

NHTSA and the Future of Automotive Technology

Building a safety foundation through cooperation and oversight

By James C. Owens

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The auto industry is witnessing a technological revolution, and tens of billions of dollars have been invested in automation research and development that holds the potential one day to change fundamentally the way we drive and to reduce dramatically vehicle-related deaths and injuries. But in a heavily regulated industry, these exciting developments carry with them a significant challenge: How can we protect public safety as the technology matures and, at the same time, provide sufficient breathing space for groundbreaking innovation to grow, so that we can all one day realize the potential safety benefits that such innovation promises?

Fortunately, the National Highway Traffic Safety Administration is up to this challenge, and has already laid the foundations for this transformational journey. The Secretary of Transportation, Elaine L. Chao, has stressed the importance of ensuring America's continued global leadership in emerging technologies, and under her leadership, the U.S. Department of Transportation as a whole and NHTSA in particular have taken careful steps to protect the traveling public while removing counterproductive regulatory barriers to innovative technologies. With the ongoing development of technologies such as advanced driver assistance systems (ADAS), connected vehicle-to-everything communications technology (V2X), and Automated Driving Systems (ADS), America once again has the potential to transform the future of transportation.

I. NHTSA's Core Mission Is Safety

Motor vehicles are an immense blessing. Automobiles democratized prosperity by ensuring that every corner of our Nation—not just the major transportation hubs—can participate fully in our national economy. Vehicles also democratized personal liberty, enabling each of us the freedom to travel when and where we want, and not be tied to the routes and schedules set by others. Vehicles gave us the latitude to choose where we live, whether it be in the cities, in the suburbs, or in the countryside. In short, automobiles have given most Americans the kind of prosperity and personal liberty that was unimaginable by even the wealthiest robber barons a little more than a century ago.

But these blessings came at a cost. Drivers make errors, and by the middle of the twentieth century, vehicle crashes became one of the leading causes of death in America. In 1970, more than 52,000 people lost their lives in traffic crashes—a rate of 4.74 fatalities per 100 million

vehicle miles traveled (VMT). That same year, President Nixon and Congress established the National Highway Traffic Safety Administration to address motor vehicle safety. By 2019, the traffic fatality rate had fallen to 1.1 fatalities per 100 million VMT—less than a quarter of what it had been in 1970, despite there being many more vehicles on our roads. This improvement is astonishing, and it reflects the enhanced safety of vehicles, as well as important changes in social norms and driving laws that have helped Americans drive more responsibly than before.

NHTSA and many others—including State and local governments, those advocating for tougher laws on impaired and distracted driving, and the investors who are putting capital into the development of new safety technologies—have worked tirelessly to make our Nation’s roads safer. But we still have a long way to go. In 2019, 36,096 Americans lost their lives on our Nation’s roadways. Each one of those lives lost had profound effects on our society. They are parents, children, siblings, friends, and colleagues, and we all suffer for having lost them. The goal of reducing these losses is why the women and men at NHTSA will continue in our mission to advance highway safety, and why we—like so many others—are intrigued by the potential safety benefits of automation and other advanced vehicle technologies. If vehicles can avoid crashes or reduce the severity of those that do occur, then we may see many fewer lives lost on our roads every year.

II. NHTSA’s Role in Improving Safety

As our Nation’s highway traffic safety watchdog, NHTSA conducts research to evaluate new technologies that automakers develop, establishes regulatory minimum safety standards when necessary and appropriate, empowers American families with comparative information about vehicle safety, investigates potential defects, and takes enforcement action to ensure that any motor vehicle or piece of equipment that presents an unreasonable risk to safety is recalled and repaired. These are critical and necessary roles, and NHTSA never hesitates to take action to protect public safety.

But the Federal Government is not an innovator in vehicle safety technology. NHTSA can mandate or ban existing technology, can create incentives for new technological innovations (e.g., the five-star safety ratings New Car Assessment Program), and sometimes can support industry’s research activities (e.g., through the cooperative agreement that supports industry’s passive alcohol detection research). But American families principally rely on automakers and others to conduct the research and make the investments in developing new technology that improves vehicle safety. Just about every major safety invention, from seat belts to electronic stability control, was pioneered by industry and later adopted by NHTSA, not the other way around. Once the technologies were proven, NHTSA moved quickly to require or otherwise encourage their adoption, but regulatory mandates governing these technologies only came about after industry had developed them and proven their value.

NHTSA’s Regulatory Authorities. Under longstanding U.S. law, and unlike many other nations, the Federal Government does not engage in pre-market permitting or “type approval” of vehicle equipment. Instead, all manufacturers must self-certify that their vehicles or equipment meet all applicable regulatory standards before they can sell their vehicles or equipment. NHTSA establishes performance standards, known as Federal Motor Vehicle Safety Standards

(FMVSSs), governing specific aspects of motor vehicles or equipment. The FMVSS only cover a relatively small part of motor vehicles and equipment. But that does not mean that those other aspects are unregulated. Far from it: *All* vehicles and equipment (including those for which no individual performance standards have been established) are subject to a common performance standard, which is that they may not present an unreasonable risk to safety. NHTSA exercises its broad enforcement authority to investigate possible defects and to require the recall and repair of defective vehicles or equipment.

The structure of NHTSA's legal authorities carves out space for innovation. Automakers are able to test new equipment and technologies, and to incorporate them into their vehicles so long as they do not interfere with the FMVSSs and do not pose an unreasonable risk to safety. This breathing room for innovation has led to the development of many new technologies, such as air bags and electronic stability control. As automakers develop such technologies, NHTSA's own research team will engage with the developer and begin to evaluate the safety improvement potential of their innovation. That research in turn informs the Agency's determination as to whether it would be appropriate to establish a regulatory performance standard and thereby mandate the new technology.

NHTSA's regulatory authorities, laid out in the National Traffic and Motor Vehicle Safety Act, require that any standard the Agency sets must meet a clear safety need, be practicable, and be accompanied by clear test procedures that are objective, repeatable, and reproducible (see 49 U.S.C. § 30111(a)). The rulemaking process is a long and deliberate one, for good reason: NHTSA is a data-driven, science-based agency. Before most regulation is crafted, the Agency first collects data and conducts substantial research to measure the scope of the issue and to determine where the greatest safety benefit lies. Data and sound science are essential to ensuring that standards actually improve safety instead of merely providing a false sense of security, and avoids foreseeable unintended consequences that could introduce risks or cause harm.

NHTSA's rulemaking process is a transparent one; the Agency does not write rules without significant public input. NHTSA receives comments from a diverse audience, including the public, local law enforcement, industry, safety advocates, and cities and States. These voices, combined with the diligence and expertise at NHTSA, result in an improved final product, one that is scientifically sound, repeatable, and designed to ensure real safety benefits.

As the regulatory process makes clear, NHTSA must rely on sound science and solid data before proposing and establishing regulatory standards. That not only means that the technology being evaluated must exist, but it must be sufficiently mature so as to enable the Agency to determine whether it would reliably improve safety, whether it would be practicable to mandate, and whether the Agency could establish scientifically precise test and performance metrics so that anyone in the world with the wherewithal to do so could replicate the test and determine whether a particular vehicle or piece of equipment satisfies the performance requirements. So, to put it simply, regulations must necessarily follow technological maturity.

If a technology is not yet mature—that is, for instance, if the designs are still fluid, or the performance is uncertain or unreliable—then that makes it impossible for the Agency to establish objective testing and performance standards, or even to determine whether the technology would

improve safety or be practicable. Moving forward with regulatory standards prematurely would be inconsistent with our statutory requirements, and risks being reckless and irresponsible. The potential downsides to safety are very real. Without sound science and solid data, it is impossible to know if the new standard would improve safety. Intuition is not science, and it is not enough. The Agency must understand not only the potential benefits of technology, but also the potential for unintended consequences.

This sense of appropriate, scientific caution is a fundamental part of NHTSA's history and staff culture, and it comes out of hard experience. Early seat belts, we now know, created specific types of safety risks because they restrained passengers too tightly, which in turn transferred too much of the kinetic energy of crashes to the body's internal organs. Similarly, history informs us that the Agency lacked important information about early air bag technologies when it established regulatory mandates, and as a result, we know that many people—women in particular—were killed or seriously injured because they were too close to the steering wheel when such air bags deployed. Today, thanks to further innovation and sound science, seat belts and air bags are among the most important devices for vehicle safety, but no one wants to see a repeat of this history. Therefore, NHTSA's experts will continue to take a strong stance against attempting to establish regulatory standards before the technologies at issue are matured—and their capabilities and limitations are tested and understood with scientific evidence.

Thanks to the amazing advances in safety technologies, vehicles today are much safer than before—in fact a person's chances of surviving a serious crash in a new or newer vehicle are about twice that of passengers in a vehicle that is 18 years old or older (see <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812528>; <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812937>; <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812690>). Safety isn't something that should be reserved for the privileged few, and the safety benefit of newer vehicles is so significant that NHTSA must account for the impact on price and affordability of any new regulation to ensure that modern safety features are not something that only the affluent can enjoy. Regulations are a hidden tax on modern vehicles, and we must also consider the safety disadvantages that working families would face if these taxes price them out of new or newer vehicles. Unfortunately, this is borne out by the fact that the average age of vehicles in the United States is nearly 12 years old—the oldest fleet in history—while new vehicles are more expensive and increasingly unaffordable for too many (see www.bts.gov/content/average-age-automobiles-and-trucks-operation-united-states and <https://mediaroom.kbb.com/2020-09-01-Average-New-Vehicle-Prices-Jump-Nearly-4-Year-Over-Year-in-August-2020-According-to-Kelley-Blue-Book>). By addressing issues of affordability, NHTSA has taken steps in this Administration to help ensure that millions of additional families will be able to acquire new and newer vehicles that meet their diverse needs. Better affordability will save thousands of lives and avoid hundreds of thousands of injuries, and most of those benefits will be realized by those who otherwise would not have been able to afford new or newer vehicles (www.govinfo.gov/content/pkg/FR-2020-04-30/pdf/2020-06967.pdf).

Non-Regulatory Ways to Improve Safety. NHTSA's performance-based regulations are a powerful instrument for enhancing vehicle safety, but they are not the only tools available for the task. To continue to support innovation and improvements to safety when rulemaking is not

available, NHTSA uses its convening authority to tap into competitive market forces and encourage automakers to research and develop advanced safety features, and employs its enforcement authority to ensure the safety of the public as these innovations are deployed.

For example, NHTSA's New Car Assessment Program (NCAP), the 5-Star Safety Ratings program, recognizes excellence in safety performance, empowering American families with comparative safety information that allows them to choose vehicles that provide better crash protection (see www.nhtsa.gov/ratings). The program also recognizes high-performance advanced technology features that can help drivers avoid crashes altogether. NHTSA is currently working to update the program by adding information about newer and more advanced technologies. NHTSA has also used its convening authority in less formal ways to encourage automakers to deploy new technologies. For instance, in September 2019 a group of automakers voluntarily pledged to install child-detection technologies in all vehicles by Model Year 2025, and NHTSA created an online docket to give automakers a single place to publish updates on their progress (see beta.regulations.gov/docket/NHTSA-2019-0126).

Because this voluntary process is transparent, it taps into competitive forces to encourage automakers to make significant improvements to safety or else fall behind their competitors in the eyes of American families. This process allows manufacturers to develop different technological paths for achieving the desired goal, which in turn rewards the American public because it increases the likelihood that best technological solutions will be discovered.

NHTSA has also used innovation to improve safety in other ways. For instance, in September 2020, the Agency launched a new smartphone app that allows consumers to sign up to receive nearly real-time updates on recalls affecting their vehicles or equipment (see www.nhtsa.gov/press-releases/safercar-app). By making it easier for drivers to learn about recalls, NHTSA anticipates that more free recall repairs will be completed, which will make the vehicles on our roads safer than before.

III. NHTSA's Oversight of Advanced and Innovative Technologies

We live in an exciting era, in which significant investment and progress is being made in advanced technologies that have the potential to improve safety radically and to change the driving experience. As exciting as the prospects for these advances may be, they are still very much in development, and far from mature. Consequently, NHTSA is not now in a position to establish regulatory standards for these emerging technologies. But this does not mean that NHTSA is not carefully supervising the development, testing, and deployment of these technologies. Far from it: the Agency is actively conducting research to evaluate the known technologies, conducting investigations into alleged safety defects of the technologies, and is using its convening authority to encourage more transparency and safe testing practices among developers and better education and coordination among all levels of government. As these technologies continue to develop and start to be deployed, NHTSA will continue to exercise its enforcement authority to ensure that anything that presents an unreasonable risk to safety is recalled.

A. Automated Driving Systems (ADS)

Automated technologies are among the most exciting and promising technologies in development today. Fully automated vehicles hold the potential to revolutionize driving and to save many lives. Industry—from traditional automakers to new entrants—is investing billions of dollars to develop automated technologies and introduce novel vehicle designs. Many stakeholders, from safety advocates to governments around the world, are eager for the innovation to succeed and are starting to grapple with the complex regulatory questions that such vehicles would raise. In the United States, there are no regulatory barriers to deploying ADS at this time, but there can be a challenge developing novel vehicle designs that do not comply with FMVSSs.

NHTSA has not yet issued new performance standards for ADS because this technology is still far from its endpoint. To regulate technologies before they are market-ready would stifle their development, and thus, their lifesaving potential. Worse still, regulating without a full understanding of the technology could risk regulating the wrong aspects of performance and potentially lead to unexpected negative safety consequences in other ways.

Because it would be scientifically indefensible to propose regulatory standards for technologies that are unproven and still in development, NHTSA has initiated a variety of actions to begin the process of gathering information and engaging with all our stakeholders, and will continue to exercise careful oversight over these emerging technologies by conducting research, investigating incidents, and when necessary and appropriate, employing our broad enforcement authority. NHTSA also maintains a close dialogue with developers to ensure that our safety concerns are considered during the product development process, and, separately, the Agency has been undertaking rulemaking to identify and address existing regulatory barriers that unnecessarily may stand in the way of innovation.

Supporting Research and Demonstration Projects for Non-Conforming Vehicles. During this Administration, NHTSA has employed its existing temporary waiver (or “Box 7”) procedure, available only to imports, to authorize and oversee the operation of more than 100 vehicles equipped with ADS (that are not FMVSS-compliant) for research and demonstration projects (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/tempinfojuly2016.pdf). When the Agency learns of safety incidents, NHTSA has suspended the operations of that vehicle and similar vehicles until the incident is fully understood by the operator and any risks corrected or mitigated (see www.reuters.com/article/us-autos-selfdriving-idUSKBN20J2N6 and www.forbes.com/sites/bradtempleton/2020/05/15/easymile-self-driving-shuttles-add-seatbelts-to-get-back-in-operation/?sh=71ab74b34675).

The Box 7 program has enabled dozens of operators not only to demonstrate and extend the capabilities of their technologies, but also to begin to understand how these technologies can be used commercially. One measure of the program’s success is the fact that ADS operators have been able to put their research vehicles to use assisting in our Nation’s response to the COVID-19 pandemic. On April 10, 2020, NHTSA issued an [open letter to stakeholders](#), challenging them to use their innovative technologies to address the unique challenges posed by the national health crisis. In response, the Agency published more than a dozen of the most significant responses, with automated vehicles being used for such tasks as transporting medical tests and supplies to hospitals, and shipping prescription drugs to the homes of those unable to travel. The positive

response and creative applications provide a glimpse into what innovative automotive technologies may be able to accomplish in the future.

Underscoring the success of the Box 7 program in providing a safe avenue for researching and developing ADS vehicles that do not comply with FMVSSs, in January 2021 NHTSA issued an interim final rule effectively expanding it to authorize research and demonstration waivers for domestic as well as imported vehicles (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/preview_copy_-_exemptions_for_domestically_produced_vehicles_and_equipment_for_research-investigations-demonstrations-training.pdf).

Expanding Public-Private Cooperation and Coordination for ADS Research and Deployment: the AV TEST Initiative. State governments exercise jurisdiction over the safe operation of vehicles on their roads, while NHTSA's jurisdiction relates to the vehicles themselves. To address issues raised by the operation of FMVSS-compliant ADS vehicles on public roads, State and local governments have established their own sets of requirements and restrictions.

But having a patchwork of State and local governments evaluate the safe operation of a wide variety of vehicles being developed by many different companies is complex and inefficient. To address this situation, in June 2020 NHTSA used its convening authority to launch the Automated Vehicle Transparency and Engagement for Safe Testing (AV TEST) Initiative, the first platform connecting the public, manufacturers, developers, operators, and all levels of government to voluntarily share information about the on-road testing and development of Automated Driving Systems (see www.nhtsa.gov/press-releases/participants-automated-vehicle-transparency-and-engagement-for-safe-testing-initiative). By bringing industry and government together, AV TEST will deepen the lines of communication and coordination among its participants; help ensure that safe testing best practices are widely shared; and provide better education for participants about the state of the technologies, their capabilities, and, importantly, their limitations. The AV TEST Initiative also provides a critical resource to educate and engage the public about these vehicles, the scope and map location of on-road testing, and the stakeholders involved (see www.nhtsa.gov/automated-vehicles-safety/av-test-initiative-tracking-tool).

The AV TEST Initiative's success will be ultimately determined by the number of those who join, and the extent of their participation. The pilot program included began with nine States and nine companies. In December 2020, NHTSA opened the initiative to all interested participants. As of January 2021, there are 26 companies and 20 States and local governments, as well as three associations, participating.

Identifying and Removing Regulatory Barriers. The ongoing development of ADS has given rise to novel vehicle designs that the existing FMVSSs may unintentionally and unnecessarily prevent. NHTSA began addressing this in May 2019, publishing an Advance Notice of Proposed Rulemaking (ANPRM) on unnecessary barriers to the development and deployment of vehicles with ADS in a manner that does not have a negative impact on safety (see www.federalregister.gov/documents/2019/05/28/2019-11032/removing-regulatory-barriers-for-vehicles-with-automated-driving-systems). The public comments received in that process helped

to inform NHTSA about the scope of unnecessary regulatory barriers and appropriate ways to remove them.

To address questions of novel vehicle designs—and particularly vehicles that are not designed for human occupants or have significantly modified driver controls—in March 2020 NHTSA issued a rulemaking proposal to amend several crashworthiness regulations to clarify safety standards for motor vehicles equipped without driver controls (see www.govinfo.gov/content/pkg/FR-2020-03-30/pdf/2020-05886.pdf#page=1). For example, it may be appropriate to apply passenger side occupant protection requirements to the traditional driver seating position when a steering wheel is not present. The NPRM also proposes to exempt delivery vehicles designed never to include human occupants from existing costly and design-limiting standards designed to protect human occupants. In December 2020, NHTSA sent a draft final rule to commence interagency review of this significant rule. When finalized, NHTSA will have removed significant, unnecessary barriers to novel vehicle designs, paving the way for future ADS vehicles.

As ADS technologies continue to advance, NHTSA anticipates that it will receive a growing number of petitions seeking exemptions from existing safety standards for limited volume commercial applications, which the Agency may grant (for up to 2,500 vehicles per year for 2 years) if the petitioner can demonstrate that the vehicle is at least as safe as an FMVSS-compliant vehicle. Anticipating an increase in the demand for exemptions, NHTSA updated and streamlined the petition process in December 2018 (see www.federalregister.gov/documents/2018/12/26/2018-27795/temporary-exemption-from-motor-vehicle-safety-and-bumper-standards). Several such petitions have already been filed, and in February 2020, NHTSA granted the first-ever exemption for an ADS vehicle to a petition from Nuro, a California robotics company (see www.nhtsa.gov/press-releases/nuro-exemption-low-speed-driverless-vehicle). Nuro had requested an exemption from certain crashworthiness standards that apply to low-speed vehicles so that it could deploy a novel ADS vehicle. Unlike a conventional low-speed vehicle, the Nuro R2 is designed to have no human occupants and operates exclusively using an Automated Driving System. The exemption allows the company to deploy up to 5,000 of the Nuro R2, a low-speed, occupantless electric delivery vehicle, as part of a proposed local delivery service for restaurants, grocery stores, and other businesses. To protect the public, the exemption includes significant reporting and other requirements (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/nuro_grant_notice_final-unofficial.pdf).

Establishing Future Performance Standards. Today, NHTSA principally engages with ADS development by supporting research efforts (including through the AV TEST Initiative, as well as the Box 7 program and others) and by removing unnecessary regulatory barriers to innovative designs. The next phase of ADS development will arise when the technologies begin to mature and the near-term prospects for commercial deployment grow. When the technology is mature, NHTSA and other safety regulators will have to determine whether and how to regulate the ADS operation technologies to ensure that the vehicles can operate safely and reliably.

While it is plainly premature and unscientific to establish test metrics and performance standards before the technology becomes available and its capabilities and limitations are well-understood,

it is nevertheless appropriate for NHTSA to begin the long-term process of envisioning how such regulations may be established and whether such future standards would be best articulated in a manner different from the way in which conventional FMVSS performance has been regulated. In 2018, NHTSA published research on developing a framework for ADS testing (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13882-automateddrivingsystems_092618_v1a_tag.pdf).

In November 2020, NHTSA launched the first-ever rulemaking addressing the safety of ADS operations by publishing an ANPRM seeking comments on ways the Agency could establish a framework of safety principles for ADS (see www.federalregister.gov/documents/2020/12/03/2020-25930/framework-for-automated-driving-system-safety). This document invites public comment on a variety of approaches and mechanisms that, together, would allow NHTSA to identify and manage safety risks related to ADS in an appropriate manner. NHTSA envisions that a framework approach to safety for ADS developers would use performance-oriented approaches and metrics that would accommodate the design flexibility needed to ensure that manufacturers can pursue safety innovations and novel designs in these new technologies. This framework could be made up of any combination of guidance documents and, eventually, regulations.

This ANPRM is only the beginning of a long national and global conversation to come about the future oversight of ADS technologies. By initiating the discussion in this manner, NHTSA's intention is to carefully evaluate the technologies and the different proposed methods of approaching the question of safety oversight to help determine the most effective way to ensure the safe operation of such promising—but still unproven and technologically immature—innovations. The goal is to develop a means to supervise ADS that is technology neutral, recognizes the capabilities and limitations of the systems being developed, is sufficiently flexible both to assure safety and provide room for continued development and innovation, and most importantly, provides real-world safety benefits.

B. Advanced Driver Assistance Systems (ADAS)

While much of the attention and excitement around automated technologies has focused on ADS research and development, American families are already experiencing the conveniences of Advanced Driver Assistance Systems (ADAS) in vehicles today (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13423-vehicletechguide-4x6-brochure_2pagespread_042418_v5-tag.pdf). These technologies are at SAE Levels 0-2, and are intended to augment and support, not replace, the human driver, and they have the potential to help drivers avoid crashes or reduce the severity of crashes that occur. The data so far suggests great promise for new technologies including Automatic Emergency Braking (AEB), Pedestrian AEB, Blind Spot Warning/Intervention, Lane Departure Warning/Assist, Cross Traffic Alert, and Intersection Movement Assist (IMA). Some ADAS technologies have been in the market for a long time, and some, such as IMA, are more recent. As these systems continue to develop and are deployed more widely, it will be increasingly necessary to help drivers understand their capabilities and limitations if the potential safety benefits are to be fully realized.

Supporting Deployment of ADAS Features. NHTSA has encouraged the development of ADAS features and has supported manufacturer efforts to deploy them in their fleets. In 2015, NHTSA updated the New Car Assessment Program to incorporate crash-specific ADAS features—crash imminent braking and dynamic brake support—as part of the NCAP Recommended Advanced Technology Features (see www.federalregister.gov/documents/2015/11/05/2015-28052/new-car-assessment-program-ncap). This upgrade empowers consumers to shop for vehicles that include these features. In October 2019, NHTSA announced that it was preparing significant additional upgrades to NCAP, including the incorporation of additional ADAS features (see www.nhtsa.gov/press-releases/ncap-upgrades-coming). The Agency submitted a draft proposal for interagency review in November 2020, and anticipates publishing the proposal in early 2021 (see www.reginfo.gov/public/do/eoDetails?rrid=131430). Adding technologies to NCAP will provide a significant market-based mechanism for encouraging further deployment of additional ADAS features.

NHTSA has also informally encouraged automakers to deploy ADAS features. In 2016, NHTSA worked with IIHS and automakers to secure a voluntary pledge to install AEB as standard in every new vehicle by August 2023, and every year the Agency publishes information about each automaker’s progress toward meeting that goal (see www.iihs.org/news/detail/u-s-dot-and-iihs-announce-historic-commitment-of-20-automakers-to-make-automatic-emergency-braking-standard-on-new-vehicles). Industry is making great strides toward meeting their goals: In 2020, ten automakers reported they are already installing AEB in all new passenger vehicles, while another four manufacturers are equipping more than 75% of their vehicles with AEB (see www.nhtsa.gov/press-releases/aeb-installation-update-2020).

Evaluating Safety Benefits of ADAS: PARTS. NHTSA has also taken steps to help assess the effectiveness of certain ADAS features. In 2018, the Agency announced a pilot program for a voluntary, data-driven safety partnership between NHTSA and the automotive industry called the Partnership for Analytics Research in Traffic Safety (PARTS), and in January 2020 expanded the program to include most of the U.S. automotive market (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/parts_program011520.pdf). The PARTS program works by using a third-party intermediary to collect automaker data along with police-reported crashes from NHTSA’s databases to explore the effectiveness of certain ADAS features. The ADAS features incorporated into the 2020 PARTS program include automatic emergency braking, adaptive cruise control, and lane keep assist. This program adds another mechanism to NHTSA’s toolset of compiling data on the effectiveness of these technologies, and then sharing top-line information with the public. Such information puts NHTSA in position to assess which technologies should be included in updates to NCAP and to determine whether it would be appropriate to include any of these features in future rulemakings.

Supporting Research for Newer ADAS Features. As manufacturers continue to develop and deploy ADAS features for new vehicles, NHTSA’s research office is carefully monitoring and evaluating these new technologies. As with ADS technologies, innovation continues with ADAS features as well, in terms of both the introduction of new functionality, as well as progressive performance improvements in existing systems. With operational complexity come the challenges of establishing appropriate methods to assess their safety performance. To address this, in November 2019 NHTSA published a request for comments (RFC) on a series of nine

draft research test procedures developed by the Agency to assess the performance of certain types of ADAS features available to the public (see www.federalregister.gov/documents/2019/11/21/2019-25217/advanced-driver-assistance-systems-draft-research-test-procedures). The intent of this RFC is to help NHTSA develop objective methods of assessing the capabilities and limitations of newer ADAS features in a test-track environment. The draft test procedures included Active Parking Assist, Blind Spot Detection and Intervention, Intersection Safety Assist, Opposing Traffic Safety Assist, Pedestrian Automatic Emergency Braking, Rear Automatic Braking, Traffic Jam Assist, and Forward Collision Warning/Automatic Emergency Braking for heavy vehicles.

Separately, NHTSA is also conducting research into so-called human factors engineering, which involves questions about the human-machine interface, the layout of equipment, and the risk that technologies and the manner in which they are implemented could cause driver distraction (see www.nhtsa.gov/research-data/human-factors). In late 2016, NHTSA published human factors design guidance to help automakers incorporate best practices into their designs (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812360_humanfactorsdesignguidance.pdf). In 2018, the Agency published guidance on incorporating human factors into Level 2 and Level 3 technologies (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13494_812555_1213automationhfguidance.pdf). And in 2020, the Agency began reviewing emergent technologies and recent human factors research results to identify whether or how its existence guidance may be updated.

Addressing Public Confusion and Error. The general public is sometimes confused about the differences between ADAS and ADS. This confusion sometimes manifests on how ADAS features are described and marketed, including the use of certain trade names. Drivers of ADAS-equipped vehicles must remain fully engaged in the driving task at all times. The fact is that ADAS systems today do not and cannot replace the human driver; this is not what they are designed to do. They have natural limitations, and while they assist drivers in avoiding crashes when they can, they cannot do so under all circumstances. The safety benefit they bring in is built on the assumption that drivers will be fully attentive at all times. That safety benefit falls apart if drivers treat ADAS as fully effective and stop being attentive. While avoidance of a portion, but not all, of rare circumstances when an attentive driver may find him or herself distracted may be fantastic, additional crash circumstances an inattentive driver would introduce would likely more than negate the system's benefit. Overreliance on ADAS features is therefore a form of distracted or reckless driving and has caused serious and fatal crashes.

In the summer of 2020, NHTSA launched a public awareness campaign to remind drivers that there are no fully self-driving vehicles available for sale and on the roads today, and that all vehicles equipped with ADAS features require a driver who is responsible for the safe operation of the vehicle at all times (see, e.g., https://twitter.com/hashtag/YourCarNeedsYou?src=hashtag_click). NHTSA has also conducted outreach to educate law enforcement about these technologies, and to encourage traffic safety officers to take measures against reckless and distracted drivers who are abusing their ADAS features by treating them as if the vehicle is actually capable of driving itself (see www.policechiefmagazine.org/from-the-deputy-administrator-looking-ahead-to-safer-roadways/; <https://twitter.com/TheIACP/status/1291394161552363521>). To help the driving

public better understand the type of ADAS features installed in new vehicles and to address a bewildering array of trade names, NHTSA has supported efforts by third parties to provide a simpler, common set of naming conventions covering categories of ADAS features (see www.transportation.gov/briefing-room/us-transportation-secretary-elaine-l-chao-announces-new-initiatives-improve-safety). And finally, while NHTSA does not have jurisdiction over marketing matters, the Agency has in the past coordinated with the Federal Trade Commission on matters involving false advertising of vehicle safety ratings and features, (see, e.g., www.washingtonpost.com/technology/2019/08/07/federal-safety-regulators-scolded-elon-musk-over-misleading-statements-tesla-safety/) and is prepared to continue doing so when necessary and appropriate.

Removing Unnecessary Barriers. As with ADS, certain existing regulatory requirements may unnecessarily impede the development of specific ADAS features. When necessary and appropriate, NHTSA has taken action to remove such barriers to innovation. For example, in October 2018, NHTSA published a proposal to amend the FMVSS to allow the use of adaptive driving beam headlighting systems (see www.govinfo.gov/content/pkg/FR-2018-10-12/pdf/2018-21853.pdf#page=1). These technologies have the potential greatly to improve visibility for drivers while mitigating potential harm to oncoming traffic. NHTSA has reviewed public comments on this proposal and anticipates publishing the final rule in early 2021 (see www.reginfo.gov/public/do/eAgendaViewRule?pubId=202010&RIN=2127-AL83).

The Prospect for Future Regulation. As discussed above, NHTSA is working to collect and assess data about the operation of ADAS systems. However, as with ADS, NHTSA is not presently in a position to establish regulatory standards for all ADAS features. Although ADAS technologies are further along than ADS, some of these features are still in early stages of rollout and evolving. For instance, in some cases there are differences in performance for the same ADAS features in different vehicles, and the research suggests that these differences may imply both benefits and drawbacks for different real-world situations. And that means that substantial additional work is required before agency staff are able to understand the capabilities and limitations of these technologies, and just as importantly, the tradeoffs and unintended consequences of selecting certain testing or performance metrics. Therefore, for the present, NHTSA's efforts are focused on establishing reasonable and scientifically repeatable tests for these features, collecting better data on the safety consequences of the different technologies, and providing room for further innovation. These efforts will help ensure that when the technology finally matures, NHTSA staff will be in a better position to determine whether and how to establish minimum performance standards, and this helps ensure that the technologies are given the opportunity to deliver the safety enhancements they seem to promise.

C. NHTSA and Other Advanced Technologies

In addition to ADS and ADAS, there are other promising avenues for innovation that have the potential to help make the vehicles safer, and NHTSA will continue to play a role in supporting and evaluating the development of these technologies.

Cybersecurity. Vehicles today are increasingly driven by software, and software is likely to play an ever-growing role in the future. Because many advanced safety and other features are driven

by computers—and especially given the prospect of ADS and more elaborate ADAS features—it will be critical for automakers and their suppliers to ensure the cybersecurity of their vehicles. In addition, automakers increasingly are turning to Over-The-Air systems for updating vehicle software, and while this promises to enhance their ability to ensure that critical updates and (software-related) defect repairs reach many more vehicles, it also creates a potential for cybersecurity vulnerability.

Cybersecurity is a fast-moving realm. Vulnerabilities can be uncovered and exploited quickly, and one of the best methods of addressing this situation is to mitigate the scope of the vulnerability or secure the systems quickly so as to limit a malicious actor's return on investment. The system must be flexible and adaptable, characteristics hard to achieve with regulation alone.

NHTSA has taken and will continue to take concrete steps to address cybersecurity and protect the public. The Agency receives information about potential cybersecurity vulnerabilities, and NHTSA has established internal procedures for assessing the potential threat and determining whether it presents a risk to safety. NHTSA treats cybersecurity in the same manner as other potential vehicle defects—anything that presents an unreasonable risk to safety must be recalled and repaired. For instance, in 2015 one automaker announced the recall of approximately 1.4 million vehicles associated with cybersecurity vulnerabilities of the infotainment system (see <https://media.fcanorthamerica.com/newsrelease.do?&id=16849&mid=1>; <https://static.nhtsa.gov/odi/inv/2015/INIM-RQ15004-62686.pdf>). NHTSA's enforcement and research offices continue to evaluate potential cybersecurity vulnerabilities, and the Agency never hesitates to take action to protect the safety of the traveling public.

To assist and encourage automakers and suppliers to dedicate the right resources to address cybersecurity, NHTSA developed a best practices guidance document, published in 2016 (see www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812333_cybersecurityformodernvehicles.pdf). In 2020, NHTSA developed a substantial update and revision to this guidance document, and submitted it for interagency review in December 2020 (see www.reginfo.gov/public/do/eoDetails?rid=131473). The Agency anticipates that the document will be published for public comment in early 2021.

NHTSA has also strongly encouraged industry stakeholders to work together on their shared interest in reducing the threat and harm associated with cybersecurity breaches. In 2015, NHTSA encouraged the establishment of the Automotive Information Sharing and Analysis Center (Auto-ISAC) to promote collaboration among stakeholders in the auto industry. Since then, NHTSA has strongly supported the Auto-ISAC's operations and has encouraged other stakeholders to join and participate (see, e.g., www.nhtsa.gov/speeches-presentations/james-owens-auto-isac-2019-summit; www.nhtsa.gov/speeches-presentations/auto-isac-annual-summit-2020; and www.cisa.gov/cyber-storm-2020).

Finally, vehicular cybersecurity requires a specific and unique set of skills. Recognizing this, NHTSA announced in January 2021 that it is working with the Auto-ISAC to support and launch a cybersecurity training initiative that will help career professionals deepen their technical skills and enhance industry-wide coordination on protecting vehicle software.

Interconnected Vehicles and Intelligent Transportation Systems. Another technical area that promises significant improvements to vehicle safety and traffic management involves communications technologies, often called Vehicle-to-Everything (V2X) communications (see www.transportation.gov/v2x). These technologies have the prospect of allowing vehicles to communicate directly with each other and with smart infrastructure, which in turn can help drivers avoid crashes (particularly in places where line-of-sight detection is impossible or impeded), and potentially even to help protect vulnerable road users who may be carrying compatible devices (see, e.g., www.fhwa.dot.gov/publications/research/safety/15007/15007.pdf and <https://one.nhtsa.gov/Research/Crash-Avoidance/Vehicle-to-Vehicle-Communications-for-Safety>). From the infrastructure side, V2X could allow local traffic management centers to collect data from vehicles that in turn could help with congestion management (for instance, using Signal Phase and Timing protocols to reduce delays at traffic lights) and infrastructure maintenance (for example, using vehicle data on wheel friction to identify icy locations or hydroplaning incidents).

NHTSA issued an NPRM supporting interconnected communications technologies in 2017, although the proposal did not address all technical issues that would have to be resolved before a regulatory standard could be established (see www.federalregister.gov/documents/2017/01/12/2016-31059/federal-motor-vehicle-safety-standards-v2v-communications). One regulatory question has been the so-called network effects issue; that is, whether consumers would have sufficient incentive to purchase vehicles with V2X features when they are unlikely to realize substantial safety benefits until the technology is installed in most of the U.S. fleet. However, that analysis intentionally did not take smart infrastructure into account. Car buyers could realize immediate benefits from V2X features, regardless of how many other vehicles are equipped with the same features, if the local infrastructure is connected. Accordingly, the long-term deployment of V2X technologies may focus on the rollout of smart infrastructure as a way of encouraging demand for the technology, which in turn would lead to better traffic and safety outcomes. In the meantime, to empower consumers with information about V2X technologies, NHTSA indicated in 2019 that it would take comment on the potential inclusion of V2X features in its forthcoming NCAP proposal (see www.nhtsa.gov/press-releases/ncap-upgrades-coming).

V2X technologies exist today, and hundreds of localities have been deploying them on a research or pilot project basis, and automakers have pledged to install millions of V2X devices in vehicles (see www.autosinnovate.org/posts/press-release/consensus-on-safety-spectrum-band-plan), although recent actions by the Federal Communications Commission may have the effect of impeding or further delaying the eventual deployment of these advanced technologies (see www.fcc.gov/document/fcc-modernizes-59-ghz-band-improve-wi-fi-and-automotive-safety-0). NHTSA will continue to support the development and deployment of V2X systems, and will work with all stakeholders to identify effective non-regulatory ways to address technical issues and promote the technology.

Passive Alcohol Detection Systems. Crashes involving alcohol-impaired drivers result in more than 10,000 fatalities every year in the United States, approximately 30% of all crash fatalities. Eliminating a significant fraction of these crashes has the potential to save thousands of lives every year. Since 2008, NHTSA has provided more than \$50 million supporting industry

research into passive alcohol detection systems. The project, which is called the Driver Alcohol Detection System for Safety (DADSS), is a collaborative research partnership between NHTSA and the Automotive Coalition for Traffic Safety, representing 17 automobile manufacturers, to develop alcohol-detection technologies to create countermeasures for times when the driver's blood alcohol concentration exceeds the legal limit of .08 grams per deciliter (g/dL) (see <https://one.nhtsa.gov/Vehicle-Safety/DADSS>). The purpose is to explore the feasibility, the potential benefits of, and the potential challenges associated with a more widespread use of in-vehicle technology to prevent alcohol-impaired driving (see www.dadss.org).

This project has made significant technical breakthroughs in making the system more accurate and reliable, and within the next year may make designs for a limited fleet version of the system available for commercial deployment. Over the next decade, DADSS has the potential to make both a passive breath reader version and a touch-sensor technology available for widespread commercial deployment.

Meanwhile, to ensure technological neutrality and to encourage the development of additional technologies, in November 2020 NHTSA issued a request seeking public comment on the existence or development of alternative technologies that may help reduce or eliminate alcohol-impaired driving (see www.federalregister.gov/documents/2020/11/12/2020-24951/request-for-information-impaired-driving-technologies). The prospect for reducing and eventually eliminating alcohol-impaired crashes has never been closer.

Lithium Battery Safety. Another avenue for innovation in the automotive world has been the development and growing deployment of electric vehicles. These vehicles, supported by tax and regulatory incentives, have already grown to about 2% of the vehicle sales market. But it is also understood that lithium batteries can be dangerous. In fact, in 2019 the Pipeline and Hazardous Materials Safety Administration effectively banned lithium batteries as cargo on planes except under limited conditions, and the Federal Aviation Administration has banned lithium batteries in checked baggage (see www.federalregister.gov/documents/2019/03/06/2019-03812/hazardous-materials-enhanced-safety-provisions-for-lithium-batteries-transported-by-aircraft-faa; and [www.faa.gov/news/fact_sheets/news_story.cfm?newsId=23054#:~:text=Spare%20\(uninstall ed\)%20lithium%20metal%20batteries,passenger%20in%20carry-on%20baggage.&text=Check%20the%20FAA%27s%20Pack%20Safe,other%20dangerous%20goods%20in%20baggage](http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=23054#:~:text=Spare%20(uninstall ed)%20lithium%20metal%20batteries,passenger%20in%20carry-on%20baggage.&text=Check%20the%20FAA%27s%20Pack%20Safe,other%20dangerous%20goods%20in%20baggage)).

Automobiles are also at risk: for example in early 2020, NHTSA ensured the recall of certain plug-in hybrid vehicles whose batteries were at risk of overheating even when the vehicle was turned off (see <https://static.nhtsa.gov/odi/rcl/2020/RCMN-20V334-1674.pdf>), and in November 2020, the Agency oversaw the recall of approximately 50,000 electric vehicles whose lithium-ion batteries had an increased risk of catching fire; in some cases, these fires burned down garages and homes where the vehicles had been parked for overnight recharging (see <https://static.nhtsa.gov/odi/rcl/2020/RMISC-20V701-4459.pdf>). In the latter case, NHTSA took the extraordinary step of warning consumers not to park their vehicles in or near their homes until the defect had been remedied (see www.nhtsa.gov/press-releases/consumer-alert-chevrolet-bolt-recall-fire-risk). The Agency is also aware of additional fire incidents overseas

(see www.reuters.com/article/us-tesla-china-safety/tesla-says-single-battery-module-caused-car-fire-in-shanghai-has-changed-vehicle-settings-idUSKCN1TT154).

Unlike internal combustion engine vehicles, battery electric vehicles are at risk of catching fire during and after recharging, which in most cases takes place inside garages or near homes. Such a fire, particularly if it occurs at night when most recharging occurs, presents a significant risk to the home's occupants who may be asleep when the fire erupts. Accordingly, before battery electric vehicles represent a significant part of the overall market, it is crucial for NHTSA to expand its research into battery fires and coordinate with industry to determine whether and how to set safety standards governing the chemical safety of lithium batteries and the cybersecurity of battery power management software systems. In January 2021, NHTSA announced the creation of a Lithium-Ion Battery Safety Initiative to coordinate these research, rulemaking, and enforcement efforts going forward.

IV. Looking to the Future

We find ourselves in an era of exciting and fast-moving innovation in the automotive world. Advances in ADAS and higher levels of automation are proceeding rapidly, and the natural and necessary demand to conduct real-world testing will only continue to increase. While many within industry seem to agree that true Level 5 systems remain elusive, Level 4 systems are being developed quickly by many competitors. Although the complex technical requirements for establishing reliable Level 4 Operational Design Domains may make it difficult to scale many of these systems quickly, nevertheless very limited commercial operations involving FMVSS-compliant vehicles has already begun (see, e.g., www.wsj.com/articles/driverless-cars-are-coming-but-not-yet-to-take-over-11606909414). Meanwhile ADAS systems are also developing quickly, and some ADAS features are already being deployed in most new vehicles today. Because ADAS features have the potential to increase safety today and at more reasonable prices, these systems may create a challenge to the business cases behind slower-developing but much more expensive and risky ADS technologies (see, e.g., www.wsj.com/articles/self-driving-cars-have-a-problem-safer-human-driven-ones-11560571203).

While the structure of the SAE levels of automation may be taken to suggest that ADAS technologies are merely an interim step toward higher levels of automation, it is not a foregone conclusion that ADAS technologies will have a lower ceiling and that the future will be strictly ADS. In fact, if the human-machine teaming or symbiosis that can be seen in modern "centaur" chess (see, e.g., <https://jods.mitpress.mit.edu/pub/issue3-case/release/6> and www.parc.com/blog/half-human-half-computer-meet-the-modern-centaur/), and advanced fighter jets (see, e.g., <https://www.darpa.mil/news-events/2020-08-26> and www.defense.gov/Explore/News/Article/Article/628154/work-human-machine-teaming-represents-defense-technology-future/) are any indication, there may be a case for developing ADAS or Level 3 features that combine the best of what humans and machines do, while compensating for the known limitations of both.* For instance, a system designed to augment the driver by maintaining and increasing the human driver's interest and focus on the driving task while improving the driver's situation awareness and compensating for slower reaction times may be comparable or even superior to purely machine-operated vehicles in the medium or perhaps even long term. Only time will tell.

Whatever happens, it is clear that there will be many different technological paths in the coming years and decades, and the women and men of NHTSA will continue to provide effective oversight to protect the traveling public, ensure that these technologies are safely tested and, as they are deployed, do not present an unreasonable risk to safety. Our nation is a leader in vehicle technologies because we allow innovators to develop safety-enhancing technologies here and now without requiring pre-market approval, as long as the vehicle complies with existing laws. When the time is right, when the data is available, and when the technology is proven—we may adopt performance-based standards for ADS, ADAS, and other technologies that may emerge.

In the meantime, NHTSA is taking measured steps to protect safety while allowing these promising technologies the breathing room needed to grow.

* As Garry Kasparov once explained, teaming the human player with artificial intelligence led to more superior results than either the human or the computer on their own: “The teams of human plus machine dominated even the strongest computers. The chess machine Hydra, which is a chess-specific supercomputer like Deep Blue, was no match for a strong human player using a relatively weak laptop. Human strategic guidance combined with the tactical acuity of a computer was overwhelming.” Kasparov, G. (2010, February 11). The Chess Master and the Computer. New York Review of Books. www.nybooks.com/articles/2010/02/11/the-chess-master-and-the-computer/.