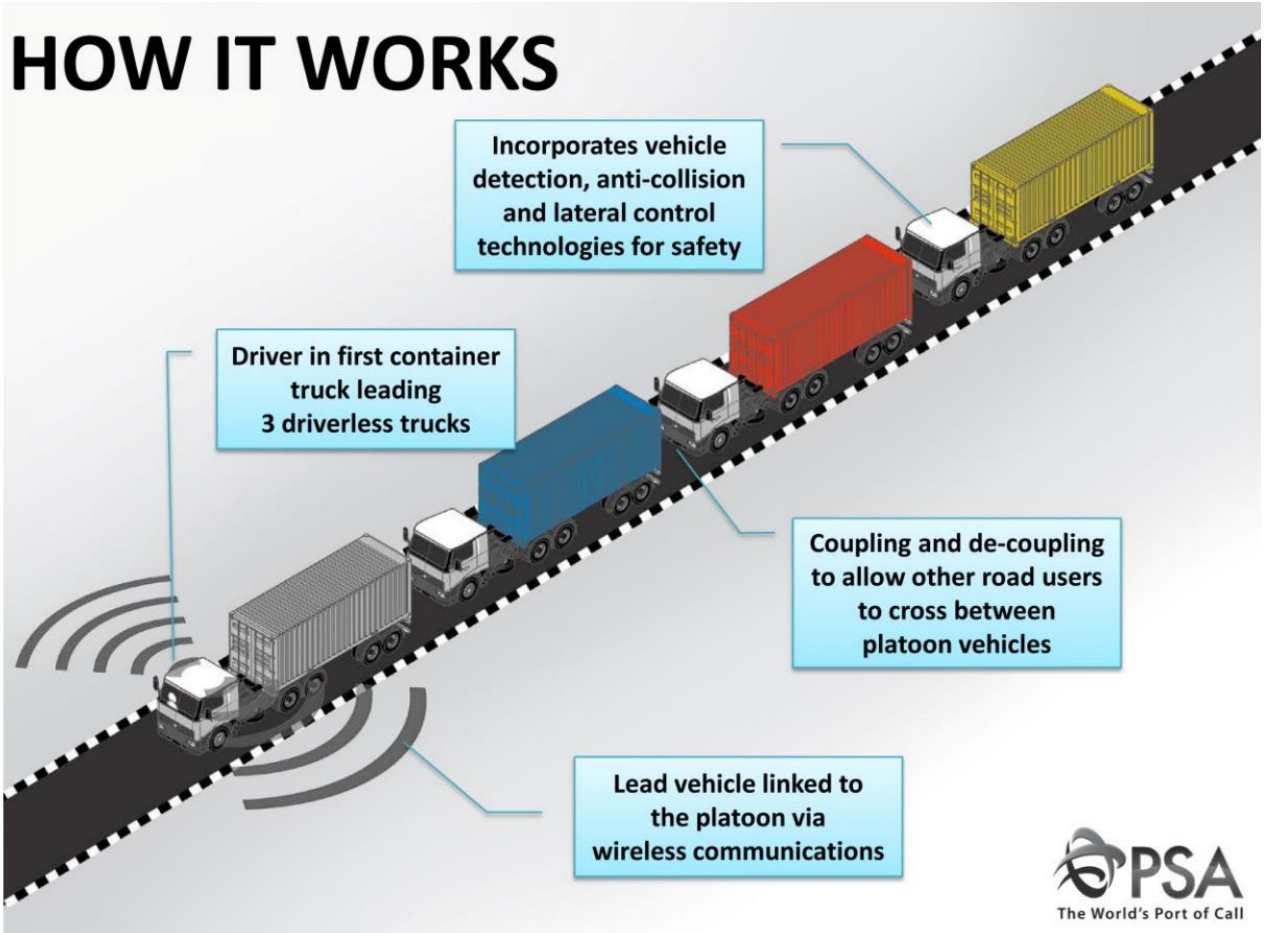

Figure 4 Diagram on how truck platoons works Source: https://newatlas.com/self-driving-trucks-singapore-ports/47360/

almost exclusively on multi-lane, divided limited access highways and interstates and when traffic and weather conditions are acceptable.

Truck platoons cut wind resistance and air drag by setting and maintaining a constant gap between trucks. This reduces fuel consumption by roughly 10.0% and 4.5% for the trailing trucks and lead truck respectively. Traffic flow also improves as the truck platoon maintains spacing and pace. These systems can also detect a vehicle crossing in between platooned vehicles and automatically adjusts speeds to maintain a safe following distance.

Front mounted radar can “see” farther than the driver and can react faster and apply brakes quicker to obstacles in front of the truck. These systems improve safety and help prevent crashes.

Once these technologies have been thoroughly vetted, in order to employ them on the state highway network, laws pertaining to following distance will need to be set to ensure safety and the driving experience for other road users is not eroded. These regulatory adjustments can be made with no new costs.

- AV Vehicle Standardization

Standardization has been pursued by the 3rd Generation Partnership Project (3GPP), where there are two competing standards for AV communication, C-V2X and DSRC. C-V2X, deployed in 2021, uses Long Term Evolution, 5G technology, and LTE technology when 5G data is not available. This system uses cellular data that is not tied to a specific network and the coverage range exceeds one mile. Additional improvements are being investigated such as changing the utilization spectrum from 3.4 GHz to 5.9 GHz. Major steps recently have started to make the 5.9 GHz the new standard with direction from USDOT. With this, most AV deployments in recent years have used the 5.9 GHz frequency as the main method of communication between other AVs and related infrastructure.

DSRC has been used in AVs since 2017 and was adopted in 2019. It is based on Wi-Fi technology that allows for V2V, V2I, and V2X communications. This is a short-range form of communication that allows the AV to communicate with several nearby vehicles, infrastructure, and other forms of transportation.

There is ongoing debate between the C-V2X system and DSRC system. However, many automotive industry companies are supporting C-V2X 5.9 GHz, so it is likely it becomes the main method of AV communication. Despite this, many predict AV’s using both forms of communication as the complement each other for effective short-range and long-range communication.

11.5 STATE AND FEDERAL CAV PROGRAMS AND PILOT PROJECTS

TNC companies such as Uber and Lyft, auto manufacturers such as Toyota, GM, and Ford, and technology companies such as Good and Panasonic are investing into the design and development of CAV systems and technologies, as well as purchase vehicle fleets to deploy their ADS. The commonality of these efforts is that they are being made by the private sector with low public involvement. However, a successful path to safe testing and deployment of ADS requires government oversight, engagement of key stakeholders, and development of uniform, consistent and reciprocal polices, regulations, and standards. In addition, the deployment of V2I roadside units will require the investment of public funds.

Nevada was the first state to authorize the operation of autonomous vehicles in 2011. Since then, 21 other states—**Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Louisiana, Michigan, New York, North Carolina, North Dakota, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, and Vermont**—and **Washington D.C**. have passed legislation related to autonomous vehicles. Governors in **Arizona, Delaware, Hawaii, Idaho, Maine, Massachusetts, Minnesota, Ohio, Washington,** and **Wisconsin** have issued executive orders related to autonomous vehicles.

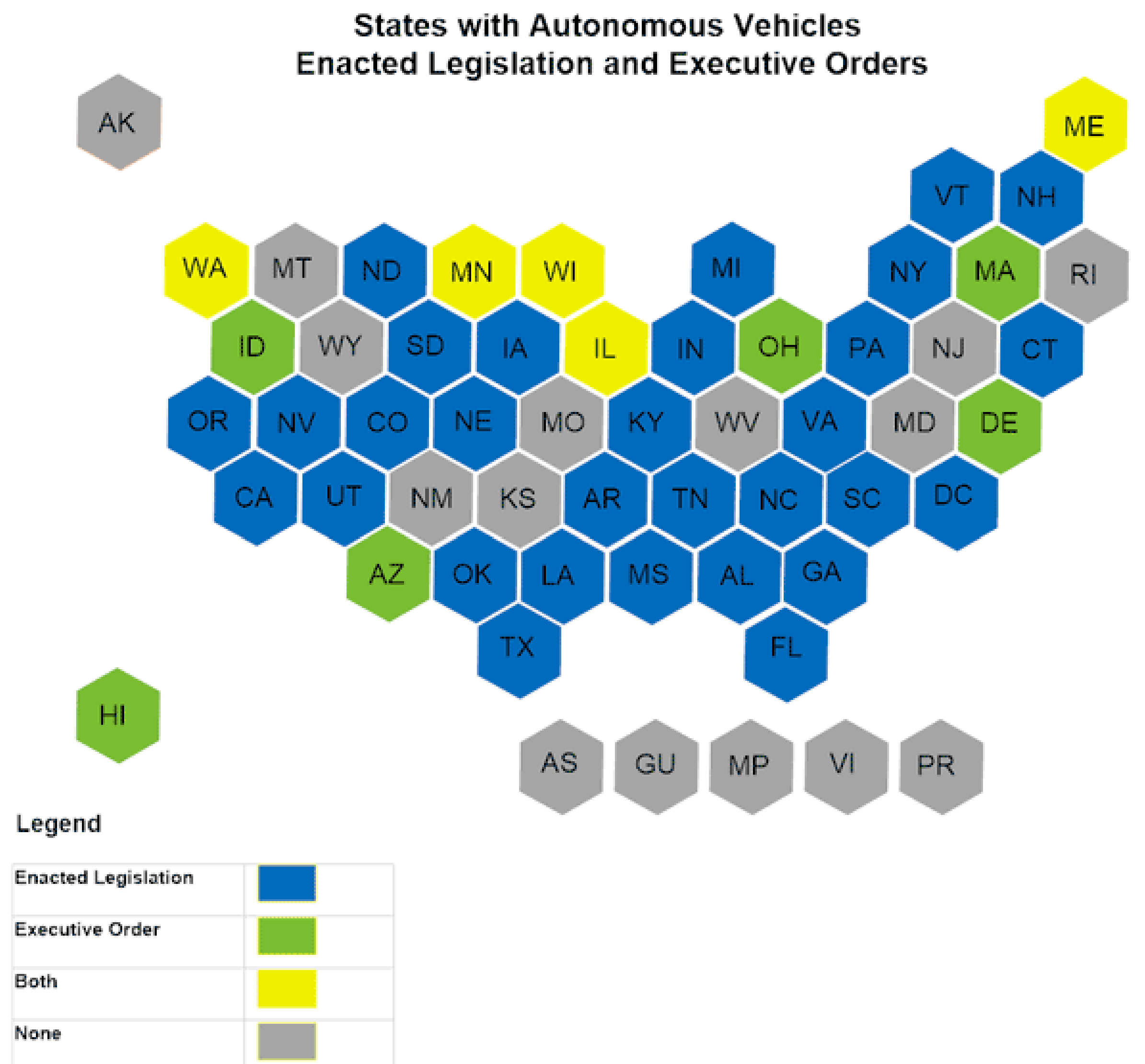

Figure 5 States that have executive orders related to AV's Source: https://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx (National Conference of State Legislatures)

These state actions typically establish committees, commissions, or work groups to develop guidelines for the testing of AVs on public roads and support deployment of AVs. Some legislation requires the presence of an operator while other states allow AVs to operate on their own. Despite differences in language, the goal of the legislation is to encourage partnerships with the private sector to ensure safe testing and ultimate deployment of AVs.

Connecticut has initiated efforts to test connected and autonomous vehicle systems and technologies. The following are brief overviews of some these efforts:

- Connecticut

  In 2017, the State of Connecticut enacted legislation (Public Act 17-69) that authorized the state to establish and implement a pilot program for testing fully autonomous vehicles, as defined as either Level 4 or Level 5 on the SAE classification scale. Under the program, the Office of Policy and Management will solicit AV proposals and select up to four municipalities to participate in the program. Two of the selected participants need to meet set population thresholds and targets. The program is being initiated in consultation with the Department of Motor Vehicles (DMV), Department of Transportation (DOT), Department of Emergency Services and Public Protection (DESPP) and the Connecticut Insurance Department (CID).

  The pilot program aims to encourage and allow for the testing of fully autonomous vehicles on local roadways in Connecticut. The municipalities must outline the location and routes where AVs may operate, hours of operation for vehicle testing, as well as record the make, year, and model of the test vehicles. Partnerships with an automated vehicle manufacturer, university, and service provider (Lyft, Uber, etc.) are encouraged for purposes of providing shuttle services and other programs. The legislation requires a tester to be seat in the driver's seat and be capable of taking immediate control of the AV and prohibits testing on limited access highways.

  The legislation also established a task force to study fully autonomous vehicles, evaluate the pilot program, and develop recommendations on how Connecticut should promote and regulate AVs in the state.

  OPM received its first applications in 2018.

  In 2021 CTDOT published a strategic plan specifically for AVs. CTDOT refers to this technology as Connected and Autonomous Vehicles (CAV). The strategic plan can be found on their website[2]. The vision of the plan is to ensure CAV transportation is safe and to determine ways that CAV technology can be used as a powerful tool to improve safety. Near-term, CTDOT will focus on policy development, infrastructure preparation, and developing pilot test programs. Long-term, CTDOT will establish a feedback loop to engage with the public to continue to advance, policies, technology, larger deployments, and upgrade infrastructure to support CAV.

  CTDOT plans to launch full-sized autonomous buses to run on CT Fastrak between New Britain and Hartford. Beginning testing in 2023, the potential benefits of automated

[2] https://portal.ct.gov/-/media/DOT/PLNG_STUDIES/CT-CAV-Report-Final.pdf

transit buses, particularly on BRT routes such as CT Fastrak, could be significant. By reducing operating costs and necessary downtime, automated buses may allow for more frequent service without requiring additional personnel or equipment. Additionally, automated buses have the potential to reduce dwell time by more closely aligning boarding doors with platforms, making it easier for passengers using mobility assistance equipment to enter and exit the bus.

A second pilot, focused on testing V2I and ITS technology, will take place on the Berlin Turnpike. 28 signalized intersections will be upgraded to include communications equipment allowing for real time signal timing changes and traffic signal priority for transit buses and emergency vehicles.

Both projects will require a public investment but will demonstrate the transformative potential of these technologies in the NVCOG planning region and all of Connecticut. As these technologies advance toward widespread deployment, NVCOG and our member municipalities will closely follow developments to ensure that our transportation systems remain current and competitive.

- New England Transportation Consortium

  The New England Transportation Consortium is a joint research organization sponsored by the Departments of Transportation of the six New England States. Its mission is to conduct shared transportation research initiatives. Currently, they are assessing existing and future legal issues, regulatory concerns, and policy management. To do this, they are collaborating with other organizations interested in AV technology and researching laws and regulations that may impede testing of this new technology throughout the region. They will then provide recommendations to all the New England states.

- American Association of State Highway Transportation Officials

  The American Association of State Highway Transportation Officials (AASHTO) drafted a letter on April 1st, 2021, regarding the use and testing of AVs. They encourage the importance of adhering to federal, state, and local regulations when it comes to the enforcement of the new technology. They go on to encourage the Federal Agencies to encourage collaboration between government agencies and automotive and technical experts as standards for the technology are determined. AASHTO envisions AVs within the near future and has supported and will continue to support research within this field.