

Issues in Autonomous Vehicle Deployment

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Summary

Autonomous motor vehicles have been a topic of congressional hearings in recent years. Congress is considering legislation that would, for the first time, provide new regulatory tools to the National Highway Traffic Safety Administration (NHTSA) to oversee autonomous vehicles.

As the capacity of compact computers has gone up and their cost has dropped, the prospect of converting many driver-controlled functions to technology-control has increased significantly. Consumers are demanding that their vehicles have more telecommunications applications, while ride-sharing has prompted new concepts of mobility for the elderly and disabled, and people who do not own cars. In addition, more autonomous vehicles are seen as a way to reduce U.S. motor vehicle fatalities. There were over 40,000 deaths from traffic accidents in 2016, nearly all caused by driver error.

The federal government and the states share motor vehicle regulation, with the federal government responsible for vehicle safety and states for driver-related aspects such as licensing and registration. While NHTSA has the statutory authority to regulate all types of motor vehicles, its traditional standard-setting process would take many years at a time when vehicle innovation is changing rapidly; standards envisioned now could be obsolete by the time they took effect. In the absence of NHTSA regulation of autonomous vehicles, nearly half the states have enacted laws on different aspects of autonomous vehicle deployment, resulting in a patchwork of state regulation.

On July 27, 2017, the House Energy and Commerce Committee unanimously ordered to be reported legislation—H.R. 3388—that would preempt state regulation of some aspects of autonomous vehicle deployment, while providing new regulatory tools to NHTSA. With some provisions recommended in a 2016 NHTSA report, H.R. 3388 would

- preempt states from regulating the design of autonomous vehicles, unless those laws are identical to federal law;
- expand NHTSA's authority to grant exemptions from its standards to encourage innovation;
- require each manufacturer to submit a "safety assessment certification" showing how it is addressing autonomous vehicle safety;
- mandate within one year a NHTSA report indicating what federal safety standards must be updated and its vehicle safety priorities; and
- require manufacturers to develop and publicize to consumers their cybersecurity and data privacy plans.

The legislation would also establish an advisory committee, a new regulation for rear-seat occupant alerts (to reduce infant fatalities), and a review of headlamp standards.

The Senate Committee on Commerce, Science, and Transportation has released a set of principles guiding its discussion of legislation and may develop legislation this fall.

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Introduction

Autonomous vehicles, which would carry out many or all of their functions without the intervention of a driver, may bring sweeping social and economic changes in their wake. The elderly, disabled Americans, urban residents, and those who do not own a car may have new travel options. Travel on public roads and highways could become less congested. Highway travel could become safer as well: U.S. roadway fatalities rose in 2015 and 2016, the first annual increases in more than 50 years,¹ and a study by the National Highway Traffic Safety Administration (NHTSA) has shown that 94% of crashes are due to human errors² that autonomous vehicles could reduce. As a U.S. Department of Transportation (DOT) report contends, highly automated vehicles “hold a learning advantage over humans. While a human driver may repeat the same mistakes as millions before them, a [highly automated vehicle] can benefit from the data and experience drawn from thousands of other vehicles on the road.”³

Congressional committees have held numerous hearings on federal policy regarding automated vehicles, and have debated changes in federal regulation to encourage vehicular innovation while protecting passenger safety. In July 2017, the House Energy and Commerce Committee unanimously ordered to be reported the first major legislation on autonomous vehicles; members of the Senate Committee on Commerce, Science, and Transportation have issued principles to guide them in developing similar legislation.

Technology of Autonomous Vehicles

The technologies used in autonomous vehicles are very different from the predominantly mechanical, driver-controlled technology of the 1960s, when the first federal vehicle safety laws were enacted. Increasingly, vehicles can be controlled through electronics, requiring little human involvement. Performance can be altered via over-the-air software updates. A range of advanced driver assistance systems is being introduced to motor vehicles, many of them bringing automation to vehicular functions once performed only by the driver. These features automate lighting and braking, connect the car and driver to the Global Positioning System (GPS) and smartphones, and keep the vehicle in the correct lane. There are three forces driving motor vehicle innovation:

- technological advances enabled by new materials and more powerful, compact electronics;
- consumer demand for telecommunications connectivity and new types of vehicle ownership and ridesharing; and
- regulatory mandates pertaining to emissions, fuel efficiency, and safety.

¹ In 2016, there were 40,200 fatalities from motor vehicles, a 6% increase over 2015; there were 37,757 motor vehicle fatalities in 2015, a 7% increase over 2014. These two years reverse over 50 years of declining fatalities on U.S. roadways. National Safety Council, *NSC Motor Vehicle Fatality Estimates*, <http://www.nsc.org/learn/NSC-Initiatives/Pages/Fatality-Estimates.aspx>.

² S. Singh, *Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey*, National Highway Traffic Safety Administration, DOT HS 812 115, February 2015.

³ U.S. Department of Transportation and National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety*, September 2016, p. 5, <https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016>.

Increasingly, such innovations are being combined as manufacturers produce vehicles with higher levels of automation. Vehicles do not fall neatly into two categories of “automated” and “nonautomated,” because all of today’s motor vehicles have some element of automation.

The Society of Automotive Engineers International (SAE), an international standards-setting organization, has developed six categories of vehicle automation—ranging from a human driver doing everything to automated systems performing all the tasks once performed by a driver. This classification system (**Table 1**) has been adopted by DOT to foster standardized nomenclature to aid clarity and consistency in discussions about vehicle automation and safety.

Table 1. Levels of Vehicle Automation

SAE Automation Category	Vehicle Function
Level 0	Human driver does everything.
Level 1	An automated system in the vehicle can sometimes assist the human driver conduct some parts of driving.
Level 2	An automated system can conduct some parts of driving, while the human driver continues to monitor the driving environment and performs most of the driving.
Level 3	An automated system can conduct some of the driving and monitor the driving environment in some instances, but the human driver must be ready to take back control if necessary.
Level 4	An automated system conducts the driving and monitors the driving environment, without human interference, but this level operates only in certain environments and conditions.
Level 5	The automated system performs all driving tasks, under all conditions that a human driver could.

Source: DOT and NHTSA, *Federal Automated Vehicles Policy*, September 2016, p. 9, <https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016>.

Note: SAE is the Society of Automotive Engineers International, <http://www.sae.org>.

All vehicles sold today are in the lowest two tiers of SAE’s automation rating system. Views differ as to how long it may take for full automation to become standard. Some forecast market-ready autonomous vehicles within five years.⁴ Others argue that it will take much longer, as more testing, regulation, and policy work should be done before autonomous vehicles are widely deployed.⁵

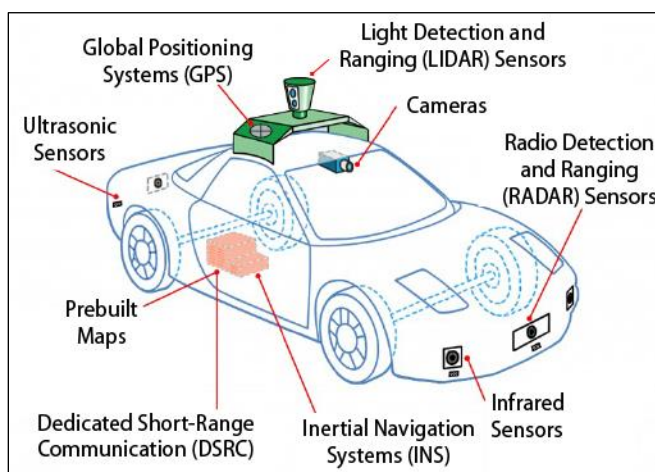
Technologies that could guide an automated vehicle (**Figure 1**) include a wide variety of electronic sensors that would determine the distance between the vehicle and obstacles; detect lane markings, pedestrians, and bicycles; park the vehicle; use GPS, inertial navigation, and a system of built-in maps to guide the vehicle direction and location; employ cameras that provide 360-degree views around the vehicle; and use dedicated short-range communication (DSRC) to monitor road conditions, congestion, crashes, and possible rerouting. These technologies are

⁴ Alexandria Sage and Paul Linert, “Ford Plans Self-Driving Car for Ride Share Fleets in 2021,” Reuters, August 16, 2016, <http://www.reuters.com/article/us-ford-autonomous/ford-plans-self-driving-car-for-ride-share-fleets-in-2021-idUSKCN10R1G1>.

⁵ Gabe Nelson, “Tap the brakes: Self-driving vehicle technology is ‘absolutely not ready,’ says robotics researcher,” *Automotive News*, March 26, 2016, <http://www.autonews.com/article/20160326/OEM02/303289956/tap-the-brakes%3A-self-driving-vehicle-technology-is-absolutely-not>.

being offered in various combinations on vehicles currently on the market, while manufacturers study how to combine them in vehicles that could safely transport passengers without drivers.

Figure 1. Autonomous Vehicle Technologies



Source: CRS, based on “Autonomous Vehicles” fact sheet, Center for Sustainable Systems, University of Michigan.

While private-sector development has focused on vehicle equipment, federal and academic researchers, along with industry, have spent over a decade developing complementary sensor technologies that could improve safety and vehicle performance. These include vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) capabilities—often referred to with the composite term V2X.

V2X technology relies on communication of information to warn drivers about dangerous situations that could lead to a crash, using DSRC to exchange messages about vehicles’ speeds, braking status, stopped vehicles ahead, or blind spots to warn drivers so they can take evasive action. V2X messages have a range of 300 meters (a fifth of a mile)—up to twice the distance of onboard sensors—cameras, and radar.⁶ These radio messages can “see” around corners and through other vehicles.

NHTSA has evaluated V2X applications and estimates that just two of them could reduce the number of crashes by 50%: intersection movement assist warns the driver when it is not safe to enter an intersection, and left turn assist warns a driver when there is a strong probability of colliding with an oncoming vehicle when making a left turn. V2V communications may also permit technologies such as forward collision warning, blind spot warning, and do-not-pass warnings. NHTSA estimated in 2014 that installing V2V communications capability will cost about \$350 per vehicle.⁷

⁶ National Highway Traffic Safety Administration, *Vehicle-to-Vehicle Communication Technology*, p. 1, <https://www.nhtsa.gov/technology-innovation/vehicle-vehicle-communications>.

⁷ *Ibid.*, p. 3.

Federal Regulatory Issues

In September 2016, DOT issued a comprehensive report on federal regulatory issues with regard to autonomous vehicles, based on consultations with industry, technology and mobility experts, state governments, safety advocates, and others. *Federal Automated Vehicles Policy*⁸ laid the foundation for future regulation and legislation by clarifying DOT's thinking in four areas:

- a set of *guidelines* outlining best practices for autonomous vehicle design, testing, and deployment;
- a *model state policy* that identifies where new autonomous vehicle-related issues fit in the current federal and state regulatory structures;
- a *streamlined review process* to expedite requests for DOT regulatory interpretations to spur autonomous development; and
- identification of *new tools and regulatory structures* for NHTSA that could aid in autonomous deployment, such as expanded exemption authority and premarket testing to assure that autonomous vehicles will be safe.

Guidelines

The guidelines identify practices and procedures that DOT expects manufacturers, suppliers, and service providers—such as driverless taxi companies—to follow in testing autonomous vehicles. DOT expects that the data generated from this research will be widely shared with government and the public while still respecting competitive interests.

Manufacturers, researchers, and service providers should ensure that their test vehicles meet applicable NHTSA safety standards⁹ and that their vehicles are tested through simulation, on test tracks, or on actual roadways. To assist in the regulatory oversight, NHTSA requests each entity testing autonomous vehicles to submit safety assessment letters that will outline how it is meeting the guidelines, addressing such issues as data recording, privacy, system safety, cybersecurity, and crashworthiness. DOT has specified that vehicle software must be capable of being updated through over-the-air means (similar to how smartphones are currently updated), so improvements can be diffused quickly to vehicle owners.¹⁰

Model State Policy

Any vehicle operating on public roads is subject to dual regulation by the federal government and the states in which it is registered and driven. Traditionally, NHTSA has regulated auto safety, while states have licensed automobile drivers and established traffic regulations.¹¹ DOT's report clarifies and restates that division for the transition to fully autonomous vehicles where the automobile is the driver.

⁸ U.S. Department of Transportation and National Highway Traffic Safety Administration, *Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety*, September 2016, <https://www.transportation.gov/AV/federal-automated-vehicles-policy-september-2016>.

⁹ Federal Motor Vehicle Safety Standards (FMVSS).

¹⁰ *Federal Automated Vehicles Policy*, pp. 11-36.

¹¹ State responsibilities include driver and vehicle licensing, enforcement of traffic laws, vehicle safety inspections, and regulating motor vehicle insurance and liability. *Ibid.*, p. 38.

The model state policy, developed by NHTSA in concert with the American Association of Motor Vehicle Administrators and other safety advocates, suggests state roles and procedures.¹² It covers administrative issues (designating a lead state agency for autonomous vehicle testing), an application process for manufacturers that want to test vehicles on state roads, coordination with local law enforcement agencies, changes to vehicle registration and titling, and liability and insurance. Liability may change significantly with autonomous vehicles, as states will have to reconsider the extent to which vehicle owners, operators, passengers, vehicle manufacturers, and component suppliers bear responsibility for accidents when no one is actively driving the vehicle.

Current Federal Regulatory Tools

In addition to its existing authority to issue federal vehicle safety standards and order recalls of defective vehicles, NHTSA has other tools it can use to address the introduction of new technologies: letters of interpretation, exemptions from current standards, and rulemakings to issue new standards or amend existing standards.

NHTSA uses letters of interpretation when it receives requests seeking clarifications of existing law. It may take NHTSA several months or even years to issue a letter of interpretation, which cannot make substantive changes to regulations.

The agency can grant exemptions from safety standards in certain circumstances. They are not granted indefinitely—an exemption may last for two or three years—or for a large number of vehicles.¹³ The approval process may take months or years. Rulemaking to adopt new standards or modify existing ones generally takes several years and requires extensive public comment periods.

Proposed New Regulatory Tools

Federal Automated Vehicles Policy identifies potential new tools and authorities that could affect the way autonomous vehicles are regulated. These include the following:

- Premarket safety assurance tools could include premarket testing, data, and analyses reported by a manufacturer to demonstrate that a new vehicle met standards before being deployed on public roads. Some of these tools could be used without new statutory authority.
- Premarket approval authority¹⁴ differs from safety assurance as well as from the self-certification process used for the past 50 years.¹⁵ It could be used to replace self-certification for autonomous vehicles, requiring NHTSA to test prototype vehicles to ensure that they met all federal motor vehicle safety standards. NHTSA would need new statutory authority and additional resources to take on certification procedures now handled by manufacturers.
- Imminent hazard authority would permit NHTSA to take immediate action to curtail serious safety risks that could harm the public. The Obama Administration

¹² Ibid., p. 37.

¹³ In most cases, NHTSA can consider an exemption for up to 2,500 vehicles per year. Ibid., p. 56.

¹⁴ Other federal agencies use this process now. For example, the Federal Aviation Administration uses it to regulate software such as autopilot programs used on commercial aircraft. Ibid., p. 71.

¹⁵ Automakers self-certify that their vehicles meet all federal motor vehicle safety standards. NHTSA does not test new models before they come on the road, but later spot tests to ensure that new vehicles are in compliance.

unsuccessfully argued that this new tool be included in the 2015 surface transportation bill.¹⁶

- Expanded exemption authority for autonomous vehicles would raise the current limit of 2,500 vehicles that can be exempted from federal safety standards. This would provide a larger database of real-world experience for analyzing on-road safety readiness of exempted vehicles. The report describes several alternative ways in which an expanded exemption could operate, and notes that “it would be important to guard against overuse of the authority such that exemptions might displace rulemaking as the de facto primary method of regulating motor vehicles and equipment.”¹⁷
- Enhanced data collection tools would allow NHTSA to utilize the large amounts of data collected by autonomous vehicles. Event data recorders, now used in a limited way on nearly all motor vehicles to record vehicle and driver information in the seconds before a crash, could be expanded for use in autonomous vehicles to identify safety-related defects. NHTSA has the statutory authority now for this tool.

State Concerns

According to the National Conference of State Legislatures, 20 states plus the District of Columbia have enacted legislation related to autonomous vehicles (**Figure 2**), and related bills have been introduced in 33 states in 2017. DOT’s model state policy and legislation ordered to be reported from the House Energy and Commerce Committee (H.R. 3388) reflect concerns that the absence of federal regulation covering autonomous vehicles may encourage states to move forward on their own, potentially resulting in diverse and even conflicting state regulations.

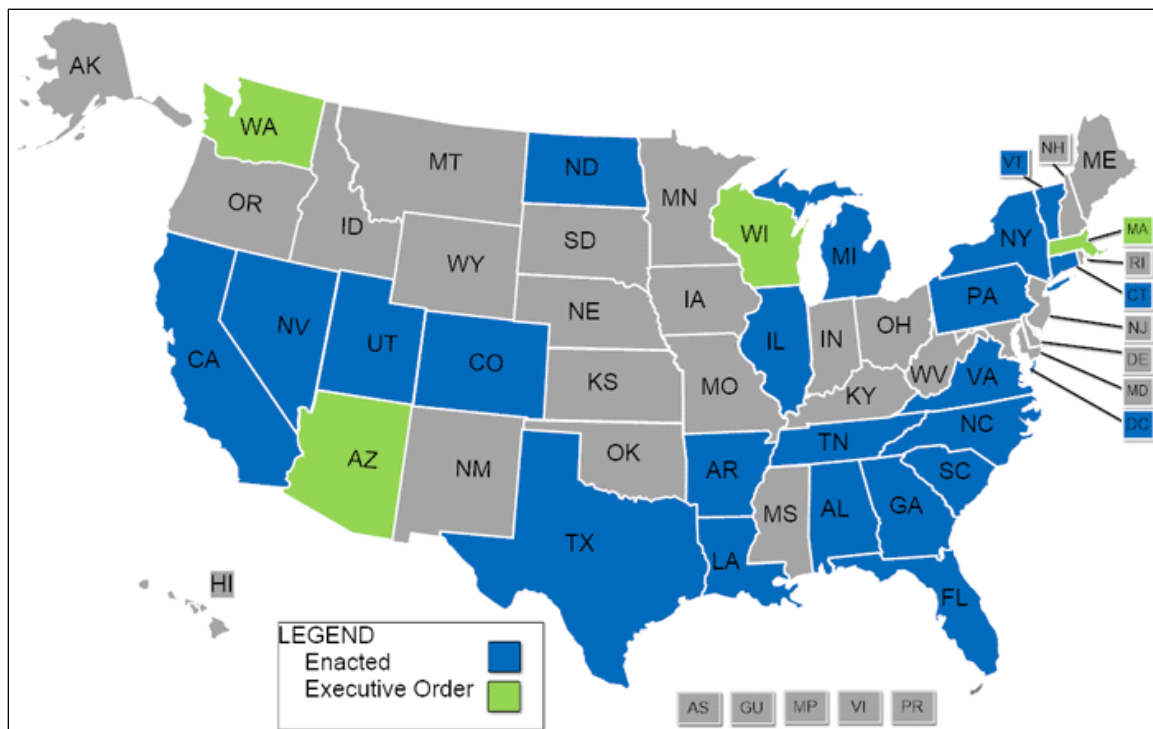
The types of state laws with regard to autonomous vehicles vary widely. For example, California, Florida, Michigan, and Nevada have passed laws governing autonomous vehicle testing procedures. Florida was the first state to permit anyone with a valid driver’s license to operate an autonomous vehicle on public roads, and it does not require an operator to be in the vehicle. In California, the regional Contra Costa Transportation Authority approved the testing on certain public roads of autonomous vehicles not equipped with a steering wheel, brake pedal, or accelerator.

A Tennessee law bars local governments from prohibiting the use of autonomous vehicles and established a new vehicle tax. North Dakota and Utah enacted laws to study safety standards and report back to the legislature with recommendations. Michigan enacted several bills in 2016 that permit autonomous vehicles to be driven on public roads, address testing procedures, and establish the American Center for Mobility for testing vehicles.¹⁸

¹⁶ Fixing America’s Surface Transportation (FAST) Act, P.L. 114-94.

¹⁷ *Federal Automated Vehicles Policy*, p. 76.

¹⁸ Ben Husch and Anne Teigen, “Regulating Autonomous Vehicles,” National Conference of State Legislatures, LegisBrief, Vol. 15, No. 13, April 2017, http://www.ncsl.org/documents/legisbriefs/2017/lb_2513.pdf.

Figure 2. States with Enacted Autonomous Vehicle Measures

Source: National Conference of State Legislatures, <http://www.ncsl.org/research/transportation/autonomous-vehicles-self-driving-vehicles-enacted-legislation.aspx>.

Note: States in gray have not enacted autonomous vehicle legislation.

Congressional Action

Committees in the House of Representatives and Senate have held numerous hearings on the technology of autonomous vehicles and possible federal issues that could result from their deployment.

House of Representatives

On July 27, 2017, the House Energy and Commerce Committee unanimously ordered to be reported H.R. 3388, the Safely Ensuring Lives Future Deployment and Research In Vehicle Evolution Act—or SELF DRIVE Act. The bill addresses concerns about state action replacing some federal regulation, while also empowering NHTSA to take unique regulatory actions to ensure safety and encouraging innovation in autonomous vehicles. It retains and clarifies the current arrangement of states controlling most driver-related functions and the federal government being responsible for vehicle safety. The major provisions focus on the following:

State Preemption. States would not be allowed to regulate the design, construction, or performance of highly automated vehicles, automated driving systems, or their components unless those laws are identical to federal law.¹⁹ The legislation reiterates that vehicle registration,

¹⁹ The bill would permit states and the federal government to prescribe higher standards for autonomous vehicles they purchase for their own use.

driver licensing, driving education, insurance, law enforcement, and crash investigations should remain in state jurisdiction as long as they do not restrict autonomous vehicle development. H.R. 3388 states that nothing in the preemption section should prohibit states from enforcing their laws and regulations on the sale and repair of motor vehicles.

New Safety Standards. Within two years of enactment, DOT would have to issue a final rule requiring each manufacturer to show how it is addressing safety in its autonomous vehicles, with updates every five years thereafter. DOT would not be allowed to condition vehicle deployment on review of these certificates, however. The regulation establishing the safety assessment certifications would have to specify the testing requirements and data necessary to demonstrate safety in the operation of the autonomous vehicle. In the interim, manufacturers would have to submit safety assessment letters.²⁰

Safety Priority Plan. DOT would be expected to submit a safety priority plan within a year of enactment, indicating which existing federal safety standards must be updated to accommodate autonomous vehicles, the need for new standards,²¹ and NHTSA's safety priorities for autonomous vehicles and other vehicles.

Cybersecurity. Highly autonomous vehicles will rely on computers, sensors, and cameras to navigate, so cybersecurity protections will be necessary to ensure vehicle performance. The legislation stipulates that no highly autonomous vehicle, or one with partial driving automation, could be sold domestically unless a cybersecurity plan has been developed by the automaker. The plan would have to include

- a written policy on mitigation of cyberattacks, unauthorized intrusions, and malicious vehicle control commands;
- a point of contact at the automaker with cybersecurity responsibilities;
- a process for limiting access to automated driving systems; and
- the manufacturer's plans for employee training and maintenance of the policies.

Exemption Authority. As recommended in DOT's 2016 *Federal Automated Vehicles Policy*, the bill would expand DOT's ability to issue exemptions from existing safety standards to encourage autonomous vehicle testing.²² To qualify for an exemption, a manufacturer would have to show that the safety level of the automated vehicle equals or exceeds the safety level of that standard for which an exemption is sought.

Whereas current laws limit exemptions to 2,500 vehicles per manufacturer per year, the bill would phase in increases over four years of up 100,000 vehicles per manufacturer per year. DOT would be directed to establish a publicly available and searchable database of motor vehicles that have been granted an exemption.

Privacy. Before selling highly automated vehicles, manufacturers would be required to develop written privacy plans concerning the collection and storage of data generated by the vehicles, as well as a method of conveying that information to vehicle owners and occupants. However, a manufacturer would be allowed to exclude processes from its privacy policy that encrypt or make

²⁰ The concept of safety assessment letters was identified as an interim tool in DOT's 2016 *Federal Automated Vehicles Policy*.

²¹ New standards might include human machine interface, sensors, software, and cybersecurity.

²² For example, Federal Motor Vehicle Safety Standard 111 governs the performance and location of the rearview mirror. Fully autonomous vehicles would not need to be equipped with such mirrors because they rely on rear-facing sensors.

anonymous the sources of data. The Federal Trade Commission would be tasked with developing a report for Congress on a number of vehicle privacy issues.

Consumer Information. DOT would be directed to complete a research program within three years that would lay the groundwork for a consumer education program about the capabilities and limitations of highly automated vehicles. DOT would be mandated to issue a regulation requiring manufacturers to explain the new systems to consumers.

Highly Automated Vehicle Advisory Council. A new NHTSA advisory group would be established with up to 30 members from business, academia, states and localities, and labor, environmental, and consumer groups to advise on mobility access for senior citizens and the disabled; cybersecurity; labor, employment, environmental, and privacy issues; and testing and information sharing among manufacturers.

The legislation also addresses several vehicle safety standards not directly related to autonomous vehicles:

Rear Seat Occupant Alert System. In an effort to reduce or eliminate infant fatalities, the bill would direct DOT to issue a final regulation within two years requiring all new passenger vehicles to be equipped with an alarm system to alert the driver to check the back seats after the vehicle's motor or engine is shut off.

Headlamps. DOT would be directed to initiate research into updating motor vehicle safety standards to improve performance and safety, and to revise the standards if appropriate. If NHTSA chooses not to revise the standards, it must report to Congress on its reasoning.

Senate

The Senate Committee on Commerce, Science, and Transportation has not voted on autonomous vehicle legislation, but the committee's chairman and ranking member²³ issued a set of principles in June 2017 that may form the basis of the legislation that the committee may consider. Their principles call for legislation that will

- *prioritize safety*, acknowledging that federal standards will eventually be as important for self-driving vehicles as they are for conventional vehicles;
- *promote innovation* and address the incompatibility of old regulations written before the advent of self-driving vehicles;
- *remain technology-neutral*, not favoring one business model over another;
- *reinforce separate but complementary federal and state regulatory roles*;
- *strengthen cybersecurity* so that manufacturers address potential vulnerabilities before occupant safety is compromised; and
- *educate the public* through government and industry efforts so that the differences between conventional and self-driving vehicles are understood.

²³ Bipartisan Principles for Self-Driving Vehicles were announced by Senators John Thune, Bill Nelson, and Gary Peters on June 13, 2017. Senator Gary Peters, "Senators Release Bipartisan Principles for Self-Driving Vehicles Legislation," press release, June 13, 2017.

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