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Assembly
California Legislature

ASSEMBLY COMMITTEE ON TRANSPORTATION
JIM FRAZIER, CHAIR

INFORMATIONAL HEARING

Driverless Disruption: Balancing the Safety Benefits and Concerns of Automated Vehicles

Monday, May 7, 2018
2:30 P.M. ♦ State Capitol, Room 4202

Background

Purpose of Hearing

Automated vehicles (AVs) will make a large impact in California and there are many policy questions regarding AVs. Who will be liable in the case of an accident? What impacts will AVs have on the workforce? Will AVs increase vehicle miles traveled and greenhouse gases, and if so, should all AVs be required to be zero emission vehicles? Should the state promote policies that would result in a fleet model instead of individual car ownership, and if so, how will the state make up for the loss of transportation-related revenue?

This hearing is focused exclusively on public safety, and what, if any, role should the state play in ensuring AVs are tested and deployed safely. The federal government has called for the states to leave safety up to them, but has provided no laws or regulations to ensure these vehicles are safe on public roads.

There are major questions that need answers, including whether the state should be involved in ensuring the safety of these vehicles, and if so, is DMV equipped to handle the safe testing of these vehicles? Have law enforcement been properly briefed on how to handle an accident involving an AV? Should cyber security requirements be higher for AVs considering any one of them could be turned into a 2,000 pound weapon, and is law enforcement prepared for such a scenario? Should the state allow testing for large vehicles that weigh tens of thousands of pounds when manufacturers have not proven that an AV passenger vehicle is safer than a vehicle with a regular driver? Are these vehicles capable of recognizing traffic signs, including a red light signal that may be broken, or a reduced speed limit due to construction? Are AVs that still require drivers safe to be on public roads? Can the federal government ensure that AVs follow California's distinct rules of the road?

This hearing will give the Legislature the opportunity to learn what potential safety issues exist for AVs, and what role the state should play to ensure these vehicles are safe.

Introduction

Not much has changed in transportation since the invention of the automobile. The vehicles operate much as they did 100 years ago. General Motors dreamed of a future of electrified automated highways, proudly displaying their "Futurama" at the 1939 World's Fair in New York. But just like Leonardo Da Vinci's helicopter, their dreams lacked the necessary components to make the driverless car a reality. With the advent of the computer age, programmers and innovators have been inspired to change that by developing a driverless vehicle.

Today, computers can compute mathematical equations and outsmart any person in games like chess and Jeopardy. However, as noted in the book *Driverless: Intelligent Cars and the Road Ahead* by Hod Lipson and Melba Kurman, the programming feat behind making a driverless car does not require a computer to have the intelligence of a genius, but the perception of a child. AVs need programing that can perceive the world the way a human can and react to changing rules of the road, bad drivers, pedestrians, cyclists or other objects that may require changes in driving behavior.

Developing that perception would have a radically disruptive effect on the world. Every year 1.1 million people are killed as a result of a vehicular accident. It is the leading cause of death for people between the ages of 19 and 35. These deaths have become so commonplace and acceptable in today's society that we often forget that cars kill more people per year than war, murder, and drugs combined.

A car that can perceive danger better than a human could save millions of lives. This prospect alone should make the development and deployment of AVs a priority for the state and the country. The state must work with leaders in the industry to address any roadblocks in the law that may affect their ability to properly test and develop the technology necessary to make the automobile fully autonomous.

At the same time, the Legislature needs to consider the potential safety hazards of this emerging technology. As developers look toward deploying AVs, the Legislature must consider the potentially deadly outcomes of drivers becoming over reliant on a technology that has failed to develop the perception necessary to properly navigate the roads in a safe manner. Releasing these vehicles on the road before they are ready could ultimately hinder public trust in the technology, and slow the eventual evolution toward autonomous driving.

Federal Law and Regulations

The Federal Government has been working to establish a regulatory framework for the rapidly changing technology. In 2017, the U.S. Department of Transportation (USDOT) and the National Highway Traffic Safety Administration (NHTSA) released a report called *Automated Driving Systems: A Vision for Safety 2.0*, which provides voluntary safety guidance for manufacturers developing AVs and best practices for state legislatures to regulate AVs. The document stresses that none of the safety regulations are mandatory, and are only best practice recommendations. Despite not having any mandated safety requirements, USDOT and NHTSA recommend that states play little role in ensuring the safety of these vehicles, and to limit safety regulations to requiring manufacturers when testing to notify public safety when they are testing the vehicles.

The federal guidelines include the following suggestions to automakers:

1) Entities are encouraged to follow a robust design and validation process based on a systems-engineering approach with the goal of designing the automated driving system (ADS) free of unreasonable safety risks.

2) Entities are encouraged to define and document the Operation Design Domain (ODD) for each ADS available on their vehicles as tested or deployed for use on public roadways, as well as document the process and procedure for assessment, testing and validation of ADS functionality with the prescribed ODD (note: ODD includes what conditions the vehicle can operate, including weather, speed, and roadway type limitations).

3) Entities are encouraged to have a documented process for assessment, testing, and validation of their ADS's Object and Event Detection and Response (OEDR) functions, which are expected to be able to detect and respond to other vehicles (in and out of its travel path), pedestrians, bicycles, animals, and objects that could affect the safe operation of vehicle.

4) Entities are encouraged to have a documented process for transitioning to a minimal risk condition when a problem is encountered or the ADS cannot operate safely.

5) Entities are encouraged to develop validation methods to appropriately mitigate the safety risks associated with their ADS approach.

6) Entities are encouraged to consider whether it is reasonable and appropriate to incorporate driver engagement monitoring in cases where drivers could be involved in the driving task so as to assess driver awareness and readiness to perform the full driving task.

7) Entities are encouraged to follow a robust product development process based on a systems engineering approach to minimize risks to safety, including those due to cybersecurity threats and vulnerabilities.

8) Entities are encouraged to consider methods of returning ADSs to a safe state immediately after being involved in a crash.

9) Entities are encouraged to establish a documented process for testing, validating, and collecting necessary data related to the occurrence of malfunctions, degradations, or failures in a way that can be used to establish the cause of any crass. Data should be collected for on road testing and use.

10) Entities are encouraged to develop, document and maintain employee, dealer, distributor, and consumer education and training programs to address the anticipated differences in the use and operation of ADS's from those of the conventional vehicles that the public owners and operates today.

11) Entities are encouraged to document how they intend to account for all applicable federal, state and local laws in the design of the vehicles and ADS's.

California Legislation and Department of Motor Vehicles (DMV) Regulations

The Legislature passed SB 1298 (Padilla), Chapter 570, Statutes of 2012, which permitted AVs to be operated on public roads for testing purposes by a driver under certain conditions. The legislation requires a manufacturer to submit an application to the DMV to test AVs on public roads. The law requires a certification from the manufacturer that the automated technology:

1) Has the ability to engage and disengage in a manner that is accessible to the operator;

2) The AV has a visual indicator inside the cabin to indicate when the autonomous technology is engaged;

3) The AV has a system to safely alert the operator if an autonomous technology failure is detected while the autonomous technology is engaged, and alert the driver to take control of the vehicle or come to a complete stop;

4) Allows the operator to take control in multiple manners, including, without limitation, through the use of the break, accelerator pedal, or steering wheel, and alert the operator that the technology has been disengaged; and,

5) Requires the vehicles to have sensor data for at least 30 seconds before a collision occurs.

In addition, SB 1298 requires that the technology not make inoperative any Federal Motor Vehicle Safety Standards for the vehicle's model year and all other applicable safety standards and performance requirements set forth in state and federal law. Finally, it requires a manufacturer to maintain insurance, a surety bond, or proof of self-insurance in an amount of $5 million.

California's AV laws keep safety in mind. The law requires DMV to promulgate regulations on testing, equipment, and performance standards.

DMV regulations for the testing of driverless AVs took effect on April 2, 2018. The regulations are safety focused, and, amongst other things, include the following safety provisions:

1) Requires the vehicles to meet industry standards on defending against cyber-attacks.

2) Requires manufacturers to provide law enforcement with an interaction plan and local authorities and DMV with a written notification of where and when the vehicles will be tested.

3) Prohibits the testing of vehicles over 10,000 pounds, buses, and vehicles carrying hazardous materials.

4) Requires manufacturers to provide the DMV with ODD.

5) Requires manufacturers to provide a yearly report summarizing how many miles were driven in autonomous mode and when autonomous modes had to be disengaged and why the disengagement occurred.

6) Requires testing drivers to be trained on how to operate the vehicle and have 3 years of driving experience, no more than 1 point on their license, no DUIs for 10 years, and not to have been at fault for a collision resulting in serious injury or death.

7) Requires the vehicle to have a communication link between the vehicle and remote operator to provide information on the vehicle's location and status and to allow for two-way communication between the remote operator and the passengers.

Society of Automotive Engineers (SAE) Levels of Autonomy
SAE International is a U.S. based professional association of engineers. SAE's *Taxonomy and Definition for Terms Related to Driving Automation Systems for On-Road Motor Vehicles* have become the accepted engineering definitions for the different levels of automation with NHTSA and DMV. SAE has designated six different levels of Automated Vehicles (AVs):

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. An example includes adaptive cruise control.

Level 2: ADAS can 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. Examples would include Tesla's Autopilot and Cadillac Super Cruise.

Level 3: ADS can 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: ADS can 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: ADS can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving.

Both the federal and state law defines AVs as vehicles with automated technology of levels 3-5.

Programming Challenges

The programming challenge behind AV's is not one of intelligence, but one of perception. Vehicles need to be able to perceive unexpected, rare events. As noted in *Driverless: Intelligent Cars and the Road Ahead*, roboticists have given the name of the unexpected rare events that take one percent as corner cases. The more corner cases that exist, the more difficult it is to program artificial intelligence to react. Not only do cars need to be able to anticipate these corner cases, but they also need to be able to perceive various road signs signals, including temporary ones established for changing conditions.

The difficulty of developing AVs has been a lack of computing power for a machine to properly have *machine vision.* In 2012, a major breakthrough occurred that has allowed for the development of AVs: *Deep learning.* Deep learning has made it so software can correctly classify random objects in thousands of digital images, granting the foundation for artificial perception.

The race to build a safe AV has generally relied on Light Detection and Ranging (LIDAR), which is a remote sensing method that uses light in the form of a pulsed laser to measure ranges. LIDAR emits pulses of infrared light millions of times a second and compiles the results into a 3-D map in real time. While most companies have relied on LIDAR to solve the perception problem, other companies like Tesla, have taken an alternative route and instead use highly pixelated cameras.

The technological problems do not end with perception, however. In order to ensure safety, these vehicles may need to be hack proof and the computer systems crash proof, a difficult feat for any computer.

How Safe Do These Vehicles Need To Be?

While there are over 37,000 traffic fatalities per year, human drivers have very few accidents for the number of miles driven. Nationally, there at 3.4 million vehicle hours between fatal crashes, or 390 years of non-stop driving, and 61,400 vehicle hours between injury crashes, or seven years of non-stop driving. How much safer should AVs be compared to a human driver, and how can a developer prove their system has reached the target safety level? Hod Lipson and Melba Kurman in *Driverless* suggest that NHTSA should certify vehicles based on how safe they are compared to human drivers, and maybe even require higher safety comparisons for certain types of vehicles, like commercial trucks, school buses, and vehicles carrying hazardous waste.

Are Level 3 Automated Vehicles Safe?

As noted above, Level 3 vehicles are nearly fully automated, but may require a driver to take over at times. Experts and some AV developers have questioned whether Level 3 vehicles are safe at all, as it creates a split responsibility between drivers and machines. In October of 2015, Google released a report on its experiences with its driverless technology. In 2012 several Google employees were allowed to use one of Google's vehicles on autonomous mode for the freeway portion of their commute to work. Every employee was warned that the car is in its beginning stage, and they should pay attention 100 percent of the time. Each car was equipped with a video camera inside that would film the passengers.

Despite Google's instructions, videos showed that some drivers completely turned away from the driving seat to do things like search for a cell-phone charger, while others simply relaxed. Engineers call this behavior automation bias.

Google stated in their report: "We saw human nature at work: people trust technology very quickly once they see that it works. As a result, it's difficult for them to dip in and out of the task of driving when they are encouraged to switch off and relax."

Waymo, Google's automated vehicle arm, has publicly stated they will not be releasing Level 3 vehicles.

Research at Virginia Tech University sponsored by General Motors (GM) and the Federal Highway Administration found similar results. Twelve drivers were given vehicles with adaptive cruise control that handled a car's steering and breaking and put on a test track. Drivers were provided reading material, food, drinks and entertainment media. A passenger joined them and was watching a DVD during the test drive. 58 percent of drivers watched the DVD for some time during the three hour trip. 25 percent of the drivers enjoyed the free time to get some reading done, increasing their risk of a car crash by 3.4 times. Overall, drivers were estimated to be looking away from the road about 33 percent of the time during the course of the three-hour trip.

Conclusion
The 1930s-dream of driver automation is potentially around the corner. GM has announced plans to mass produce self-driving cars that lack steering wheels and brakes by 2019. In a May 2017 TED Talk, Elon Musk claimed that Tesla would be capable of level 5 by 2019. The Alliance for Automobile Manufacturers estimates that 20-40 percent of all vehicles sold in the 2030s will be AVs. If done correctly, these vehicles can save thousands of lives, but the public is deeply skeptical. A Pew Research Poll found that nearly 60 percent of Americans say they would not want to ride in a driverless vehicle. Of those who do not want to ride in an AV, 7 of 10 mention a lack of trust, a fear of losing control, and/or general safety concerns. Both policy makers and auto manufacturers will need to do more to develop public trust in this technology.