OOIDA Foundation

RESEARCH · SAFETY · ECONOMICS

WHITE PAPER

The Challenges of Automated Vehicles in the Trucking Industry

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Table of Contents

Introduction

In September 2016, the National Highway Traffic Safety Administration (NHTSA) released a guidance document aimed at developing a regulatory framework for highly automated vehicles (HAVs) entitled *Federal Automated Vehicle Policy: Accelerating the Next Revolution in Roadway Safety*. While the document was the first of its kind, it was most definitely not to be the last as the Department of Transportation (DOT) has already released further guidance with more promised to come. What began as a seemingly quiet process to develop driverless cars behind the closed doors of major tech companies and vehicle manufacturers, has suddenly become catapulted into the limelight. Though the revolution of automated technology had its roots in cars, it has quickly transitioned to large trucks. And while several experts have estimated that highly automated commercial vehicles (HACVs) are at least a decade away or more, and even longer before they represent a majority of commercial motor vehicles (CMVs) on the roadways, many corporations and lawmakers have sought to fast track the development of what has been termed the largest technology revolution since the horse and buggy.

Today, there are 44 companies working towards autonomous vehicles and while there have been a number of technological achievements, a number of concerns and questions remain unanswered and or unidentified.[1] Thus it is critical that the appropriate agencies within DOT, such as NHTSA, the Federal Highway Safety Administration (FHWA), and the Federal Motor Carrier Safety Administration (FMCSA), conduct a comprehensive and thorough analysis of HACVs and their potential impacts by taking an empirical and holistic approach. While some entities are eager to push forward and rapidly remove any regulatory roadblocks to HACVs, the Owner-Operator Independent Drivers Association Foundation (OOFI) believes that this would be an ill-fated and imprudent approach with possibly devastating consequences upon owner-operators, professional drivers, and the motoring public.

Economy

The first of these potential negative consequences is the effect that HACVs will have upon the workforce. There are currently 3.9 million commercial driver's license (CDL) holders actively driving in commerce within the United States.[2] These men and women represent the driving force behind the U.S. economy, delivering 70 percent of all freight worth $11.7 trillion[3] while collecting $726.4 billion in gross revenue.[4] A hurried introduction of HACVs would not only have a negative impact on safety, but would possibly disrupt the trucking industry's workforce and the overall economy.

A study released by four European organizations entitled *Managing the Transition to Driverless Road Freight Transport* concluded that driverless trucks have the possibility of eliminating half of the driver

[1] https://www.cbinsights.com/blog/autonomous-driverless-vehicles-corporations-list/

[2] FMCSA, *Regulatory Evaluation of Entry-Level Driver Training Notice of Proposed Rulemaking,* Federal Motor Carrier Safety Administration (2016), pg. 53

[3] Bureau of Transportation Statistics, *Transportation Statistics Annual Report 2016*, Department of Transportation (2016) pg. 58

[4] *American Trucking Trends 2016*, American Trucking Association, http://www.trucking.org/article/ATA-American-Trucking-Trends-2016

workforce by 2030.[5] If such an outcome is realized, it would certainly impact the overall economy while also forcing thousands of hardworking Americans out of a job and, in the case of owner-operators, out-of-business. The importance of the professional truck driver and owner-operator cannot be stressed enough, as many of the nation's rural communities are only able to subsist and thrive because of large trucks.

While some entities have claimed that automated vehicles will help to create jobs in the trucking industry, others such as the American Trucking Association (ATA) have stated that they do not expect fully autonomous trucks for many years to come. Instead, the primary focus of the mega carriers that ATA represents is not driver "less" technology but rather driver "assist" technology. While this large corporate perspective might appear harmless, it contains an overlooked caveat. Namely that the hours-of-service regulations would be modified in such a way to essentially permit a team driving operation between a human and the HACV. Thus a driver would be confined within a truck cab for 24-hours a day, and although the truck's overall productivity would certainly increase, it is doubtful the driver's wages will. OOFI therefore asks what the value of a driver is in a partially automated truck. Will they need to obtain a special degree or a particular endorsement on their CDL? Will such additional requirements and training impact driver wages? There are many unanswered questions concerning the influence of HACVs on the workforce and the overall economy of the nation.

Safety

Regardless of the economic impact, it is important to understand the safety implications of automated vehicles on public roadways. Despite the various claims that HACVs will lead to zero deaths, news articles and case studies have presented real-world situations, although not always in the transportation sector, in which automation has failed thereby requiring human intervention.[6] While automated driving systems (ADS) have the potential to improve safety under certain conditions, they also pose to create new risks. The National Academy of Sciences published a National Cooperative Highway Research Report stating that HAVs with "flawed hardware or software could cause accidents, including those caused by the types of errors that humans would not make.[7]"

The highly publicized Tesla crash involving a Level 2 automated vehicle and a CMV is an unfortunate example highlighting the safety risks that HACVs might impose. According to the docket opened by the National Transportation Safety Board (NTSB), the driver of the Tesla vehicle had engaged the Autopilot,

[5] *Managing the Transition to Driverless Road Freight Transport*, International Transport Forum (2017

[6] Tomas o. Lackman and Karl Soderlund, "Situations Saved by the Human Operator when Automation Failed," The Italian Association of Chemical Engineering (2013)

[7] Johanna Zmud et al., *NCHRP Research Report 845: Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies*, Transportation Research Board (2017), pg. 11

which included Autopark, Traffic-Aware Cruise Control, Austosteer, Auto Lane Change, and Forward Collision Warning (FCW), for 41 minutes prior to the crash.[8]

Despite the Autopilot system, the seven warnings issued by the Tesla system to the driver, and the determination by NTSB that the tractor-trailer should have been in view for seven seconds prior to impact, neither the FCW system or the Tesla driver attempted to avoid the accident. OOFI applauds the objective to make roads safer but is concerned that an overreliance upon technology will cause accidents rather than prevent them. There is no technology that performs perfectly 100 percent of the time, however an error in a HACV presents a grave concern both for the truck driver and the motoring public. And when failed automation does lead to a crash who will be held liable, the motor carrier, the driver, or the systems manufacturer? Perhaps the biggest impediment to HACVs is not the technology, but the issue of liability. What insurance company is currently willing to insure an automated vehicle? OOFI would argue none.

When considering HACVs, it is also important to recognize that there might never be a truly autonomous truck as there are numerous circumstances in which only a professional driver will be able to appropriately and safely operate their vehicle, such as in highly congested urban areas or in rural communities. The members of the Owner-Operator Independent Drivers Association (OOIDA) have over twenty years of experience within the trucking industry and over 2 million miles of safe, accident free driving. They understand it is better to accelerate in the event of a steer-tire blowout or to steer their truck into the side of a mountain in the event that they lose their brakes while traversing a steep downgrade.[9] An experienced trucker also knows how to best navigate snow and ice-covered roads, whereas an autonomous vehicle needs to create high-resolution 3D roadway maps in good weather first via its light detection and ranging (LiDAR) sensor system before it can ever locate itself via GPS during a storm. However, GPS systems do not function in all parts of the U.S., neither are they always accurate. In order for a HACV to drive in inclement weather, current GPS systems would have to become far more precise.[10]

In short, there are numerous situations in which a HACV will not be able to safely operate without an experienced driver behind-the-wheel, which actually leads to further safety issues, including automation bias, fatigue, and overall driver performance. In March 2018, the first at fault fatal crash involving a pedestrian and an automated vehicle occurred in Tempe, Arizona, where an Uber vehicle failed to see a woman crossing an empty four-lane road because of a blind spot in the car's sensing system. While driverless cars are supposed to avoid accidents with LiDAR, they are not failsafe as Uber's sport utility vehicle had a blind zone around the perimeter of the SUV, in part because the company had reduced the number of sensors and because they had transitioned from a car, which sits lower to the ground, to a SUV. Thus the Uber vehicle was unable to fully detect pedestrians. And although a safety driver was behind the wheel at the time of the crash, video showed that he was "clearly distracted and looking down from the road. It also appears that both of the safety driver's hands were not hovering about the steering

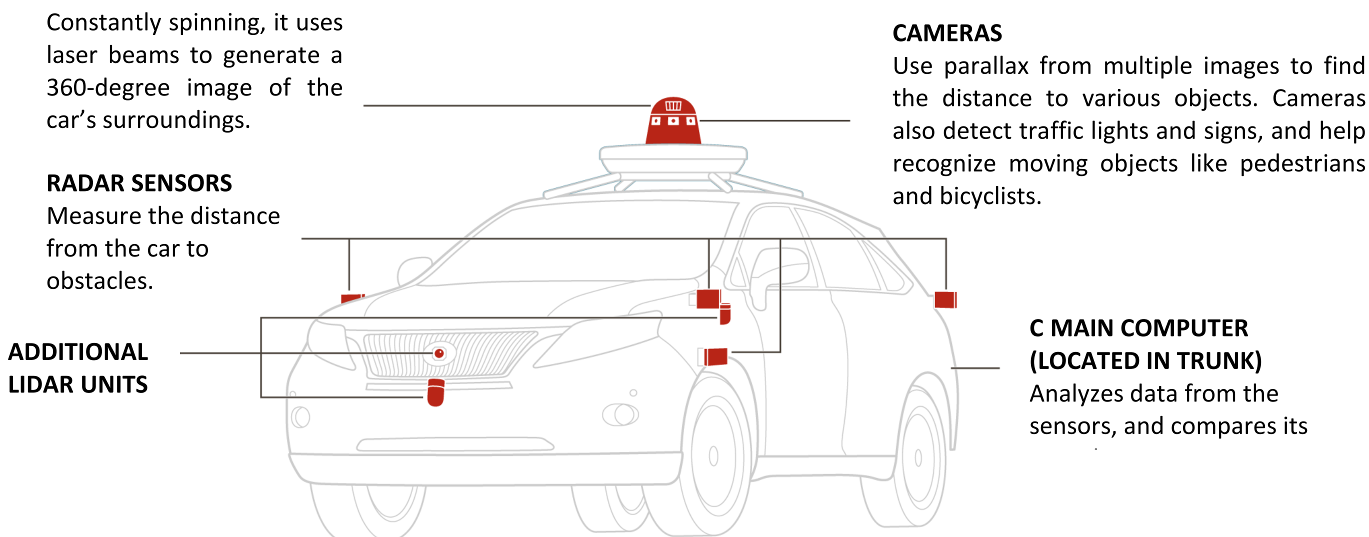
[8]https://dms.ntsb.gov/pubdms/search/hitlist.cfm?docketID=59989&CurrentPage=1&EndRow=15&StartRow=1&order=1&sort=0&TXTSEARCHT=

[9] http://trucker.com/dashcam/dash-cam-week-its-all-downhill-here

[10] Sean Kilcarr, "Self-driving in the snow: Five key steps," *Fleet Owner* (2016) http://fleetowner.com/blog/self-driving-snow-five-key-steps

wheel, which is what most backup drivers are instructed to do because it allows them to take control of the car quickly in the case of an emergency.[11]"

Figure 1: How a Self-Driving Car Works



By Guilbert Gates | Source: Google | Note: Car is a Lexus model modified by Google. Uber's sensing system uses similar technology.

The accident was an unfortunate reminder that self-driving technology is still in its infancy, especially in regards to CMVs. In a Reuters' news event, Toyota North American CEO Jim Lentz said, "The reality is there will be mistakes along the way. A hundred or 500 or a thousand people could lose their lives in accidents like we've seen in Arizona. That's really going to slow down the adoption of autonomous driving.[12]"

Though proponents believe that ADVs could eventually save 35,000 lives annually, OOFI sees the potential for new and unidentified safety risks. For example, the fatal crash in California where a Tesla Model X crashed into a concrete highway divider near Mountain View, California. Again, the Autopilot function was engaged, and according to Tesla, "the driver had received several visual and one audible hands-on warning earlier in the drive and the driver's hands were not detected on the wheel for six seconds prior to the collision. The driver had about five seconds and 150 meters of unobstructed view of the concrete divider with the crushed crash attenuator, but the vehicle logs show that no action was taken.[13]"

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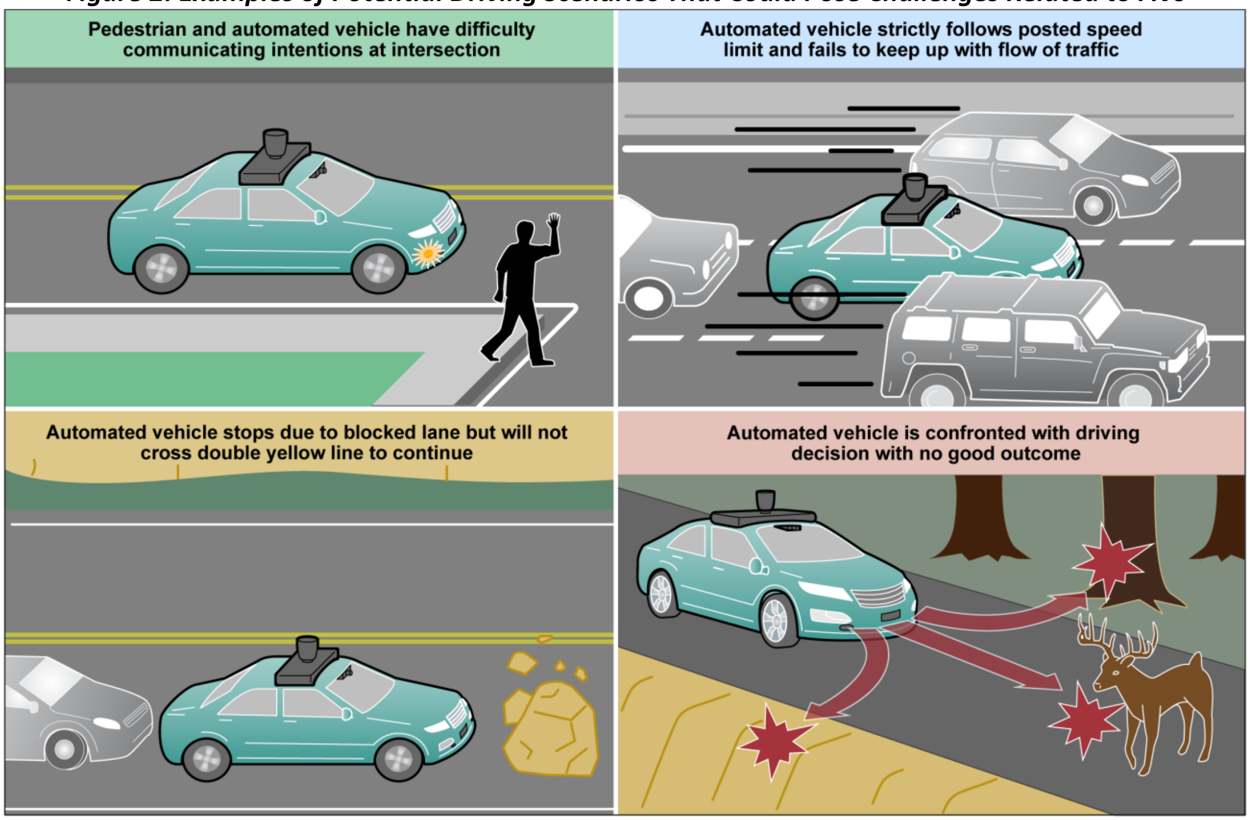
[11] Troy Giggs, "How a Self-Driving Uber Killed a Pedestrian in Arizona," New York Times (March 2018), https://www.nytimes.com/interactive/2018/03/20/us/self-driving-uber-pedestrian-killed.html

[12] Nathan Bomey, "Self-driving cars could kill hundreds but save tens of thousands, Toyota executive says," USA Today (March 2018), https://www.usatoday.com/story/money/cars/2018/03/29/self-driving-cars-uber-crash-toyota/468804002/

[13] Jonathan Landay, " NHTSA criticizes Tesla for releasing data on Model X crash," Autoblog (April 2018), https://www.autoblog.com/2018/04/02/nhtsa-criticizes-tesla-model-x-crash/

OOFI fears that crashes such as these will become more frequent as people become more reliant upon technology without truly realizing its limitations. It is important to note that automation is still in its experimental stage. Most of the technology equipped on CMVs and passenger vehicles today are designed primarily to assist drivers with routine tasks. However, manufactures and software developers often promote these technologies as "self-driving." False advertising will only serve to induce new safety risks such as automation bias as demonstrated in the Tesla and Uber crashes.

Figure 2: Examples of Potential Driving Scenarios That Could Pose Challenges Related to AVs



Source: GAO. | GAO-18-132

In January 2014, the Society of Automated Engineers (SAE) published a report titled *Automated Driving: Levels of Driving Automation Are Defined In New SAE International Standard J3016* in which they formulated a taxonomy to better inform policymakers and the public concerning the different levels of automation. NHTSA later adopted SAE's taxonomy in their federal automated vehicles policy. Table summarizes the SAE International J3016 Taxonomy and the differing levels between autonomous and human involvement. Although NHTSA defines Levels 3-5 as a HACV (the Tesla crash involved Level 2), Levels 3 and 4 will still require a human driver.

Various research conducted by the University of Central Florida's Institute for Simulation and Training and Massachusetts Institute of Technology (MIT) have demonstrated the dangers of Level 3 and 4 autonomy. The University of Central Florida's study, conducted by Professor Gerald Mathews, presented passenger-vehicle drivers with various autonomous driving scenarios during a Level 3 driver-assist simulation where the driver was required to retake control of the vehicle. The study found that automation incites rapid disengagement and "passive fatigue," meaning the fatigue related to un-engaged tasks associated with monitoring an autonomous driving system.[14]

Professor Mathews stated that passive fatigue "produces this rapid loss of task engagement. After 10 minutes, it sets in pretty quickly. We had a person drive the automatic vehicle and switch back to manual control before introducing "an emergency event" in the form of a vehicle entering the roadway ahead. We found that, again, passive fatigue was more harmful than active [fatigue]. Passive fatigue had greater influence on reaction times," meaning they were slower, less effective, more dangerous.[15]

At FMCSA's public listening session on autonomous vehicles, Fred Kovall of Anderson Trucking Service asked "if the driver has to be in the truck and has to have some control over it, how many hours in a row can you pay attention doing nothing" in a highly-automated-vehicle environment?[16]" This same question is relevant in regards to truck platooning where one or more trucks closely follow a lead truck in order to reduce aerodynamic drag and increase fuel savings. Studies have shown that drowsiness and hypervigilance frequently occur during highway driving and that they may have serious implications in terms of accident causation.[17] OOFI questions the effect that HACVs and truck platooning will have upon a driver's cognitive skills and performance. It is imperative that the DOT scientifically analyze this issue before proceeding forward with regulatory guidance.

MIT's research found that "there can be measureable costs to human performance when automation is used, such as loss of situation awareness, complacency, skill degradation, and automation bias," which "occurs in decision-making because humans have a tendency to disregard or not search for contradictory information in light of a computer-generated solution that is accepted as correct and can be exacerbated in time critical domains. Automated decision aids are designed to reduce human error but actually can cause new errors in the operation of a system if not designed with human cognitive limitations in mind.[18]" Automation bias is essentially broken into two fields. Firstly, errors of omission where the driver fails to recognize problems because the automation does not properly alert them and secondly, errors of commission where the driver erroneously follows automated directives or recommendations even if they are incorrect. Both error types are equally troubling especially considering the propensity for some drivers to become overly reliant upon technology.

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[14] Todd Dills, "'Driverless' vehicles: Their inevitability and increased fatigue risks," *Overdrive* (2017)
[15] Ibid.
[16] Todd Dills, "Industry reps sound off to FMCSA on autonomous vehicle tech's safety concerns, opportunities for reform," *Commercial Carrier Journal* (2017), http://www.ccjdigital.com/industry-reps-sound-off-to-fmcsa-on-autonomous-vehicle-techs-safety-concerns-opportunities-for-reform/?utm_source=daily&utm_medium=email&utm_content=04-26-2017&utm_campaign=Commercial%20Carrier%20Journal&ust_id=2fc1ef3c55c1a824e23febaa2fafae65
[17] Pierre Thiffault and Jacques Bergeron, "Monotony of road environment and driver fatigue: a simulator study," *Accident Analysis and Prevention 35* (2003), pg. 381-391
[18] M.L. Cummings, "Automation Bias in Intelligent Time Critical Decision Support Systems," Massachusetts Institute of Technology

Table 1: SAE International J3016

SAE Level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	Monitoring of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability (*Driving Modes*)
Human driver monitors the driving environment						
0	No Automation	The full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	System	Human driver	Human driver	Some driving modes
Automated driving system ("system") monitors the driving environment						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	System	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	System	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	All driving modes

Source: SAE International J3016 Taxonomy and Definition of Terms Related to Driving Automation Systems for On-road Motor Vehicles

Definitions: Dynamic driving task includes the operational (steering, braking, accelerating, monitoring the vehicle and roadway) and tactical (responding to events, determining when to change lanes, turn, use signals, etc.) aspects of the driving task, but not the strategic (determining destinations and waypoints) aspect of the driving task.

Driving mode is a type of driving scenario with characteristic *dynamic driving task* requirements (e.g., expressway merging, high speed cruising, low speed traffic jam, closed-campus operations, etc.).

Request to Intervene is notification by the *automated driving system* to a *human driver* that he/she should promptly begin or resume performance of the *dynamic driving task*.

According to a study conducted by the Virginia Tech Transportation Institute entitled *Safety Manger and Commercial Driver Opinions and Acceptance of Onboard Safety Systems*, both truck drivers and safety managers thought it was possible to become overly reliant on the stability control systems, meaning if the system did not function properly, it would result in a crash.[19] While developers and manufacturers are striving to promote the ideology that self-driving technology is safer than a vehicle operated by a human, it is critical to acknowledge that technology does not always operate correctly one hundred percent of the time. Though the consequences resulting from a malfunctioning smartphone or vending machine are relatively small, the penalties will be far worse for an 80,000-pound vehicle. Self-driving technology will never be completely autonomous as humans have played some role in the process, whether in the developmental phase or in its manufacturing. Imperfect people cannot make a perfect device.

Another safety issue to consider is the interaction between automated and non-automated vehicles on the public roadways. In February 2016, a Google self-driving Lexus RX450h struck the side of a bus after the bus driver did not behave as the autonomous car predicted.[20] This is possibly the first accident in which the AV was at fault. According to Google, the crash took place when the Lexus RX450h sought to get around some sandbags in a wide lane. The vehicle and the test driver both believed the bus would slow down or allow the AV to continue, but three seconds later, as the AV re-entered the center of the lane, it struck the side of the bus. Google issued a statement following the accident, saying, "From now on, our cars will more deeply understand that buses (and other large vehicles) are less likely to yield to us than other types of vehicles, and we hope to handle situations like this more gracefully in the future.[21]"

OOFI does not doubt Google's sincerity, but it does severely question the ability of current and future self-driving technology to a handle similar interactions. If AVs were to have a more prominent presence on the nation's highways, how will the various levels of autonomy interact together? Will they be able to operate safely while sharing the same roads? Again, who is liable when a crash does occur? Will it be the technology company, the software developer, the parts and equipment manufacturer, the owner of the vehicle? Currently, there are more questions than answers.

Data sharing

In addition to the economic and safety issues surrounding HACVs, OOFI believes that any process to advance automated truck technology must be met with increased data transparency from manufacturers. This will help educate consumers, the industry, and regulators about the actual reliability of autonomous technology. A session in 2017 on a House Energy and Commerce subcommittee considered a package of 14 various bills regarding autonomous vehicles, of which some proposed to limit data transparency

[19] Jessica Mabry et al., *Safety Manger and Commercial Driver Opinions and Acceptance of Onboard Safety Systems*, Virginia Tech Transportation Institute (2012), pg. 13
[20] David Shepardson, "Google says it bears 'some responsibility' after self-driving car hit bus," *Reuters* (Feb 2016), http://www.reuters.com/article/us-google-selfdrivingcar-idUSKCN0W22DG
[21] Ibid.

significantly. Data transparency is essential to ensure the safety of the motoring public. For example, how many crashes have occurred on the roadways involving automated vehicles?

Other than a few publicized incidents, the crash rate of autonomous vehicles is largely unknown. Google for example has admitted to an unknown number of accidents involving their autonomous vehicles, but yet the company is quick to note that most of these crashes are not at the fault of the Google vehicle. While the industry might accept this, FMCSA has repeatedly claimed that carriers and drivers who have experienced an accident, regardless of fault, are more likely to be involved in future crashes. According to a report conducted by the University of Texas at Austin, Google accumulated 12 crashes in 1.2 million miles between 2009 and 2015,[22] which equates to 1,000 crashes per 100 million vehicle-miles traveled, or a crash every 100,000 miles. These statistics are astounding compared to the 148.5 and 220.6 crashes per 100 million VMT for large trucks and passenger vehicles respectively.

As far as OOIDA is aware, the accident with Google's self-driving Lexus is the only incident where the manufacturer took full responsibility for the crash. Moreover, it was only after the fatal crash in Arizona that documents began to come forward on the reliability of Uber's systems. Such information is paramount to safety. Before large truck and passenger-car drivers are asked to share the road with HACVs, it is important that all safety data be disseminated to the motoring public in order to hold manufacturers accountable, particularly when their systems are claimed to improve safety.[23]

Federal Regulations

Although trucking potentially offers a shorter pathway to automation than passenger vehicles, it does come with additional challenges. Not the least of which is the Federal Motor Carrier Safety Regulations (FMCSRs). The John A. Volpe National Transportation Systems Center (Volpe) was tasked by the U.S. DOT to evaluate how the current FMCSRs may challenge the operation of automated CMVs, and how automated CMVs may introduce challenges to the application of the existing regulations.

According to Volpe, the FMCSRs "were drafted during a time when sole responsibility for operating a CMV was assumed to fall to a human driver. Therefore, before automated CMVs can operate in interstate service, their operation will need to avoid conflicts with the FMCSRs. Moreover, the state enforcement agencies that administer FMCSR requirements will need clarity on how the provisions of the FMCSRs apply to automated CMVs.[24]"

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[22] Kara Kockelman et al., *An Assessment of Autonomous Vehicles: Traffic Impacts and Infrastructure Needs—Final Report*, Center for Transportation Research at the University of Texas at Austin (March 2017), pg. 5-6

[23] https://www.carcomplaints.com/news/2017/lawsuit-nhtsa-freedom-of-information-act-request.shtml

[24] David Perlman et al., *Review of the Federal Motor Carrier Safety Regulations for Automated Commercial Vehicles: Preliminary Assessment of Interpretation and Enforcement Challenges, Questions, and Gaps*, Volpe (March 2018), pg. 1

Volpe therefore reviewed the FMCSRs to identify potential compliance and enforcement challenges associated with varying concepts of automated trucks and buses and to identify potential gaps in the current regulations with respect to the safe operation of automated CMVs. The most significant challenge in complying with the FMCSRs was also the most obvious one, the driver. In particular, the Volpe team found that a majority of the problems traced back to the definition of "driver" as contained in part 390.

Volpe noted "Automated CMV concepts that retain direct human driver involvement in control of the vehicle, at least occasionally, will face the fewest challenges in complying with the current FMCSRs. Operating concepts that relegate human involvement to an onboard supervisory role may face more significant challenges, both in terms of compliance with and enforcement of the FMCSRs, though the extent and nature of these challenges depend significantly on how the definitions of "driver" and "operator" are applied. Finally, operating concepts that require no onboard human operator could face the most significant challenges in meeting the current FMCSRs.[25]" Volpe identified the following issues in their report:

- Requirement for driver to be secured by seatbelt at driver's seat
- General requirements regarding unsafe driving and operation and installation of additional equipment that may decrease safety
- Skills, knowledge, and licensing of drivers
- Clarification of "safety-sensitive function"
- Hours of service requirements
- Alcohol and controlled substance restrictions
- Physical qualifications for drivers
- Inspection and cargo securement procedures
- Definition of "disabling damage" in the context of a DOT reportable accident

The Volpe team also found areas where the FMCSRs would not provide the same level of safety assurance for automated vehicles and their operators as they do for human drivers. For example, Volpe did not find specific language explicitly requiring a human driver to be present in a CMV while it is in operation. Nevertheless, there are regulations that require certain activities to be conducted while a CMV is underway, such as periodically inspecting the load and equipment.

This concept also applies to the performance of any safety-critical equipment on the tractor-trailer, including brakes, lights, tires, etc. The report notes experienced drivers are likely to change their driving behavior according to the physical performance of their truck and or trailer. And when the performance of the physical equipment begins to degrade, drivers are often required to replace or repair said equipment. However, how will an HACV be able to perform such tasks in order to maintain safety? Moreover, how will enforcement personnel be able to inspect an HACV properly for any hardware or software malfunctions? Before automated CMVs can become a reality and operate in interstate

[25] Ibid., pg. 8

commerce, FMCSA, as well as NHTSA, must conduct a thorough examination of current federal regulations to ensure the safe operation of such vehicles.

Cybersecurity

As more technology is integrated into CMVs and their autonomy increases, the opportunity for cyberattacks will escalate in return. Until recently, hackers have seemed more occupied penetrating computer systems at banks, retailers, and government agencies where they can access more money and data and create substantial disruption.[26] However, current high-profile ransomware attacks, such as the one conducted on AP Moller-Maersk, the world's largest container shipping line that also affected some of FedEx's facilities, indicate that the transportation industry is becoming a target as well. Such disruptions in HACV's and the trucking industry would have disastrous consequences. Moreover, as demonstrated in the successful hacking of a Jeep Cherokee in Missouri[27] and an autonomous truck in Michigan[28], there is a credible concern that malicious actors could use a HACV as a weapon.

The concern increases as more parts of the truck and trailer are plugged into the internet via an array of sensors designed to collect, transmit, and even accept a wide variety of data.[29] The numerous points of entry into a self-driving vehicle's computer system only serves to give thieves and cyber terrorists multiple opportunities to take control of the vehicle. For example, in 2010, one man in Austin, Texas triggered horns and disabled the ignition systems in more than 100 *non-autonomous* vehicles by hacking into an auto dealer's computer system. While hackers like these can control non-autonomous vehicles through entry points like internal network systems, entertainment systems, hand-free cell-phone operations, and satellite radio, self-driving vehicles are even more vulnerable to attacks, because they have all of those entry points plus many more.[30]

Earlier this year, the Transportation Security Administration (TSA) released a report *Vehicle Ramming Attacks: Threat landscape, Indicators, and Countermeasures*. The report detailed that terrorist networks have utilized CMVs to carry out attacks in recent years. As HACVs enter the marketplace, regulations must

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[26] Claus Herbolzheimer and Max-Alexander Borreck, "Time For Transportation & Logistics To Up Its Cybersecurity As Hackers Put It On Target List," *Forbes* (Jun 2017), https://www.forbes.com/sites/oliverwyman/2017/06/28/time-for-transportation-logistics-to-up-its-cybersecurity-as-hackers-put-it-on-target-list/#4ef0c6dd6fb9

[27] http://www.cnbc.com/2016/07/21/could-autonomous-trucks-be-the-next-weapon-for-terrorists.html

[28] http://www.salon.com/2016/08/03/as_era_of_autonomous_trucking_arrives_michigan_researchers_prove_how_easy_it_is_to_hack_trucks/

[29] Sean Kilcar, "Cybersecurity is a core trucking concern now," Fleet Owner (April 2016), http://www.fleetowner.com/blog/cybersecurity-core-trucking-concern-now?spvc=42&NL=FO-01&Issue=FO-01_20170816_FO-01_418&sfvc4enews=42&cl=article_6&utm_rid=CPENT000002367899&utm_campaign=13652&utm_medium=email&elq2=a71db75ac9614a9b91005d31ad390e38

[30] Bryan Cave, "Cybersecurity Issues of Self-Driving Vehicles," JD Supra (July 18, 2017), https://www.jdsupra.com/legalnews/cybersecurity-issues-of-self-driving-27237/

be established that require manufactures to prioritize cybersecurity concerns not only as a deterrent for terrorism but also cybercrimes and cargo theft.

Before proceeding with any guidance, it is critical that the U.S. DOT allow NHTSA to first complete their study concerning security for both cars and trucks as proposed by Rep. Joe Wilson (R-SC) and Rep. Ted Lieu (D-CA) in early 2017. H.R. 701, "The Security and Privacy in Your Car Study Act of 2017," would require NHTSA to determine and recommend standards for the regulation of the cybersecurity of motor vehicles manufactured or imported for sale in the United States.

Infrastructure

Finally, it is important for the DOT to consider infrastructure funding moving forward. In their 2017 Infrastructure Report Card, the American Society of Civil Engineers graded the nation's overall infrastructure as a D+. The rating details that, "the infrastructure is in poor to fair condition and mostly below standard, with many elements approaching the end of their service life. A large portion of the system exhibits significant deterioration. Condition and capacity are of serious concern with strong risk of failure."[31] While the state of our nation's infrastructure is problematic for the current fleet of highway vehicles, it is especially problematic for HACVs. HACVs have to depend on cameras and radar systems to detect lane markings, signage, and pavement conditions among other infrastructure conditions. Low-quality highway infrastructure will inhibit the productivity of HACVs and could create a significant safety risk. Lawmakers and regulators must address the state of the nation's infrastructure before HACVs can be fully, or even partially, deployed. A D+ highway environment will limit the efficiency of HACVs.

HACV proponents suggest that autonomous technology will solve congestion problems throughout the country. However, research effectively demonstrates that the introduction of automated cars and trucks will only increase congestion as individuals who have traditionally been unable to obtain transportation, such as the blind or elderly, will now have the means to travel. The same is also true when considering "deadheading" where a vehicle is in transit without a passenger or driver. Howard Jennings, managing director of the Mobility Lab festivities, stated, "Ironically, the efficiency of AVs has long been touted as a solution to traffic, but new research is beginning to suggest that AVs will, in fact, generate more of it. Simply put, there is no guarantee the traffic effects of AVs will be handled. It is entirely possible that they will spread widely and, without adequate policies, many places may never manage their impacts. By eliminating most of the hassles of driving, such as parking and lost productivity time, AVs will induce not only more trips, but longer ones. Additionally, AVs waiting to pick up new riders will add 'deadheading' miles. Placed all together, this suggests they will almost certainly increase vehicle-miles traveled (VMT), energy use, and emissions.[32]"

[31] https://www.infrastructurereportcard.org/making-the-grade/what-makes-a-grade/
[32] Sean Kilcarr, "Will autonomy actually make traffic congestion worse?" *Fleet Owner* (May 2017)

The International Transit Forum and Corporate Partnership Board published a 2015 Urban Mobility study that concluded that AVs would generate up to 35 percent more VMT when compared to manually driven vehicles.[33] Such increases in VMT and congestion will have a deleterious effect on the nation's infrastructure. It is also important to note that in order for fully automated trucks to become a reality, the country's infrastructure would need the ability to speak to the CMVs in what is called vehicle to infrastructure technology. It is important for lawmakers and regulators to consider whether the current Highway Trust Fund could accommodate such impacts and if it is appropriate to divert funds to support autonomous technology.

In promotion of an infrastructure proposal released by the Whitehouse in February 2018, U.S. DOT Undersecretary for Policy Derek Kan emphasized that states could finance freight infrastructure designed to facilitate the movement of self-driving trucks under the proposal's "transformative" and "incentives" titles.[34] Moreover, the 2018 consolidated appropriations bill included $100 million for a highly automated "vehicle research and development" program. In particular, the bill blocked off $60 million in grants "to fund demonstration projects that test the feasibility and safety" of AVs, while $38 million was designated for U.S. agencies to conduct further research into self-driving cars.[35] OOFI is concerned that additional highway use fees will be syphoned from the HTF to fund a technology that the average American is apprehensive of.

Conclusion

Although advancements in autonomous technology are impressive, there are a number of challenges associated with automated vehicles and as the technology becomes increasingly more complex so too will the number of ways in which they can fail. Fred Andersky, director of government and industry affairs at Bendix Commercial Vehicle Systems, has pointed to "things like weather. If it starts snowing and the lines on the road start to disappear, that makes it hard for the cameras to see.[36]" Thus HACVs need to use LiDAR to create high-resolution 3D maps. However, cameras have trouble distinguishing between minor issues such as puddles and major hazards such as sinkholes. Oil spots also can confuse sensor-providing data to self-driving systems on trucks. These hurdles mean it will be some time before there are fully self-driving trucks on the roadways. In the interim, there are a number of unintended consequences in regards to HACVs which lawmakers and regulators should consider, including:

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[33] Ibid.

[34] Eugene Mulero, "Trump Infrastructure Proposal Could Fund Self-Driving Truck Lanes, DOT Official Says," Transport Topics (March 2018), http://www.ttnews.com/articles/trump-infrastructure-proposal-could-fund-self-driving-truck-lanes-dot-official-says

[35] David Shepardson, "U.S. spending plan include $100 million for autonomous cars research, testing," Reuters (March 2018), https://www.reuters.com/article/us-autos-selfdriving-congress/u-s-spending-plan-include-100-million-for-autonomous-cars-research-testing-idUSKBN1GY074

[36] Clarissa Hawes, "Emerging Safety and Autonomous Technologies Put Trucks to the Test," *Trucks* (May 2017), https://www.trucks.com/2017/05/12/autonomous-technology-platooning-moving-forward/

- **Automation bias**: While developers have designed automated decision aids to reduce human error, they actually can cause new errors in the operation of a system as human drivers become overly reliant upon automation and thus exhibit errors of omission and or commission.
- **Ethics**: In circumstances where a crash is inevitable, what action will an HACV undertake? How will such a system make its choice between striking a school bus and putting itself into a ditch? Critical situations occur on the roadways every day, thus ethical considerations will be inevitable as accidents involving autonomous vehicles become a reality. How will scientific models address these situations, especially considering there is no comprehensive model today that can mirror the underlying cognitive processes of moral judgment and human behavior? Whatever algorithms are utilized will likely affect millions of vehicles at a time, which will increase the impact of any inherent biases or failures, thereby increasing the importance of getting it right.[37]
- **Performance and interaction with non-autonomous vehicles**: Fully autonomous vehicles are decades away, how will Levels 3 and 4 interact with the other trucks, cars, and buses on the roadways? In the case of Google's self-driving Lexus, the AV incorrectly predicted the behavior of the bus driver thereby causing the crash.
- **Situational awareness**: In the event of a steer-tire blowout or severe weather, how will a HACV perform in order to ensure the safety of the driver, if not fully autonomous, and the motoring public? An experienced driver understands when it is best to pullover and wait for a storm to pass. How will HACV's handle poor brake performance, construction zones, variable speed limits, detours and routing changes, load securement, etc.?
- **Congestion and increased pavement damage**: New research demonstrates that HACVs will likely increase traffic and VMT, thereby increasing the pavement damage to the nation's already crumbling infrastructure. Additionally, the more vehicles there are on the road, the greater the number of interactions with other vehicles and thus the greater likelihood of being involved in a crash.
- **Insurance**: How will the inception of HACVs affect insurance rates? How will this affect the trucking industry and who will be liable in the event of a crash? Will a crash caused by the failure of the automated system be included in a motor carrier's Compliance, Safety, and Accountability report?
- **Unemployment**: Research has shown that HACVs have the potential to eliminate thousands of drivers from the industry workforce. How will this affect owner-operators and professional drivers? How will this affect the economy?

The potential introduction of HACVs on the nation's highways invites more questions than it answers. For example, what impact will HACVs have on the FMCSRs? Will regulations such as hours-of-service need to be altered or simply eliminated altogether? What type of qualifications will a truck driver need to have in

[37] Leon R. Sütfeld et al., "Using Virtual Reality to Assess Ethical Decisions in Road Traffic Scenarios: Applicability of Value-of-Life-Based Models and Influences of Time Pressure," Neuroinformatics, Institute of Cognitive Science, Osnabrück University (July 2017), https://doi.org/10.3389/fnbeh.2017.00122

the future? Will they need specialized training or a specific degree in order to correctly and safely operate an autonomous truck? What training will law enforcement personnel need to acquire in order to identify malfunctions properly with HACV? Other possible issues to consider are:

- What effect will automated Levels 3 and 4 have on a driver's performance? Will it increase fatigue and or lead to an escalation in crashes?
- How will an HACV perform zipper type merges or navigate roundabouts that are becoming increasingly popular among states?
- What effect will truck platooning have on traffic and the motoring public? How will a passenger-car driver safely pass three trucks with at least a 15 foot following distance equaling approximately 240 feet of continuous trucks?
- How will HACV's obey signals from a police officer including pulling into a weigh station for a roadside inspection?
- If a malfunction occurs within the autonomous system, will the truck be able to safely pullover and come to a complete stop?