Autonomous and Connected Multimodal Transportation: A Global Game Changer

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Autonomous and connected vehicles are on the brink of changing global transportation and land use forever. These types of vehicles will, among other things: (1) significantly reduce highway deaths by reducing human error; (2) improve goods movement by streamlining the exchange of articles in commerce; (3) change land use by reducing the need for things such as parking lots; and (4) improve environmental conditions by, for example, decreasing idling emissions and utilizing zero-emission vehicles. All of this can be accomplished while providing truly individualized and convenient transit otherwise thought to be the hallmark of driving one's own automobile. This article explains what autonomous and connected modes of transportation are and the advantages of a multimodal system. We will also discuss some of the many legal concerns with such a system and the societal changes that may result. Although not discussed in this article, it is important to note that this monumental transportation change is not limited to traditional modes of transportation; new modes such as Hyperloop One and SpaceX Hyperloop are testing and planning implementation and could soon be part of the multimodal system.

Differences between Autonomous and Connected Vehicles

An autonomous vehicle and a connected vehicle are not the same thing. An autonomous vehicle (AV) senses the environment and navigates on its own. A fully autonomous vehicle needs no human involvement to reach its destination. Whereas a connected vehicle is one that communicates with other vehicles and to infrastructure. A vehicle can be autonomous and not connected, connected and not autonomous, or both autonomous and connected. For example, there are currently levels of automation in certain vehicles today. Known as "driver assist" capabilities, these levels of automation include such things as: lane departure warning, lane change assistance, adaptive cruise control, forward collision warning, driver drowsiness detection, and parking assist. Vehicles are classified based on their level of automation, with level 1 being the lowest level of automation, and level 5 being the highest. The driver assist category is classified as Level 1 automation. There has not always been agreement on what constituted a level 4 or 5 automated vehicle, and it was important to get the vehicle industry to use the same standards. Ultimately, industry adopted the Society of Automation scale defining automation in vehicles from level 1 (driver assist) through level 5 (full automation). A level 5 vehicle is capable of performing all driving functions under all conditions; a human in the vehicle is not necessary. The consistent classification language, however, enables the industry to develop technology and testing parameters to meet the stated level.

U.S. Federal and State Autonomous Vehicle Legislation

The United States is clearly on a path to embrace and benefit from AV technology. On September 14, 2016, then U.S. Transportation Secretary Anthony Foxx announced a 10-year, nearly $4 billion investment to accelerate the development and adoption of safe vehicle automation through real-world pilot projects. The U.S. Department of Transportation (DOT) also released *Automated Driving Systems 2.0: A vision for Safety* in September 2017 and *Preparing for the Future of Transportation: Automated Vehicles 3.0* in October 2018 to provide guidance. 83 Fed. Reg. 50,746 (Oct 9, 2018). The DOT identifies its automation principles in version 3.0 as: (1) prioritize safety; (2) remain technology neutral; (3) modernize regulations; (4) encourage a consistent regulatory and operational environment; (5) prepare proactively for automation; and (6) protect and enhance the freedoms enjoyed by Americans. And according to the National Conference of State Legislatures, the states are not lagging; 41 states have enacted or are pursuing autonomous vehicle legislation. DOT, *Preparing for the Future of Transportation: Automated Vehicles 3.0,* iv (Oct. 2018).

As DOT provided in its *Automated Vehicles 3.0*, part of the federal policy for regulating AVs is to actually remove regulations that may trip up innovation. Since DOT's guidance was released, the National Highway Traffic Safety Administration (NHTSA) has published in the *Federal Register* an advanced notice of proposed rulemaking (ANPRM) entitled Removing Regulatory Barriers for Vehicles with Automated Driving Systems, 84 Fed. Reg. 24,433 (May 28, 2019). In the preamble, NHTSA states that its "long-term goal is to use what the agency learns from the ANPRM, as well as the agency's other research efforts, to develop a proposal to amend the crash avoidance [Federal Motor Vehicle Safety Standards (FMVSS)]," and previews further regulatory action, including revising other safety standards, to make the way for automated vehicles. *Id.*

Importantly, NHTSA has preemptive authority when it promulgates safety standards, and states cannot enforce their own safety standard unless it is identical to NHTSA's. 49 U.S.C. § 30103(b). With future rulemakings, NHTSA will be limiting the field in which the states can play a role, providing uniformity to the safety standards applicable to autonomous

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vehicles nationwide. However, federal agencies will need to provide clear guidance on how their actions will affect the regulated community in this regard, or risk further confusion. As the American Association of Motor Vehicle Administrators put it in its response to the ANPRM:

> As cited in previous petitions against the testing standard, AAMVA requests clarity from NHTSA on whether or not granting an exemption (even temporary) would absolve OEMs from adhering to state (or local) vehicle testing requirements or operational constraints. The granting of a federal exemption from FMVSS that effectively removes a driver may mean different things to different parties. The more up-front clarity provided to consideration of exemptions and how they relate to operational constraints and testing versus deployment, the better.

In addition to the above ANPRM, DOT is working on other regulatory developments to usher in the automated age of transportation. DOT appears to understand that the technology advancements are moving at a rapid pace and therefore, any regulation runs the risk of being too prescriptive and hampering development. At the same time, regulation is necessary to standardize the industry and ensure vehicle safety. Legislators and administrative agencies would be well-advised to balance these potentially competing needs by crafting goal-driven laws and regulations that foster development while not sacrificing effective oversight.

Regulatory guidance for autonomous transportation must be fluid. In January 2020, USDOT released *Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0* (AV 4.0). The focus of AV 4.0 is to identify how to unify efforts of government agencies and stakeholders toward research and deployment of this world changing technology while also keeping the United States in the forefront.

It is also important to note that the United States is not alone in the development and testing of autonomous and connected vehicles. Several countries are pursuing this technology and implementing testing.

Automation Planning Progress for Other Transportation Modes: Rail, Maritime, and Aircraft

Rail. On March 29, 2018, the Federal Railroad Administration (FRA) published in the *Federal Register* a Request for Information, seeking from industry and other stakeholders comment on "the future of automation in the railroad industry" in the hopes of understanding "the current stage and development of automated railroad operations and how the agency can best position itself to support the integration and implementation of new automation technologies to increase the safety, reliability, and the capacity of the nation's railroad system." The Association of American Railroads in its May 18, 2018 response to the FRA's request, stated that there "is no single industry-wide 'plan' or schedule for automation. Rail needs to develop standards and an automated rail taxonomy—a system of standards to clarify and define different levels of automation in trains is appropriate because neither the SAE nor the UITP taxonomies referred to in the FRA RFI perfectly fit the rail industry." Association of American Railroads, response at 3.

Norfolk Southern Railroad also provided comments to FRA, stating that for whatever guidance document FRA publishes, the "underlying purpose must remain clear: to provide flexible, outcome-based standards that allow and encourage the development of safety-enhancing, error-reducing technologies through private innovation and experimentation." *See* Norfolk Southern Comments at 3. As with vehicles, "outcome-based" standards encourage technology advancements rather than having regulations first and stifling innovation. Clearly, the FRA is preparing to engage with regulation of autonomous rail and asking for input from industry at the beginning is a good sign that outcome-based standards will be utilized.

Notably, there is only one fully autonomous railroad currently in the world. The Rio Tinto mining company in Western Australia runs three locomotives remotely operated over approximately 60 miles. They also combine the operation with autonomous trucking.

Maritime. Richard Balzano, deputy administrator, U.S. Maritime Administration (MARAD) states that: "The Maritime industry is connected to all the modes— train, rail and trucking are very much a part of loading and unloading our ships. And our industry is transforming; automation is coming to our industry with automated vessels and port services and self-driving trucks." Greg Rogers, *USDOT Unveils Ambitious Multi-Modal Automation Initiative, Automated Vehicles 3.0*, Eno Trans (March 9, 2018). MARAD is establishing the Autonomous Ship and Port Operations Working Group and is working with the Office of Naval Research on the Overlord project that will completely automate three cargo ships and operate them for 90 days at a time. This technology will change the ocean-going shipping sector.

Aircraft. Changes are ripe for automated technology with aircraft as well. The U.S. Air Force has been remotely piloting aircraft such as the Global Hawk and Predator for years and the Air Force allows specially trained enlisted members (who are no longer required to be certified pilots) to operate them. The commercial cargo aircraft industry may be the largest consumers of this technology. As stated in an October 11, 2018, article in Transportation Topics, "for the air-cargo industry, where package containers don't require safety assurances, the prospect of single-pilot operations—and eventually autonomous flight—holds a definite appeal, especially in areas where air cargo growth may outpace pilot supply." Justin Bachman, *Air Cargo Looks to Single-Pilot Jets as Autonomous Flight Nears*, Transport Topics (Oct. 11, 2018).

Advantages of Automation and Connectivity

The DOT's *Preparing for the Future of Transportation: Automated Vehicles 3.0* directs that its agencies review automation for their respective modes. As explained above, each mode of transportation is working toward automation, but it is yet to be seen whether the modes can work collectively to create an integrated network of autonomous vehicles, leading toward a truly connected multimodal transportation system. As we explain below, connecting the modal systems so that autonomous vehicles can "speak" with one another is primed to bring about a radical change in the transportation industry for the better.

At the risk of prophesizing, automating the transportation network will bring monumental positive advantages.

Connecting these autonomous networks allows for the different modes of transportation (and vehicles within the same mode) to work fluidly together.

Safety may be the largest advantage and the most important reason we must pursue this technology. Having autonomous cars communicate on the road will, simply put, reduce fatalities. NHTSA reports that 94 percent of fatal crashes involve human error, and automation can eliminate this unacceptable fact, which will help protect vehicle occupants, bicyclists, and pedestrians.

- 2015: 35,092 fatalities in motor vehicle related crashes
- 2016: 37,461 fatalities (including 5,987 pedestrians)
- 2017: 37,133 fatalities (including 5,977 pedestrians killed by motor vehicles in 2017, representing 16 percent of all motor vehicle fatalities

See NHTSA 2016 Fatal Motor Vehicle Crashes: Overview (DOT HS 812 456); *NHTSA 2017 Fatal Motor Vehicle Crashes: Overview* (DOT HS 812 603). The fatality numbers are alarming. The connectivity of autonomous vehicles and the removal of distracted, aggressive driving will increase the safety for the traveling public (including bicyclists and pedestrians) by eliminating the number one cause of crashes, the human element.

Convenience would be another advantage offered by AVs. A constant complaint regarding public transit is the lack of convenience. AVs that can come to you at the time you request, make stops to pick up your family members, and take all of you home at a pre-determined time would solve that problem. No longer would you have to wait on a bus to take you to a train stop where you have to wait for the train for your commute, and even worse, when that bus is late and you miss your train. While nothing may seem more liberating than hopping in your own car and driving to your chosen destination, the fact of the matter is that public transit is necessary in ever-denser urban centers. Connecting and automating these transit systems will make mass transit more responsive. Mobility options will improve for those that cannot drive and will enable more independent living possibilities. Furthermore, NHTSA reports that

> Roads filled with automated vehicles could also cooperate to smooth traffic flow and reduce traffic congestion. Americans spent an estimated 6.9 billion hours in traffic delays in 2014, cutting into time at work or with family, increasing fuel costs and vehicle emissions. With automated vehicles, the time and money spent commuting could be put to better use. A recent NHTSA study stated that automated vehicles could free up as much as 50 minutes each day that had previously been dedicated to driving. *Automated Vehicles for Safety* (2019), nhtsa.gov.

Additionally, shared vehicles are more efficient, while our individual cars sit idle approximately 94 percent of the time.

Connected AVs will also provide more efficient goods movement, since they can move together more efficiently, and enable faster and cheaper freight deliveries. Platooning of trucks (i.e., having trucks move closer together) for example, will allow for reduced costs and increased safety.

In addition, AVs could offer environmental improvements. AVs can drive in a way that enhances fuel economy, improves air quality, and reduces greenhouse gas (GHG) emissions. Zero-emission vehicles will ensure even better air quality and no GHG emissions.

Furthermore, land use planners will be able to better utilize space. No need for large parking lots because connected AVs will be dropping off passengers and then going on to pick up the next passenger. Parking lots account for an enormous amount of space and can be converted to other uses. Curbside parking will also disappear, allowing for safer bike lanes and wider sidewalks. Bicyclists and pedestrians could also be linked into the connected network of AVs via smartphones and other mobile tech so a cyclist could be notified that the car next to them is going to turn right. The connectivity of the vehicles also allows for narrower lanes because the cars could operate closer together. This technology allows planners to increase capacity without having to acquire more rights-of-way.

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In an emergency, connected AVs could also get a message that an emergency vehicle is approaching, and the cars would pull over or take an alternate route. Such technology will avoid human drivers that panic and stop in intersections causing congestion and ultimately hindering emergency response times. First responders will have clearer paths and faster response times in a connected environment that will save lives.

Potential Legal Concerns for AVs

With such transformation comes a multitude of legal issues. For example, under the National Environmental Policy Act (NEPA), 42 U.S.C. § 4321 *et seq.*, and state-level equivalents, such as California's Environmental Quality Act (CEQA), Cal. Public Resources Code § 21000 *et seq.*, projects that will have an impact on the environment and require government approval must conduct an environmental assessment. One area that projects undergoing environmental review must look at is traffic impacts, e.g., whether the project will increase congestion, risk more vehicle accidents, or cause greater idling times with attendant air emissions. Automated vehicles can be employed by such projects in order to avoid what otherwise could be substantial impacts of the project: for a hazardous waste transportation project, the risk of a release may be severely curtailed by eliminating human driver error; for a mass transportation project, idling times may be limited

or eliminated by automated and connected vehicles that only run and arrive when needed; and across the spectrum, employment of connected AVs may drastically reduce congestion. Project proponents should be on the lookout for creative ways to incorporate this new technology, reducing impacts to the environment, and saving costs on the scope of environmental review.

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Another potential area of concern relates to hazardous waste transport and manifesting. Presently, when a hazardous waste generator seeks to have their wastes hauled off-site and treated or otherwise disposed of, a manifest is used to track all parties who have contributed to the handling of the material (generator, transporter, treatment/disposal facility operator). 40 C.F.R. § 260 *et seq*. Typically, these entities must sign the manifest, leaving a paper trail of responsibility in case the hazardous material is improperly handled. These manifests have historically served as prime evidence for establishing liability under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), because it allows regulators to trace where the contamination at a given site came from. The modern era has replaced the paper manifests of old with "e-manifests," allowing for the electronic tracking of hazardous waste. These rules will need to be updated to incorporate the possibility of connected AVs becoming the primary transporters of such waste, including consideration of who will be responsible for ensuring the accuracy of the transporter details on the manifest, and who will be responsible if the hazardous waste is not loaded onto the transport vehicle properly and results in a spill.

Issues related to cybersecurity also present potential challenges. The integrity and security of the connected AV system must be a paramount goal. A transportation network cannot be compromised. Industry will need to create several layers of firewalls and breach detection in order to prevent hacking of the interconnected system. A large-scale system failure could result in fatalities and have a catastrophic impact on goods movement. Should a system get hacked, who is legally responsible for the resulting consequences? What should be the criteria for setting up the parameters to prevent hacking? Furthermore, planners and engineers need to ensure the interoperability of the multimodal systems at this stage, avoiding the creation of independent systems that later need to be merged and patched, creating system-wide vulnerabilities.

Similarly, data management and security issues should be considered. An enormous amount of data will be generated from people using the system and the modes of transportation. The data will need to be protected and secure. There are fundamental questions that must be addressed such as: Who owns the data that is collected from the system and trips made? What data is permissible to collect and store? How can the data be used? Who is responsible for data leaks? What are the privacy expectations? Such legal issues are still playing out in the telecommunications and social media industries, and there is a potential that connected AVs could (and should) adopt similar data ownership and management principles. Western Digital's comment letter to a NHTSA 2019-0036 rulemaking notice stated that "Data storage is an increasingly important aspect of automated driving systems and of connected vehicles regardless of their level of automation. As vehicles employ an expanded array of sensors and processing capabilities, for example, the quantity of data generated by such vehicles is exponentially higher than in conventional vehicles: on the order of 4 terabytes of data per hour." The letter goes on to state that data storage requirements should be addressed in the FMVSS to include such things as memory speed and access, data integrity, storage capacity, and data segregation (local versus cloud storage). This is an issue that will need to be addressed in the technological developments to come. *See* Western Digital, Comment letter in response to NHTSA's ANPRM Removing Regulatory Barriers for Vehicles with Automated Driving Systems (July 29, 2019), regulations.gov/document?D=NHTSA-2019-0036-0032.

FMVSS will also need to be updated to include self-driving vehicles. The same is true for standards applying to autonomous and connected maritime, aviation, and rail modes. Consistency between federal and state standards will need to be achieved, including identification of areas where uniformity is of such interest that federal standards should preempt those of the states.

Insurance and liability will need to adapt. Connected AVs turn the business model for the automotive insurance industry upside down. If a human driver can no longer be at fault, where is the blame placed? And who actually needs insurance? No longer will each driver need insurance with a shared mobility transportation system. A fleet of cars will likely be insured by their owner, much like rental cars are today. Insurance products for vehicle manufacturers, software developers, and hardware manufacturers will be needed. Should an accident occur, the process of determining fault may be very similar to what exists today except that the occupant will no longer be to blame, and it may be a bit easier to determine what part of the system failed due to the data generated. Regarding the passenger, there has been discussion of a potential "personal mobility coverage" that protects the passenger rather than the vehicle. Insurance for maritime, rail, and aviation will also change due to the lack of human error.

Finally, what about people who still want to drive? Will human drivers be restricted or not permitted? The goal of automation is to create a safer and more efficient transportation system. Human interaction accounts for the vast majority of crashes and injuries. As trust in the automated system builds and people choose to opt out of car ownership expenses and utilize shared transportation, we expect that the percentage of human drivers will decline. There will be options for human drivers for years to come as the automated system builds, and there will have to be consideration of how to meld human-operated transportation with autonomous vehicles.

Societal Changes

A fully autonomous, connected transportation system will bring major changes to the way we work, live, and play. With shared vehicles, there will not be a need for car ownership, payments, insurance, or maintenance costs. Driver's licenses will be a thing of the past, as will garages on homes and at work. There will be job changes with the loss of transportation operator positions. Industry should be looking for opportunities to retrain transportation operators to reduce the impact. For example, there will be jobs with software, maintenance, and security of the interconnected system.

Police utilization will also change. With a connected transportation system and the drastic drop in crashes, fewer police officers will be needed to respond to traffic incidents. Traffic violations will also be a thing of the past (which will reduce revenue for some jurisdictions). Police can focus on the many other aspects of their important duties and communities can have more police in their area able to respond to other emergencies and crimes. There are issues that will need to be resolved regarding policing. For example, what happens when someone is committing a crime in an autonomous vehicle? Let's say two inebriated individuals get into the car leaving a bar and have an altercation in the car. Will the system be able to stop the car so police can stop the fight?

Transit will improve with the shared mobility system that is truly individualized and convenient. A connected system will be greener and more efficient. Most importantly, we will have a drastic drop in highway deaths, which is what we have been striving for with the driving laws and vehicle advances.

An autonomous and connected multimodal goods movement system will also be safer, more efficient, and less expensive. E-commerce is growing rapidly, and a connected system will enable transportation to be electronically arranged as soon as an order is received. Routing of packages and goods will be better managed. Automated systems at ports will be a major improvement enabling cargo carriers to arrive at the precise time their cargo is ready to be loaded or unloaded.

Looking to the Future

Automation is here today and will continue to grow with new technology. The safety and convenience of these systems will be embedded into our everyday lives. The transportation industry must collaborate and communicate at this stage to ensure a more productive transition to a multimodal autonomous environment. The rail, maritime, and aviation industries need to develop common levels of automation standards within their modes and be able to translate and connect those platforms with other modes. Planners and government officials must incorporate this technology now into their long-range, land-use general plans and regional transportation plans. The AV industry must make the integrity of the system a priority and work together across all modes of transportation to eliminate vulnerabilities. Doing so will allow connected AVs to reap all the impressively expansive advantages of a seamless transportation network, making our roads safer, our deliveries faster, and our environment cleaner.