

**TRANSPORTATION AND HOUSING AND URBAN
DEVELOPMENT, AND RELATED AGENCIES
APPROPRIATIONS FOR FISCAL YEAR 2017**

WEDNESDAY, NOVEMBER 16, 2016

U.S. SENATE,
SUBCOMMITTEE ON THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2:20 p.m., in room SD-192, Dirksen Senate Office Building, Hon. Susan Collins, (chairman) presiding.
Present: Senators Collins, Cassidy, Daines, Reed, and Murphy.

THE AUTOMATED AND SELF-DRIVING VEHICLE REVOLUTION:
WHAT IS THE ROLE OF GOVERNMENT?

OPENING STATEMENT OF SENATOR SUSAN M. COLLINS

Senator COLLINS. This hearing will come to order.

Good afternoon. I'm pleased to be joined today by our ranking member, Senator Jack Reed, and by Senator Cassidy and others who will be joining us, as we hold this hearing to examine the role of government in enhancing roadway safety through the careful deployment of automated and self-driving vehicles, which could revolutionize our transportation system.

I also welcome our panel of witnesses. We are joined today by Mark Rosekind, the Administrator of the National Highway Traffic Safety Administration; Deborah Hersman, the President and CEO of the National Safety Council; Paul Brubaker, the President and CEO of the Alliance for Transportation Innovation; and Dr. Nidhi Kalra, the Senior Information Scientist at the RAND Corporation. I look forward to hearing from each of you.

The potential of the new technology that we're examining today is exciting, cars that drive themselves and avoid accidents, seniors and disabled individuals able to retain or gain their ability to get around town. At first, it sounds like science fiction or an advance far, far off into the future. But this technology is being tested and perfected right now, and it could save thousands of lives.

According to the most recent statistics from the National Highway Traffic Safety Administration, more than 35,000 lives were lost in crashes on U.S. roadways in the year 2015. Preliminary estimates indicate a 10 percent increase in the first half of 2016. It is important to highlight that 94 percent of these crashes are the result of human factors or, simply put, driver error such as distracted driving—sometimes caused by hands-free technology—impaired

driving, and speeding. These crashes are preventable, and we should be doing everything we can to eliminate them.

The testing and safe deployment of automated vehicle technologies has the potential to reduce substantially the number of driver-related crashes and fatalities. Let me emphasize that point: if this technology were to be perfected, automated vehicles could eliminate many of the crashes on our Nation's roadways and save thousands of lives each year.

While fully self-driving autonomous vehicles are still years away from being available to the general public, many new vehicles already have driver-assisted features such as automatic emergency breaking, rearview cameras, my personal favorite, and lane-keep assist systems. These technologies are already making a difference, saving lives and reducing injuries.

In addition to improving safety, self-driving vehicles can provide mobility options to our seniors and disabled people, particularly those living in rural communities like my State of Maine, where many of our older drivers currently do not have an easy way to get to the doctor or to the grocery store. Public transportation is non-existent in much of Maine, and taxi service is very limited in rural areas. Seniors who can no longer drive often have very few options.

A self-driving car, or even one with limited automated features, could help seniors feel more secure driving at night and could help those who currently must rely on others to get around, to maintain their independence. A recent survey of drivers over the age of 50 showed that almost 80 percent of those who plan to buy a car within the next 2 years will be seeking automated features such as blind spot warning, crash mitigation, and lane departure warning systems. Yet many consumers remain wary of purchasing a fully autonomous vehicle anytime soon. I know that the RAND Corporation has done a lot of work in the area of the potential benefits of automated technologies for our seniors.

To help accelerate the safe testing and development of autonomous vehicles, the Department of Transportation released its "Federal Automated Vehicles Policy" on September 20th, which includes vehicle performance guidance, model state policy, an assessment of current regulatory tools, and a discussion of future regulatory tools that Congress may want to consider.

While this was an important first step, it is clear that the DOT's guidance document needs further refinement to help ensure that automakers are able to bring the safety and mobility benefits of autonomous vehicles into the marketplace without unnecessary government regulations. I am particularly interested in hearing from our witnesses today on what improvements can be made to these guidelines.

Automobile manufacturers face a number of roadblocks integrating autonomous vehicles onto our Nation's highways. Some have called on the Administration to put the brakes on autonomous vehicle deployment by imposing onerous requirements through a rulemaking process which could take several years to finalize, and my fear is that that would stifle innovation in the meantime.

We must recognize that automated vehicle technology is advancing faster than government agencies can act, and in this instance impeding the advancement of technology may prevent us from sav-

ing lives. On the other hand, we also know that there have been some problems with the automated technology that has increased the incidence of distracted driving and perhaps led to additional accidents. The Department's guidance provides a more effective voluntary 15-point safety assessment that incentivizes automakers to certify that they have addressed all relevant issues ranging from cybersecurity to human-machine interface to ethical considerations.

Another challenge facing autonomous vehicles is the vast number of State and local governments that are seeking to regulate this technology. Unlike vehicle safety, which is governed by Federal law, the safety and licensing of drivers are under the jurisdiction of State governments. While the Department's guidance deters States from interfering with Federal vehicle safety standards, one topic we will explore is whether or not DOT's approach also has the effect of encouraging State governments to set prohibitive requirements related to testing, licensing, and registration for automated vehicle testing.

Given the public's keen interest in self-driving and automated vehicles, it is important for State governments to take a balanced approach in allowing the research, development, safe testing, and deployment of such vehicles. However, I would note that one serious accident, such as occurred in Florida, can cause great mistrust of this new technology, and that could lead to greater State restrictions on testing and deployment. It is particularly important that DOT work with automotive manufacturers, suppliers, and technology companies, as well as with the commercial end users of automated vehicles, to ensure that they are operating with an abundance of caution to avoid excessive government intervention that could interfere with the timely development of technologies that truly could save thousands of lives.

[The statement follows:]

PREPARED STATEMENT OF SENATOR SUSAN M. COLLINS

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I also welcome our panel of witnesses. We are joined today by Mark Rosekind, Administrator of the National Highway Traffic Safety Administration; Deborah Hersman, President and C.E.O. of the National Safety Council; Paul Brubaker, President and C.E.O. of the Alliance for Transportation Innovation; and Dr. Nidhi Kalra, Senior Information Scientist at the RAND Corporation. I look forward to hearing from each of you.

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could eliminate many of the crashes on our Nation's roadways and save thousands of lives every year.

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While this was an important first step, it is clear that D.O.T.'s guidance document needs further refinement to help ensure that automakers are able to bring the safety and mobility benefits of autonomous vehicles into the marketplace without unnecessary government regulations. I am particularly interested in hearing from all of our witnesses today on what improvements can be made to these guidelines.

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Given the public's keen interest in automated and self-driving vehicles, it is important for State and local governments to take a balanced approach in allowing the research, development, safe testing, and deployment of automated vehicles. However, one serious accident, such as occurred in Florida, can cause mistrust of this new technology, and that could lead to greater local restrictions on testing and deployment. It is particularly important that D.O.T. work with automotive manufacturers, suppliers, and technology companies, as well as the commercial end users of automated vehicles, to ensure they are operating with an abundance of caution to avoid excessive government intervention.

With that, let me call upon my colleague and friend Senator Reed, the ranking member, for his opening statement.

Senator COLLINS. With that, let me call upon my colleague and friend from Rhode Island, Senator Reed, the ranking member, for his opening statement.

STATEMENT OF SENATOR JACK REED

Senator REED. Thank you very much, Chairman Collins, for your leadership on so many issues, but particularly for holding this very important hearing on the future of self-driving vehicles. Let me join you in welcoming our witnesses. Thank you for your service and your expertise.

Automated and self-driving vehicles are not yet common on our roads, but autonomous driving and safety features such as automatic emergency brakes and parking assist have been introduced gradually over the last several years. Manufacturers and innovators are now poised to take transformative leaps in the development, integration, and adoption of these technologies, and what was once novel is at the brink of becoming commonplace.

As with any change, it brings opportunity as well as risk and anxiety. Particularly for the millions of Americans who earn a living as American commercial drivers, that is a significant issue that we should address. What remains unanswered is how this transportation revolution will evolve and what steps regulators and industry should take to foster and harness the positive aspects of this new technology.

Today auto manufacturers, ride sharing companies, and other investors are funding research and development on driverless vehicles. They are also launching pilot programs to gather data and introduce consumers to different forms of the technology. Uber is allowing customers in Pittsburgh to share rides in self-driving cars. Otto, which is a self-driving bus and truck company owned by Uber, autonomously delivered commercial goods just last month. Tesla is collecting millions of miles of data from its semi-autonomous vehicles and announced that it will potentially make a full autonomous vehicle starting next year. Google has been designing and testing cars with no human driver for several years in California. And GM and Lyft have partnered to build an autonomous fleet that will be available for ride sharing.

These companies are all using different strategies to achieve seemingly different goals. Some seek to provide efficient, accessible, and cost-effective transportation similar to Transit. Others want to improve freight transportation through fleets of autonomous trucks that can save gas and operator on the clock. What is clear is that technology is fundamentally changing vehicles as we know them.

This innovation has the potential to dramatically improve highway safety, as well as expand mobility access for thousands of people, as the Chairman spoke about, seniors particularly. And it also has safety features which, as the Chairman commented on, are significant. In 2015, more than 35,000 people died in crashes on the Nation's highways. The number represents an 8 percent increase from the previous year and marked the deadliest year on record since 2008. These vehicles might help immensely in that regard. NHTSA (National Highway Traffic Safety Administration) found that 94 percent of those deaths were the result of human error, so autonomous vehicles could be a real game changer in this regard.

We have a responsibility to fulfill this technology's promise and foster American innovation. But we also must be cognizant of the consequences of these technologies for the shifts in the American

economy and effects on the American worker. Self-driving cars and trucks will certainly demand new kinds of jobs and skills, but these jobs may be in different sectors of the economy. For millions of Americans, particularly those without a college degree or advanced training, driving a bus, a cab, or a truck can provide a decent income. In fact, for many, it is the ticket to the middle class.

In the latest year of data available from the Bureau of Labor Statistics, there are more than 4 million workers in the United States employed as drivers of trucks, taxis, chauffeurs or delivery vehicles. All of these are potentially in a space where they could be replaced by an autonomous vehicle. So we have to make sure that this technology not only enables better productivity but that it doesn't disqualify millions, literally, of Americans from good, solid jobs.

We need to think through this policy very thoughtfully. This is a broader conversation not involving just the technologies but the Department of Labor, policymakers from a huge swath of the government, so that we get it right, and we get it right for the American workers as well as for the technology interest.

Our regulatory agencies—and the Chairman has made the point that it's not just Federal but its State and local—have to be harmonized. We have to do this thoughtfully, and that is why, again, I commend the Chairman for calling this hearing today.

NHTSA—thank you—recently released a guidance document for comment with the intent of promoting technological advancement and preventing a patchwork of State regulations. So thank you, Administrator Rosekind, for that work.

There are many questions. When will NHTSA initiate a formal rulemaking on self-driving vehicles? When and how will the Federal motor vehicle safety standards be updated? How much data does NHTSA want to collect from industry and consumers, and how will it protect that data from cyber threats?

We know industry will continue to innovate, deploy, and develop these technologies at a faster pace than government can respond, and this will present a challenge. We have to recognize this up front.

But again, let me thank you, all of our witnesses for participating in our hearing today. I apologize for my Rhode Island accent. Other than that, I look forward to the testimony. Thank you.

Senator COLLINS. Thank you very much, Senator Reed.

I am going to put all of the witnesses' impressive bios into the record so that we can proceed with the testimony since I mentioned all of you in my opening statement.

We will start with the Administrator of the National Highway Traffic Safety Administration, known as NHTSA, the Honorable Mark Rosekind.

STATEMENT OF THE HON. MARK ROSEKIND, ADMINISTRATOR, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Mr. ROSEKIND. Thank you, Chairman Collins, Ranking Member Reed, other members of the committee. I really appreciate you holding this hearing today and for the opportunity to testify.

At NHTSA, our mission is to save lives on America's roadways. For 50 years, we have carried out that mission by writing and en-

forcing strong regulations to make vehicles safer, fighting against drunk-driving, building a national consensus about seatbelt use, and so many other efforts that have saved hundreds of thousands of lives on America's roads.

But we have far more work to do, and that work can be measured by some alarming numbers that all of you cited already. In 2015, we lost 35,092 people on our public roads. At NHTSA, we know those are not just numbers. Those are mothers and fathers, brothers and sisters, colleagues, co-workers, friends. And the problem is that it's all getting worse.

Last month we announced that roadway fatalities in the first half of this year are up over 10 percent, and it is against this backdrop that the Department of Transportation, under the leadership of Secretary Anthony Foxx, has been working so hard on our efforts to accelerate the safe deployment of automated vehicle technologies, because while automated vehicles carry enormous potential to transform mobility and reshape our transportation system, it is truly their awesome potential to revolutionize roadway safety that has all of us so motivated.

And there is one more number that helps us explain why, and that number is 94. That's the percentage of crashes that can be tied back to human choice or error. That's a choice to speed or drive drunk, send a text message from behind the wheel, or misjudge the stopping distance. That 94 percent represents the untold potential of automated vehicle technologies.

We envision a future where advanced technologies not only help reduce crashes but a world with fully self-driving cars that hold the potential to eliminate traffic fatalities altogether.

The Federal Automated Vehicles Policy, which the Department issued on September 20th, is the world's first comprehensive government action to guide the safe and efficient development and deployment of these technologies.

The policy covers four areas: one, vehicle performance guidance for automakers, tech companies, researchers, and other developers, testers, and deployers of automated vehicle technologies; two, a model state policy to build a consistent national framework for the testing and operation of automated vehicles; three, an exploration of the use of our current regulatory tools that can be used to advance these technologies; and four, a discussion of possible new tools that the Federal Government may need to promote the safe deployment of advanced technologies as the industry continues to develop.

I'd like to share just for a few moments a little bit about our approach.

For 50 years, our traditional approach at NHTSA has largely been reactive. NHTSA prescribes safety standards and then responds to problems as they arise. A traditional method of regulating these new technologies would be to engage solely in the rule-making process, writing new regulations that prescribe specific standards and typically take years to take effect. Our view is that approach would be slow, it would stymie innovation and would stall the introduction of these technologies.

Our policy takes a very different path, built on proactive safety which will better serve both safety and innovation. This policy al-

lows us to work with automakers and developers on the front end, to ensure there are sound approaches to safety throughout the entire development process. This is a new approach, and it's going to take some adjustment for everyone involved.

But we are confident that it will help us accomplish two goals: first, to make sure that new technologies are deployed safely; and second, to make sure that we don't get in the way of innovation. Our approach is non-prescriptive. It does not tell developers how they must provide safety but instead it builds a transparent and proactive approach to ensure that they are properly addressing the critical safety areas.

But that future is not without threats. As President Obama wrote when announcing the policy, quote, "The quickest way to slam the brakes on innovation is for the public to lose confidence in the safety of new technologies. Both government and industry have a responsibility to make sure that doesn't happen."

It is our view that the best way that we can build that public confidence is by working together, showing the public that the government is on the side of innovation, and that the industry is on the side of safety.

I submit the balance of my statement for the record, and I look forward to taking your questions. Thank you.

[The statement follows:]

PREPARED STATEMENT OF HON. MARK ROSEKIND

Chairman Collins, Ranking Member Reed, and Members of the Committee: Thank you for holding this hearing and inviting me to testify. My name is Mark Rosekind, and I am the Administrator of the National Highway Traffic Safety Administration, or NHTSA.

At NHTSA, our mission is to save lives on America's roadways. For 50 years, we have carried out that mission by writing and enforcing strong regulations to make vehicles safer, fighting against drunk driving, building a national consensus about seatbelt use, and so many other efforts that have saved hundreds of thousands of Americans.

But we have far more work to do. And that work can be measured by some alarming numbers.

In 2015, we lost 35,092 people on our public roads. At NHTSA, we know that is not just a number. Every one of those is a mother or father, a son or daughter, a coworker, a friend. In the United States, we lose the equivalent of a fully-loaded 747 on our roadways every single week.

And the problem is getting worse. Last month we announced that roadway fatalities in the first half of this year are up over 10 percent.

It is against this backdrop that the Department of Transportation, under the leadership of Secretary Anthony Foxx, has been working so hard on our efforts to accelerate the safe deployment of automated vehicle technologies.

Because while automated vehicles carry enormous potential to transform mobility, reshape our transportation system and transform our economy, it is their awesome potential to revolutionize roadway safety that has us so motivated.

And there is one more number that helps explain why. That number is 94. That is the percentage of crashes that can be tied back to a human choice or error. That's a choice to speed or drive drunk, to send a text message from behind the wheel or misjudge the stopping distance.

And that 94 percent figure represents the untold potential of automated vehicle technologies. We envision a future where advanced technologies not only help reduce crashes, but also make possible a world in which fully self-driving cars hold the potential to eliminate traffic fatalities altogether.

The Department of Transportation views this moment as the cusp of a new technological revolution that may transform roadway safety forever.

The Federal Automated Vehicles Policy, which the Department and NHTSA issued in mid-September, is the world's first comprehensive government action to

guide the safe and efficient development and deployment of these technologies. Today, I will discuss that Policy, how we developed it, and where we are going next.

In January of this year, Secretary Foxx made two important announcements.

First, he announced that President Obama was making a \$3.9 billion budget request for automated vehicles research. This is a major commitment from the Administration to advance this technology, and DOT continues to strongly support this request.

Second, he directed NHTSA to write a new policy covering four areas: One, vehicle performance guidance for automakers, tech companies, researchers and other developers and testers of automated vehicle technologies. Two, a model State policy to build a consistent national framework for the testing and operation of automated vehicles. Three, an exploration of the use of our current regulatory tools that can be used to advance these technologies. And four, a discussion of possible new tools that the Federal Government may need to promote the safe deployment of advanced technologies as the industry continues to develop.

Over the subsequent 9 months, NHTSA hit the road, traveling to discuss automated vehicles with industry, academics, State governments, safety and mobility advocates, and the public. This Policy is the product of that significant input.

Before discussing the individual components, I would like to share a few thoughts about our approach.

First it is important to understand our traditional approach to regulating motor vehicles. For 50 years, our approach has largely been reactive. NHTSA has prescribed safety standards, and then responded to problems as they arise.

A traditional approach to regulating these new technologies would be to engage solely in rulemaking process, writing new regulations that prescribe specific standards. Our view is that approach would stymie innovation and stall the introduction of these technologies.

It would also be a long process. Rulemakings, and the research necessary to support them, take years, meaning that any rule we might offer today would likely be woefully out-of-date by the time it took effect, given the pace of technological development in this space. Let me be clear that using the notice-and-comment rulemaking process to establish new standards will absolutely play an important role as this technology matures and is adopted. But it is not the only tool in our bag, and we have created an innovative approach that will better serve both safety and innovation in the immediate term.

Our Policy represents a continuation of the new proactive safety approach that we have built at NHTSA under the leadership of Secretary Foxx. This Policy allows NHTSA to work with automakers and developers on the front end, to ensure that sound approaches to safety are followed throughout the entire design and development process. This is a new approach, and it's going to take some adjustment for everyone involved. But we are confident that it will help us accomplish two goals: first, to make sure that new technologies are deployed safely; and second, to make sure we don't get in the way of innovation.

As the Federal regulator with the responsibility of ensuring vehicles are as safe as they can possibly be, we play an important role on behalf of the American public to ensure that vehicle technologies do not present safety threats.

At the same time, we recognize the great lifesaving potential of these new technologies, and want to do everything we can to make sure that potential is fully realized and that they are deployed as quickly as possible to save as many lives as we can.

Some people have talked about safety and vehicle automation as on the opposite ends of a spectrum, as if there were a trade-off between safety and innovation. But at the Department of Transportation, we view our role as promoting safety innovation. Our Policy is designed to promote the safe and expeditious deployment of new technologies that have the potential to reduce crashes and save lives.

Our approach is not prescriptive. It does not tell developers how they must provide safety, but instead it builds a transparent and proactive approach to ensure that they are properly addressing the critical safety areas.

Finally, I want to be clear that while this Policy establishes an important framework for the development and deployment of automated vehicles, it is not the final word. In our view, this Policy is the right tool at the right time. It answers a call from industry, State and local governments, safety and mobility advocates and many others to lay a clear path forward for the safe deployment of automated vehicles and technologies.

But we intend this Policy to evolve over time. That evolution will be based on comments we receive from the public, our own experience in implementing it over the coming months and years, and, perhaps most importantly, based on the rapid

evolution of the technology itself. We have designed this Policy to be nimble and flexible, to allow us to stay at the leading edge of this revolution.

Before I discuss each component of the Policy, allow me to say a few words on definitions.

First, it is important to note that with this Policy, we are officially adopting the SAE International levels of automation, ranging from zero to five. The primary focus of the Policy overall is on what we refer to as “highly automated vehicles”, or HAVs. Those are vehicles at levels three through five on the SAE level scale, or vehicles that—at least in some circumstances—take over full control of the driving task. A portion of the first section of the Policy also applies to Level 2 vehicle systems, which include advanced driver-assistance systems already on the road today.

The Policy covers all automated vehicles that are designed to operate on public roads. That includes personal light vehicles, as well as heavy trucks. It even includes vehicles that might be designed to not carry passengers at all.

Finally, I note that most of the Policy is effective immediately. We expect that developers and manufacturers of AV technologies will use the Policy to guide their safety approach. Some portions of the Policy—notably the Safety Assessment Letter in the Vehicle Performance Guidance—will become effective following a Paperwork Reduction Act process that we expect to be completed within the next few months.’

Vehicle Performance Guidance for Automated Vehicles

The first section is the Vehicle Performance Guidance for Automated Vehicles. This is guidance for manufacturers, developers and other organizations involved in the development of automated vehicles. The heart of the Guidance is a 15 point “Safety Assessment” that spells out the critical safety areas that developers should address for the safe design, development, testing and deployment of highly automated vehicles prior to the sale or operation of such vehicles on public roads.

The Safety Assessment covers areas such as the operational design domain—essentially the where and when an AV is designed to operate automatically—fallback conditions, cybersecurity, privacy, and the human-machine interface.

We identified these areas through our extensive consultations with industry, academia and advocates as the critical safety issues that must be addressed to ensure that automated technologies are safe.

Critically, the Guidance does not specify how AV developers are intended to address the areas. Instead, the Guidance asks developers to document their own processes and then provide NHTSA with a Safety Assessment letter in which they explain their approach. This process is expected to yield a variety of different approaches for every one of the areas. That is intentional, and is one of the ways that we are preserving and promoting the innovation process. Government does not have all the answers, and our view is that the more approaches that innovators take to solving these problems, the more likely we are to find the best way.

Model State Policy

The second section is the Model State Policy. For the last 50 years, there has been a fairly clear division of responsibility between the Federal Government and the States for the oversight and regulation of motor vehicles. Generally speaking, it has been the Federal Government’s responsibility to regulate motor vehicles and equipment safety, while the States have regulated drivers and traffic laws.

That division of responsibility may be less clear in a highly automated vehicle world where increasingly the vehicle’s automated systems become the driver.

The Model State Policy delineates the Federal and State roles for the regulation of these vehicles, and it outlines the approach we recommend to States as they consider the regulation of testing and operation of automated vehicles on their public roads. Our goal is to build a consistent national framework for the development and deployment of automated vehicles, so that users can take their vehicles across State lines as they can today, and so that developers are building toward a single set of standards, rather than 50.

The Model State Policy confirms that States retain their traditional responsibilities for vehicle licensing and registration, traffic laws and enforcement, and motor vehicle insurance and liability regimes. At the same time, the Policy reaffirms that the Federal Government will continue to be responsible for the oversight of vehicle safety and design, including automated features.

The Policy was developed in close coordination with the American Association of Motor Vehicle Administrators (AAMVA), individual States and other stakeholders. It suggests recommended areas for States to consider in the development of their own regulations, including testing regimes and registration. It also identifies a number of areas that need to be further discussed and developed, including how law enforcement will interact with highly automated vehicles, and the development of a

consistent approach to insurance and liability challenges. We also note in the Policy that States do not have to take any action at all.

NHTSA's Current Regulatory Tools

The third section addresses NHTSA's Current Regulatory Tools. This section discusses how NHTSA will use the tools currently at its disposal to promote and expedite the safe development and deployment of highly automated vehicles.

The first of those tools discussed is our interpretation authority. The current Federal Motor Vehicle Safety Standards generally do not contemplate automated vehicle technologies. Therefore, it can sometimes be unclear how those standards apply to advanced technologies. In this section, we lay out the process by which developers of AV technologies can submit interpretation requests to the agency to determine whether and how their technologies conform with the standards. The agency also commits to a greatly expedited process for reviewing these interpretation requests. On simple safety-related interpretation requests, we commit to providing answers within 60 days. Compared to historical norms, that is lightning speed.

The second tool discussed is our exemption authority. Congress has granted NHTSA the authority to provide exemptions to manufacturers to deploy vehicles that do not conform to the Federal Motor Vehicle Safety Standards. While these exemptions are admittedly limited—to 2,500 vehicles for each of 2 years—the Agency views this tool as an important way of enabling a manufacturer to put a test fleet on the road to gather critical safety data and improve its technologies. The Policy similarly commits to an expedited process on simple safety-related exemptions, providing an answer within 6 months from the application.

The Agency's broadest power is its ability to write new safety standards. While this tool tends to take the longest amount of time—usually a period of years—it is the method that will ultimately allow for the large-scale deployment of nontraditional vehicle designs and equipment under consistent, broadly applicable standards. In addition, to the extent that performance-based standards are adopted, this tool has the potential to allow for technological innovation while maintaining safety.

In this section, we also highlight that the Agency retains its broad defects and enforcement authority. We use that authority to investigate any unreasonable risks to safety, and to recall unsafe vehicles from the road. The same day NHTSA issued the Policy, we also issued an Enforcement Guidance Bulletin that makes clear that the Agency's traditional enforcement authorities extend to advanced vehicle technologies.

Modern Regulatory Tools

The fourth and final section of the Policy discusses Modern Regulatory Tools, identifying 12 potential new tools, authorities and resources that could aid the safe deployment of new lifesaving technologies and enable the Agency to be more nimble and flexible.

Today's governing statutes and regulations were developed before highly automated vehicles were even a remote notion. For that reason, current authorities and tools alone may not be sufficient to ensure that highly automated vehicles are introduced safely, and to realize their full safety promise. This challenge requires NHTSA to examine whether the ways in which the Agency has addressed safety for the last several decades should be expanded and supplemented.

The new tools identified in this section include premarket approval, expanded exemption authority, imminent hazard authority, new research and hiring tools, and others that may better equip the Agency in the future as more technologies move from the lab to the road. These tools are offered for consideration by policymakers, industry, advocates and the public as we move forward.

One thing we know for certain is that the agency will need additional resources as this technology develops and is adopted. I have great confidence in the NHTSA team's expertise and ability. But it is undeniable that as more automakers move technology from the lab to the test track to the road, we will need to make sure our Agency is properly resourced to maintain pace.

We continue to support the President's budget request for more research dollars, and are committed to working with you in the coming months and years to identify what resources—both in personnel and research funding—will be necessary to achieve our mission.

Next Steps

Finally, with respect to the Policy, I would like to highlight once again that we fully intend this Policy to be the first iteration of many to come. The Policy is effective now, and will continue to evolve based on feedback and our experience implementing it, and, most importantly, to keep pace with innovation. To that end, each

section of the Policy highlights a series of next steps that we will take to implement and improve the Policy over time.

The first is our solicitation of public input. We are doing that through an open comment period that is open now through November 22nd. NHTSA is also hosting a series of public workshops that began earlier this month on different sections of the Policy. I will note here that the full Policy, additional materials, and the portal for public comments can be found at www.nhtsa.gov/AV.

Over the coming months we will be engaging experts to review the Policy, issuing further guidance on the Safety Assessment letter, and engaging stakeholders across the spectrum to help flesh out other areas of the Policy. For example, we will work with law enforcement organizations to further the conversation about how AVs will interact with the police, and work with industry to build the framework for the data sharing discussed in the Vehicle Performance Guidance. We are also engaged with other operating modes throughout the Department of Transportation, recognizing the roles and responsibilities they play with respect to public transit, commercial freight operations, and the highway system on which automated vehicles will operate.

We do not pretend to have answered every question in this Policy, and we will continue the conversation with the public about the best ways to develop and improve our Policy as we learn more. To that end, the Department of Transportation has committed to reviewing and updating the Policy annually.

As I conclude, I want to say a few words about the importance of the present moment in history. We have an industry that is rapidly developing innovative new technologies. And we have a government that is inspired and excited about the future of this technology.

But that future is not without threats. Bad actors or bad incidents could threaten to derail our collective efforts.

I want to close with the words President Obama used when he announced our new Policy in an op-ed in the Pittsburgh Post-Gazette. He wrote, "There are always those who argue that government should stay out of free enterprise entirely, but I think most Americans would agree we still need rules to keep our air and water clean, and our food and medicine safe. That's the general principle here. What's more, the quickest way to slam the brakes on innovation is for the public to lose confidence in the safety of new technologies. Both government and industry have a responsibility to make sure that doesn't happen."

It is our strong view that the best way we can build that public confidence is by working together, showing the public that the government is on the side of innovation and the industry is on the side of safety. We encourage you to join with us as we continue to develop this Policy and show the American public that their safety is the highest priority for all of us.

Thank you.

Senator COLLINS. Thank you very much.

Ms. Hersman.

STATEMENT OF HON. DEBORAH HERSMAN, PRESIDENT AND CEO, NATIONAL SAFETY COUNCIL

Ms. HERSMAN. Chairman Collins, Senator Reed, thank you for having me today. I'd like to acknowledge my board chair, Mr. John Surma, who is here with me in the audience today.

Today we have millions of drivers behind the wheel, we spend millions of dollars on education and enforcement campaigns, but we still lose tens of thousands of people on our roadways and experience billions of dollars in economic losses as a result of highway crashes. In spite of safer vehicle designs and record-setting seatbelt use rates across the Nation, operating a motor vehicle remains one of the deadliest things that we do every day.

Compared to other high-income countries, the United States' death rate is more than double our counterparts, and it's not because we don't have automated vehicles. It's because we aren't willing to do the hard things that we know will save lives.

Three to five thousand lives per year would be saved if everyone buckled up. Ten thousand lives would be saved if nobody drove

drunk. Just three technologies that are available on cars today—automatic emergency braking, lane departure warning, and blind spot detection—if these were all standard equipment on cars, 10,000 lives could be saved.

The AV policy begins an important discussion, and we applaud NHTSA and DOT for issuing it. Federal leadership on motor vehicle safety is necessary because we can only have one level of safety when it comes to our stakeholders and our constituents. Your constituents need to be confident that vehicles are safe regardless of where they reside. Manufacturers need certainty in order to invest in design and production, and States do not possess the expertise or the resources to replicate design, testing, and reporting programs.

Further, a patchwork of requirements will result in confusion for consumers and increased costs for manufacturers and operators attempting to comply with myriad requirements.

Finally, the absence of a safe, workable standard will drive development and testing and deployment overseas, resulting in the flight of innovation from the United States and the jobs that accompany it to locations outside of our borders.

NSC fully believes that automated vehicles have the potential to save lives and prevent injuries, but here are several key issues that we recommend that policymakers consider.

Delayed integration into the fleet. It will be a long time before highly automated vehicles replace our current fleet. How do we ensure rapid acceptance and adoption of lifesaving technologies that are available today? Electronic stability control paints the picture of the headwinds that we're facing.

DSRC—also known as V2V, V2I, and V2X—complementary technology must be taken into account. We need a belt-and-suspenders approach when it comes to highway safety.

Data sharing in a post-crash event. My experience at the NTSB taught me that we must rely on the data for truths. If you can't access it, you won't learn the lessons.

De-identified data. The automotive industry must figure out how to balance privacy and proprietary concerns against the predictive value of big data. Too many lives are at stake. Cooperation will help us unravel unintended consequences and identify new failure modes.

Consumer education. Today, 40 percent of consumers are startled by the way that their car has behaved. We will not realize the full benefit of technology if we don't keep human beings in the loop.

Lack of common taxonomy and standards. Today, manufacturers have multiple names and different performance expectations for similar systems. Shouldn't all AEB systems prevent collisions?

NHTSA resources. We cannot ask NHTSA to do more with less. Automated vehicles will require more evaluation, more testing, and more expertise than NHTSA possesses today.

Although we can imagine a future with automated vehicles, the transition from Level 1 to Level 5 will be messy as we deal with predictable human-machine issues. We cannot afford to ignore the carnage on our roadways that is a national epidemic. Efforts like Road to Zero will decrease fatalities today, tomorrow, and in the future if we embrace proven counter-measures and accelerate deploy-

ment of effective ADAS technologies and highly automated vehicles.

The National Safety Council appreciates the committee's leadership. If safety for the traveling public is the ultimate goal, advanced technology provides the most promising opportunity to achieve that outcome and will go a long way toward eliminating preventable deaths in our lifetime. Thank you.

[The statement follows:]

PREPARED STATEMENT OF HON. DEBORAH A.P. HERSMAN

Chairman Collins, Ranking Member Reed and other members of the subcommittee, thank you for inviting me to testify before you today. The National Safety Council (NSC) is a 100-year-old nonprofit with a vision to end preventable deaths in our lifetime at work, in homes and communities and on the road through leadership, research, education and advocacy. Our more than 13,500 member companies represent employees at more than 50,000 U.S. worksites. For decades we have advocated for safer cars, safer drivers and a more forgiving environment in and around vehicles. We have led large scale public education campaigns on the importance of seatbelts and airbags, eliminating distracted driving, and helping consumers understand the technologies in their vehicles to reduce deaths and injuries on our roadways. We also educate close to 1.3 million drivers a year in Defensive Driving courses.

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION AUTOMATED VEHICLES POLICY

The rapid pace of technological advancement means that regulators are hard-pressed to keep ahead of industry as manufacturers offer systems unheard of just a decade ago. However, NSC believes there are appropriate and necessary roles for both innovation by manufacturers and regulation by officials charged with ensuring public safety. The NHTSA (National Highway Traffic Safety Administration) Federal Automated Vehicles Policy (AV policy) is a step in the right direction. It provides a framework in which manufacturers can work and States can establish appropriate enforcement and oversight, while underscoring NHTSA safety authority and recognizing the need for additional tools to keep pace in this fast-moving environment. It also provides guidance for more uniform Federal oversight rather than a potential patchwork of regulations by the States.

Federal leadership on motor vehicle safety is necessary because there should only be ONE LEVEL OF SAFETY. Consumers need confidence in vehicles regardless of where they reside; manufacturers need certainty in order to invest in design and production, and States do not possess the expertise and the resources to replicate design, testing and reporting programs. Further, a patchwork of requirements will result in confusion for consumers and increased cost for manufacturers and operators attempting to comply with a myriad of requirements. Finally, the absence of a safe, workable standard will drive development, testing and deployment overseas, resulting in the flight of innovation and the jobs that accompany it to locations outside of the U.S.

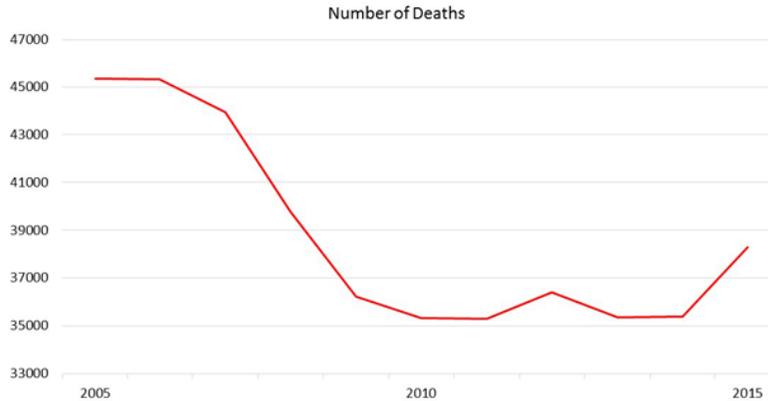
THE LIFESAVING POTENTIAL OF ADVANCED TECHNOLOGY

NSC believes advanced vehicle technology, up to and including fully automated vehicles, can provide many benefits to society. The most important contribution will be the potential to greatly reduce the number of fatal crashes on our roadways, which are increasing. Every day we lose approximately 100 people in motor vehicles crashes, and every year more than 4 million people are injured. Beyond the human toll, these deaths and injuries cost society over \$379 billion, including productivity losses, medical expenses, motor vehicle property damages and employer costs.¹

NSC data reveal that the 19,100 roadway fatalities during the first 6 months of 2016 are 9 percent higher than the same period last year and 18 percent higher than the same period 2 years ago. If we are to make a meaningful change in this trend, there must be a sense of urgency coupled with large, near term gains to save lives on our roadways.

¹Injury Facts 2016.

MOTOR VEHICLE DEATHS ON THE RISE



SOURCE: NSC analysis of National Center for Health Statistics (NCHS) mortality data and NSC estimate for 2016.

While the absolute numbers of fatalities change from year to year, many of the same behavioral problems remain persistent and have been represented in the data for decades. For example, in 2014:

9,967 people were killed in alcohol-impaired driving crashes²

3,179 people were killed in distraction related crashes³

9,385 people were killed while unrestrained.⁴

NHTSA estimates that 94 percent of all fatal crashes have an element of human error. Therefore, if we are to eliminate or reduce the number of fatalities on our roadways, advances in vehicle technology must be part of the solution. However, it will likely be decades before we have meaningful fleet penetration of fully automated vehicles.

Last month, the NSC and the National Transportation Safety Board (NTSB) hosted a full day event with dozens of expert panelists focused on Reaching Zero Crashes: A dialogue on the Role of Advanced Driver Assistance Systems (ADAS).⁵ While there is a great deal of excitement about highly automated vehicles (HAVs), automated vehicles and their potential to save lives, it is important to recognize that many legacy technologies represent the building blocks for fully automated vehicles. Greater consumer acceptance of the dozens of safety technologies that are available today would lead to more rapid adoption of them, saving lives and preventing injuries.

As an example, Electronic Stability Control (ESC) is a technology that uses automatic computer controlled braking of individual wheels to help the driver maintain control in risky driving scenarios. ESC primarily mitigates single vehicle, loss of control crashes in which drivers would run off the road. For passenger cars as well as light trucks and vans, it is estimated that ESC systems have saved more than 4,100 lives during the 5-year period from 2010 to 2014, but incorporation into vehicles on the road remains slow.⁶ The following charts from the Highway Data Loss Institute (HDLI) reveal how slowly ADAS technologies are achieving penetration in the U.S. fleet due to normal turnover of inventory—with the average age of cars in the U.S. fleet being 11.5 years old.⁷ Electronic stability control has been available for decades and was mandated on all new passenger cars by the 2012 model year, but in 2015 only 40 percent of registered vehicles were equipped with ESC. Despite

² <https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812231>.

³ <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812260>.

⁴ <https://crashstats.nhtsa.dot.gov/Api/Public/Publication/812246>.

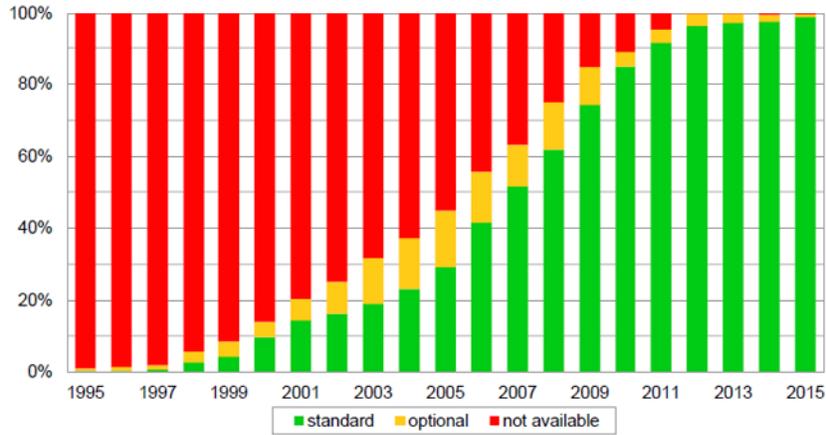
⁵ http://www.nts.gov/news/events/Pages/2016_dte_RT_agenda.aspx.

⁶ <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812277>.

⁷ http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/national_transportation_statistics/html/table_01_26.html_mfd.

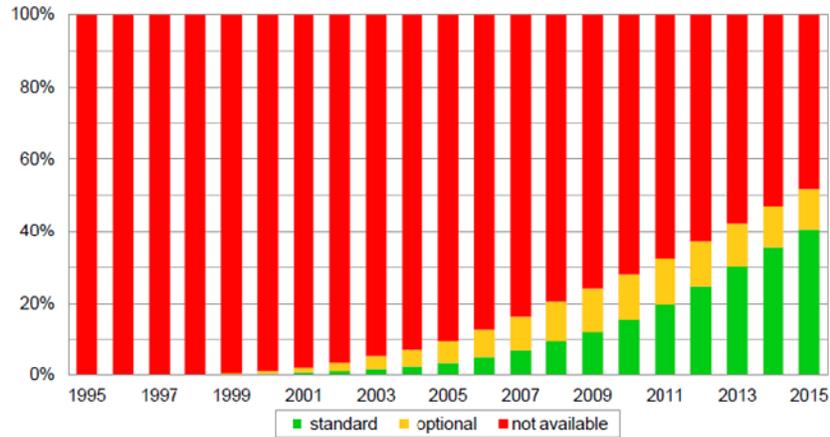
a clear life-saving benefit, full fleet penetration of this technology is not predicted until the 2040s.⁸

NEW VEHICLE SERIES WITH ELECTRONIC STABILITY CONTROL BY MODEL YEAR



SOURCE: HLDI.

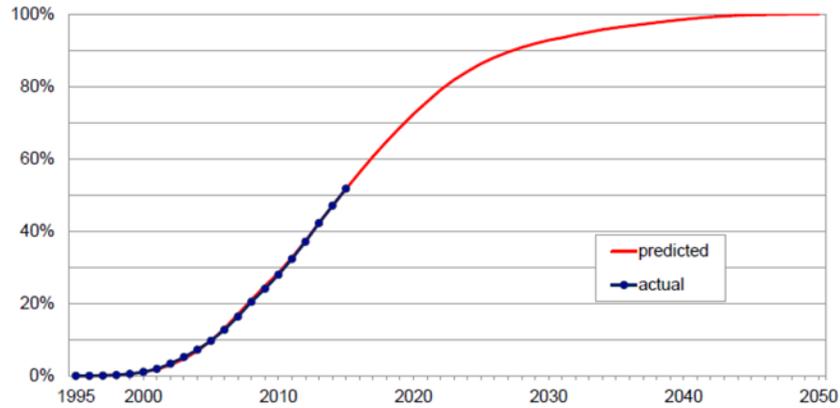
REGISTERED VEHICLES WITH ELECTRONIC STABILITY CONTROL BY CALENDAR YEAR



SOURCE: HLDI.

⁸http://www.nts.gov/news/events/Documents/2016_dte_RT_p1_p3_moore.pdf

REGISTERED VEHICLES WITH AVAILABLE ESC, ACTUAL AND PREDICTED



SOURCE: HLDI.

ADAS already operate on the roadways today, but more could be done to encourage greater fleet penetration. Features like lane departure warning systems, blind spot monitoring, adaptive cruise control and others help to prevent or mitigate crashes. The cost of these technologies is declining and their impact is measurable. According to the Insurance Institute for Highway Safety (IIHS), if four current technologies—forward collision warning/mitigation, lane departure warning/prevention, side view assist/blind spot monitoring, and adaptive headlights—were deployed in all passenger vehicles, they could prevent or mitigate as many as 1.86 million crashes and save more than 10,000 lives per year.⁹ However, front crash prevention, commonly referred to as automatic emergency braking, which was an option in about half new 2015 model year cars, was in only 8 percent of registered cars in 2015.¹⁰

CRASHES RELEVANT TO 4 CRASH AVOIDANCE SYSTEMS FARS AND GES, 2004–2008

| | all | injury | fatal |
|-----------------------------|------------------|----------------|---------------|
| front crash prevention | 1,165,000 | 66,000 | 879 |
| lane departure prevention | 179,000 | 37,000 | 7,529 |
| side view assist | 395,000 | 20,000 | 393 |
| adaptive headlights | 142,000 | 29,000 | 2,484 |
| total unique crashes | 1,866,000 | 149,000 | 10,238 |

SOURCE: Insurance Institute for Highway Safety.

Similar conclusions were reached in a July 2016, Carnegie Mellon study which stated that just three technologies—forward collision warning, lane departure warn-

⁹ <http://dx.doi.org/10.1016/j.aap.2010.10.020>.

¹⁰ http://www.nts.gov/news/events/Documents/2016_dte_RT_p1_p3_moore.pdf.

ing and blind spot monitoring—could have prevented or reduced as many as 1.3 million crashes annually and over 10,000 fatal crashes.¹¹ This study further found that almost one quarter of all crashes could be affected by these crash avoidance systems, but only 2 percent of 2013 model year cars included these systems as standard.

While many of these technologies are available on higher value cars or as part of an upgraded technology package today, they are not standard equipment on all makes and models. Safety should not be just for those who can afford it, especially for technologies that will result in thousands of lives saved every year. The Carnegie Mellon study estimated that if all light-duty vehicles were equipped with the three technologies, they would provide a lower bound annual benefit of about \$18 billion. With 2015 pricing, it would cost about \$13 billion to equip all light-duty vehicles with the three technologies, resulting in an annual net benefit of about \$4 billion or a \$20 per vehicle net benefit. By assuming all relevant crashes are avoided, the total upper bound annual net benefit from all three technologies combined is about \$202 billion or an \$861 per vehicle net benefit, at current technology costs.

NSC recognizes and applauds the voluntary commitment made earlier this year by 20 automakers to include automatic emergency braking (AEB) on all vehicles sold in the U.S. by 2022. Toyota has already committed to beat this date by several years. Given the slow turnover of the fleet, we encourage other manufacturers to view the 2022 date as a finish line rather than a starting point and accelerate the roll out of AEB and other lifesaving technologies.

Whether mandated or optional, in many cases these systems can perform driving tasks more predictably, more conservatively and more safely than a human driver, and may act without driver input if a driver is distracted, impaired or incapacitated. However, because there are no minimum standards for many of these technologies, legitimate questions about their effectiveness remain. The line between ADAS and highly automated vehicles may be blurred, as we have progressed far down the path of advanced features with few questions and widespread acceptance of semi-automated features.

DEDICATED SHORT RANGE COMMUNICATION

Another component of ADAS and automated vehicle systems is dedicated short range communication (DSRC), which would allow vehicles to communicate over dedicated spectrum bands with each other, pedestrians, and infrastructure to prevent collisions. This technology, often referred to as V2V (vehicle-to-vehicle), V2I (vehicle-to-infrastructure), V2P (vehicle-to-pedestrian), or V2X (vehicle-to-everything), is pending a rulemaking decision by NHTSA to establish performance standards. NSC encourages NHTSA to release this standard soon so that implementation of V2X can be more widespread.

DSRC can create redundant safety systems in motor vehicles. In other modes of transportation, fail-safe designs can support operator error, but in highway vehicles that task has fallen solely on drivers. DSRC would allow a vehicle to communicate with a red light to compensate for a fatigued driver, stop a car to prevent a collision with a pedestrian if a driver fails to detect him or her, and prevent or mitigate collisions between vehicles equipped with DSRC. DSRC has been deployed by some manufacturers, but NSC believes it is an important option in a safe systems approach to the design of HAVs and anticipates it will be more widely deployed if there is more regulatory certainty.

EDUCATION AND TRAINING

One component in the AV policy that should be a requirement moving forward is the incorporation of driver education and training about new safety technologies. With nearly 17.4 million new passenger cars and trucks sold in 2015,¹² understanding the technology on these vehicles is necessary, yet a University of Iowa survey found that 40 percent of respondents reported they had experienced a situation in which their vehicle acted in an unexpected way.¹³ When this occurs in a real-life driving situation, among multiple drivers, it can lead to disastrous outcomes.

The National Safety Council and our research partners at the University of Iowa are focused on educating consumers about in-vehicle safety technology through our

¹¹ <http://dx.doi.org/10.1016/j.aap.2016.06.017>.

¹² <http://www.autoalliance.org/auto-marketplace/sales-data>.

¹³ University of Iowa. National Consumer Survey of Driving Safety Technologies. July 30, 2015. Accessible at http://ppc.uiowa.edu/sites/default/files/national_consumer_survey_technical_report_final_8.7.15.pdf.

MyCarDoesWhat campaign.¹⁴ This brand agnostic education campaign informs drivers about how safety technologies work, how to best interact with them, and how to identify situations when the technology may not perform optimally and should not be relied upon. Because of the need for continued human involvement in the operation of many of these features, the campaign tagline is You are your car's best safety feature.

Visitors to MyCarDoesWhat.org realize improvement in general knowledge and accurate comprehension of vehicle safety features. Drivers cannot effectively use these life-saving technologies if they do not understand both their functions and limitations. The AV policy proposes that this education be delivered in multiple ways, including computer based, hands-on and virtual reality training, and other innovative approaches. The MyCarDoesWhat education campaign follows that approach, and is developing virtual reality modules for release early next year. Further, we recommend ongoing evaluation to determine the effectiveness of the various messages, methods of delivery and media so they can be improved over time.

STANDARDIZED NOMENCLATURE AND PERFORMANCE OUTCOMES

Another way to reduce consumer confusion is to standardize the nomenclature or taxonomy for advanced technologies. NSC, the State of California, and Consumer Reports have recommended that, at the very least, systems that are not completely automated or Level 5 should not be described as such. ADAS, with emphasis on driver assist, represents the vehicles being sold today and requires drivers to remain fully engaged in the driving task. That fact is often lost in marketing, media reports and consumer expectations. Labeling a motor vehicle as "autonomous" today, or even using terms such as "autopilot", only confuses consumers and can contribute to losses of situational awareness around the driving task.

By establishing standard nomenclature and establishing clear performance outcomes, consumers will better understand what they should expect from these technologies. For example, vehicles marketed as having AEB will not necessarily come to a complete stop before a collision.¹⁵ Some AEB systems only operate at higher speeds, and some are designed to slow rather than stop prior to a collision. These nuances may not be easily understood by consumers. IIHS reports that systems with a warning only, but no automatic corrective action, reduce frontal crash rates by about 25 percent, but vehicles with automatic braking reduce crashes by more than 40 percent. Vehicles with a warning and automatic braking reduce crash rates by about 50 percent. Establishing a standardized, results-based, understandable definition of AEB and other ADAS technologies would benefit consumers, manufacturers, and dealers, as well as organizations that evaluate vehicles for their safety benefits.

Finally, the New Car Assessment Program (NCAP) program has operated for nearly 40 years with a goal of testing vehicle safety systems and educating consumers about them. Practically, it has created a mechanism to allow consumers to evaluate vehicles on safety systems. NSC supports NCAP and believes it is an important program to improve the safety of the motor vehicle fleet. Standardized nomenclature and performance outcomes will ensure NCAP can more effectively compare vehicle safety systems between manufacturers, and even between a manufacturer's own models.

DATA PROTECTION AND SHARING

The National Safety Council is very bullish on ADAS, and eventually fully automated vehicles, because we know when implemented safely and properly, they will help us realize huge gains in reducing roadway fatalities. But a minimum requirement, if we are to realize the life-saving benefits, will be ensuring that we have reliable event data recorders that produce data in a standardized format that is downloadable for investigators, law enforcement, State highway safety offices, insurers and other relevant stakeholders. Following a crash, we must be able to answer simple questions like whether the vehicle systems or the human driver had control of the car, if and how the vehicle was communicating with the driver, and if all systems were working as designed.

The AV policy details the importance of data collection as these technologies begin to be tested in real-world scenarios. Understanding the circumstances and causes surrounding malfunctions, including at lower levels of automation, will help make this technology stronger and safer, and ensure failures are less likely to occur as technology evolves. This will be especially important in assuring consumers of the

¹⁴ www.mycardoeswhat.org.

¹⁵ [Http://www.nsc.org/learn/safety-knowledge/Pages/Driver-Assist-Technologies.aspx](http://www.nsc.org/learn/safety-knowledge/Pages/Driver-Assist-Technologies.aspx).

reliability of ADAS and automated technology. As the former Chairman of the NTSB, I believe that minimum parameters should be set for data preservation, standardization of formats, ease of access for post-crash evaluation, and establishment of privacy protections early in the process. Data-sharing programs require greater maturity and a strong safety culture committed to continuous improvement.

Event data recorders (EDRs) are widely used throughout the automotive industry in vehicles of all shapes and sizes, yielding valuable data in crash reconstruction efforts. Similar devices are used in other modes of transportation as well. Amtrak utilizes event data recorders that automatically transmit data from locomotive recorders to a control center when an event occurs. In the aviation industry, crash-hardened “black box” data recorders store thousands of parameters of data. Much of this information is collected after normal flights and analyzed by the operator to learn about and improve operations, and in the case of an incident, the data is invaluable to investigators to determine what occurred. The same could be true for motor vehicles.

Missing from the policy, however, is clarification on whether lower-level systems (below Level 3) should be subject to the same data collection guidelines. The current event data recorder standards do not require the majority of Levels 1 and 2 safety systems’ sensors be tracked.¹⁶ This lack of information limits real world data availability that could guide the future development of these technologies to make them safer. Currently, there is no easy way for manufacturers, law enforcement, investigators or vehicle owners to understand whether deployed systems were active during a crash, whether they malfunctioned, or whether they helped mitigate damage or injury or returned the car to a safe state in event of a malfunction.

Information sharing is included in the AV policy. However, the policy fails to mention the public health argument for collecting data from electronic devices in the car in the event of a crash. Acquiring an understanding of what happens when systems perform as intended, fail as expected, or fail in unexpected ways will yield valuable information for manufacturers—some of whom have common suppliers. Further, in-service data, as well as near miss and post-crash information sharing, can help civil engineers and planners design better and safer roadways, as well as help safety and health professionals design better interventions to discourage risky driving or affect the behaviors of other roadway users.

De-identified data sharing has been in existence in the aviation industry for many years and proven highly successful. The Aviation Safety Information Analysis and Sharing (ASIAS) system allows for sharing of de-identified data across the aviation industry, making it possible for the industry to identify trends and act on them. Analysis of de-identified data will provide windows in to leading indicators in the motor vehicle industry. Leading indicators are “proactive, preventative and predictive measures that monitor and provide current information about the effective performance, activities and processes of a . . . system that drive the identification and eliminate or control of risks.”¹⁷ The NSC Campbell Institute, a leader in workplace safety, health and sustainability, states that tracking leading indicators allows world-class safety organizations to make further improvements to their safety records.¹⁸

The AV policy also suggests that auto manufacturers use EDRs to gain a better understanding of how human operators engage with advanced technology. This knowledge will allow manufacturers to be nimbler and make adjustments in near real time for some systems based on what is actually occurring in the driver’s seat, rather than making changes based on assumptions and estimations that must be accommodated in a later model year. Collecting and sharing de-identified data about near misses and other relevant problems could also help by aggregating useful information for the automotive industry, allowing them to take proactive steps based on leading indicators rather than waiting for a crash or a series of crashes to occur. Finally, this data would be useful to researchers and the safety community in analyzing the safety benefits—and potential drawbacks—of these technologies as they continue to mature.

While there are competing priorities regarding protecting personal privacy and proprietary systems or designs, NSC believes that safety should be the ultimate priority, and that other concerns need to be accommodated to prioritize safety. NHTSA should facilitate data sharing as widely as possible and require that manufacturers

¹⁶ 49 CFR 563.

¹⁷ <http://www.thecampbellinstitute.org/file/download.php?id=20130925358263a8956de938e7c00a2bbbb8413d>.

¹⁸ <http://www.thecampbellinstitute.org/file/download.php?id=2015092336b107f72d10a379134af9249d3457ab>.

provide accessible, standardized data to law enforcement, State highway safety offices, investigators, insurers, and/or other relevant stakeholders.

AMERICAN NATIONAL STANDARDS INSTITUTE STANDARD

As important as it is for the average consumer to know and understand the ADAS and automated technology, there is also work to be done on this issue as it relates to the technology and its rollout to commercial fleets. As such, NSC is taking a leading role working with the American Society of Safety Engineers (ASSE) and a wide array of experts in the automotive industry, technology sector, academia and fleet management, to develop an ANSI (American National Standards Institute) standard to address policies, procedures and management processes that will assist in the control of risks and exposures associated with the operation of autonomous fleet vehicles on public thoroughfares.

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION RESOURCES AND OVERSIGHT IN THE MIDST OF CHANGING TECHNOLOGY

In response to reports of repeated incidents of unintended acceleration in Toyota vehicles in 2009–2010, the National Research Council Transportation Research Board conducted an investigation into whether NHTSA (National Highway Traffic Safety Administration) had reached the correct conclusion in its own investigation, as well as to produce advice on how to best handle future issues involving the safe performance of vehicle electronics. This research resulted in a report, released on January 18, 2012.¹⁹

The Research Council found that while NHTSA's decision to close its investigation was justified, it was "troubling that NHTSA could not convincingly address public concerns about the safety of automotive electronics." More specifically, the Research Council stated that "to respond effectively and confidently to claims of defects in the more complex electronic systems . . . NHTSA will require additional specialized technical expertise." While they acknowledged it was unrealistic to expect NHTSA to hire and maintain these specialized personnel in a constantly evolving field, they made a specific recommendation that NHTSA establish a standing technical advisory panel with members representing a wide array of technical expertise central to the design, development, and safety assurance of automotive electronics systems.

With technology advancing as quickly as it is, it is difficult to keep up with advances without appropriate resources. Last year, NSC supported the administration's NHTSA funding request of \$1.1813 billion, which included \$200 million for the Autonomous Vehicle Development program. We encourage this Committee and Congress to fully fund NHTSA, including requested investments in programs that will support the development of ADAS and HAVs. We also recommend that NHTSA consider how to best take advantage of existing knowledge by establishing an advisory committee or similar mechanism to engage experts in the field of advanced technology and automotive electronic systems.

ROAD TO ZERO

On October 5, NSC, NHSTA, the Federal Highway Administration (FHWA), and the Federal Motor Carrier Safety Administration (FMCSA) announced the Road to Zero (RTZ) Coalition. RTZ is a partnership initiative focused on dramatic reductions in roadway fatalities. Over 80 public and private organizations attended the announcement to learn more about committing to a shared vision of zero fatalities on our roadways. The first meeting of the coalition will be on December 15.

The purpose of the Road to Zero Coalition is to (1) encourage and facilitate widespread implementation of countermeasures to reduce motor vehicle crash deaths in the near term; (2) develop a scenario-based vision for zero U.S. traffic deaths in the future; and (3) provide a roadmap for policymakers and stakeholders to eliminate traffic deaths.

NSC is joined on the Steering Group for the Road to Zero Coalition by the following organizations: Advocates for Highway and Auto Safety, American Association of Motor Vehicle Administrators (AAMVA), American Association of State Highway and Transportation Officials (AASHTO), Commercial Vehicle Safety Alliance (CVSA), Governors Highway Safety Association (GHSA), Institute of Transportation Engineers (ITE), Insurance Institute for Highway Safety (IIHS), Intelligent Car Coalition, International Association of Chiefs of Police (IACP), Mothers Against Drunk Driving (MADD), National Association of State Emergency Medical Services Offi-

¹⁹<http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=13342>.

cial (NASEMSO), National Association of City Transportation Officials (NACTO), National Association of County Engineers (NACE), and the Vision Zero Network.

On behalf of the Coalition, the NSC will administer a grant program to support national non-profit organizations committed to roadway safety programs that address the overlaps and gaps between roadway users, vehicles and infrastructure. In addition, the Coalition will look at engaging others in near term solutions and countermeasures to reduce the death toll on our roadways. Finally, we will also provide critical input for the development of a future community scenario with zero traffic fatalities—an effort to look at the measures, programs and technologies will be necessary to reach zero highway fatalities in 30 years and work back from there. NHTSA, FHWA, FMCSA, and NSC are sponsoring the development of the scenario-based vision for zero traffic deaths in the U.S. in a 30-year timeframe, and the RAND Corporation has been retained to produce the scenario over the next 12–18 months. I look forward to briefing this Committee and others in Congress on the results of these activities and the efforts of the Coalition to reach zero deaths on our roadways.

CONCLUSION

Today, we have millions of drivers behind the wheel, spend millions of dollars on education and enforcement campaigns, and still recognize billions in economic losses as a result of crashes. In spite of safer vehicle designs and record-setting seat belt use rates across the Nation, operating a motor vehicle remains one of the deadliest things we do on a daily basis.

NSC believes fully automated vehicles have the potential to save lives and prevent injuries, but—as outlined above—there are several key issues that policy-makers must address. The AV policy begins this discussion, and we applaud NHTSA and DOT for issuing it.

It will be a long time before HAVs replace our current fleet. The transition will likely be messy as we deal with a complex and ever-changing Human-Machine interface. There will be an evolution of the existing technologies and perhaps a revolution when it comes to new and different technologies. We need to be prepared for unanticipated consequences and new failure modes.

Although we can imagine a future with automated vehicles, it will be a long and winding road to get to the destination of zero fatalities as a result of HAVs. We cannot afford to ignore the carnage on our highways that is a national epidemic today. The U.S. trails other industrialized countries in addressing highway deaths. Efforts like Road to Zero will decrease fatalities today, tomorrow, and in the future if we embrace proven countermeasures and accelerate deployment of effective ADAS technologies.

NSC appreciates this Committee's leadership on vehicle technology and safe roadway transportation. If safety for the traveling public is the ultimate goal, advanced technology provides the most promising opportunity to achieve that outcome, and will go a long way toward reaching the goal of eliminating preventable deaths in our lifetime.

Senator COLLINS. Thank you very much, Ms. Hersman.
Mr. Brubaker.

STATEMENT OF HON. PAUL BRUBAKER, PRESIDENT AND CEO, THE ALLIANCE FOR TRANSPORTATION INNOVATION

Mr. BRUBAKER. Chairman Collins, Ranking Member Reed, and members of the subcommittee, on behalf of the Alliance for Transportation Innovation, I would like to thank you for the opportunity to share our views on the role of government in integrating autonomous vehicles onto our Nation's roads.

The safety and social benefits that can be achieved by replacing human drivers with modern sensors and computers are too profound not to be encouraged through government policy. Yet regulation has failed to keep pace with innovation, and we see evidence of a significant gap in understanding of these technologies within all levels of government. It's a gap that must be bridged so regulators can better understand when it's best to lead, follow, or move out of the way.

We believe the Administration's recently released AV policy is a good first step in opening communication channels that can help to bridge this gap. We will formally be commenting on this policy by the end of the week.

But despite this disconnect industry and innovators are still working hard to integrate the development and deployment of autonomous systems and are investing billions of dollars with safety top of mind. These technologies are already being tested on our roads. In fact, just 3 weeks ago we saw the first commercial delivery of a truckload of beer delivered by a self-driving tractor trailer. Shortly, some in the auto industry will be prepared to offer full self-driving capability to the public, and government leaders must ensure that our current regulatory approaches do not constrain the development of these technologies. Lives depend on it.

To put a fine point on the subject, human drivers are simply killers. Errors in human judgment while at the controls of motor vehicles account for more than 90 percent of the car crashes that last year killed over 34,000 people in the United States and claimed 1.3 million lives around the globe.

Computers don't get tired. They don't text. They don't drink and drive, and they don't get road rage. Networks, sensors, maps, computing, artificial intelligence, machine learning, and vehicle controls work in concert to detect objects, analyze probabilities, consider options, make decisions, and take actions, all at the speed of light, and all with significantly greater reliability and efficiency than humans.

This capability is improving rapidly, and government needs to keep pace or risk undermining the promise of tomorrow by applying the regulations of yesteryear. Government cannot simply allow itself to be the obstacle to saving lives.

We hear a lot about these 34,000 fatal crashes and the fact that 94 percent of them are caused by human error. But the problem with statistics is they numb us with the fact that we're talking about people, individual parents, siblings, sons and daughters who are suddenly and cruelly taken away from us. Sons like Leo Vagias—and his father Teddy is right here behind me—and his best friend Sam Cali were killed in a very preventable car crash just this past June in New Jersey in a scenario that gets repeated too often and claims 96 lives a day. It needs to stop, and we have a collective obligation—industry, government, and citizens—to accelerate the development, testing and deployment of life-saving self-driving technologies.

But this journey to self-driving is complex, and integrating these technologies onto our Nation's highways will require unprecedented coordination and cooperation among industry, government, and citizens. We must win over a skeptical public by demonstrating that the underlying technologies are effective, safe and secure, and because these vehicles are going to operate on our public roadways, we've got to ensure that government encourages their safe and responsible deployment. Legal liability insurance issues must be addressed, and economic impacts and potential social disruption must be understood.

Given these complexities, ATI21.org believes that only executive leadership with Congress on this issue will provide the necessary

national vision, goals, and direction required across all sectors of our economy. That is why we recently published our National Strategic Framework to Accelerate Life-Saving Self-Driving Vehicles. We designed this document to develop a pathway to successful integration of autonomous vehicles into America's transportation system.

[The document link follows:]

[Http://www.ati21.org/wp-content/uploads/2016/10/Final-ATI-Strategy-Document.pdf](http://www.ati21.org/wp-content/uploads/2016/10/Final-ATI-Strategy-Document.pdf).

One area of emphasis in that framework is data. We believe that data is the key to speeding the safe deployment of these technologies. That's why we're recommending the creation of a National Self-Driving Data Repository. We envision that this is a highly secured, trusted, opt-in data repository with a number of positive incentives that can be leveraged in a way to encourage participation, incentives like indemnification, and rapid regulatory approvals. Such a repository will help us better understand the level of safety and performance, as well as enable us to identify real and emerging potential issues, and inform regulators, industry and the public based on near real-time data.

We have shared this national framework with the subcommittee and with the Trump transition team, and we're available to discuss this in detail.

[The article link follows:]

https://www.washingtonpost.com/local/trafficandcommuting/the-next-president-should-make-driverless-cars-a-white-house-priority-group-says/2016/10/20/6c548212-9636-11e6-bc79-af1cd3d2984b_story.html?utm_term=.3299c046b7aa.

The convergence of technology and transportation has the potential to dramatically improve the safe and efficient movement of people and goods. Over the next few years the Trump Administration and Congress will have an unprecedented opportunity to lead a cooperative effort between industry, government, and the public that holds the promise of saving lives. We look forward to working with you to advance this agenda. Thank you.

[The statement follows:]

PREPARED STATEMENT OF HON. PAUL R. BRUBAKER

Chairman Collins, Ranking Member Reed, and Members of the Subcommittee, on behalf of the Alliance for Transportation Innovation (ATI21.org), I would like to thank you for the opportunity to share our views on integrating autonomous vehicles onto our Nation's roads.

ATI21.org is a not-for-profit created to accelerate the deployment of technologies and innovation that can dramatically improve the safe and efficient movement of people and goods. Our members are associations, companies, and government and academic entities, as well as individuals who are dedicated to our mission.

The need to accelerate the path to self-driving is not only critical to our country's economic future, but also our technological standing in the world. The potential safety and social benefits are enormous, and we are on the cusp of reliably and safely replacing human drivers with technology enabled mobility platforms—self-driving vehicles—that will transform how we move people and goods.

Accelerating development and deployment of self-driving vehicles holds the promise of saving tens of thousands of lives every year, reducing crash-related injuries, and fundamentally transforming personal mobility. As soon as we achieve full self-driving, distracted and drunk driving will no longer claim lives; adult children will not have to have the conversation with aging parents about taking away their car keys; the poor will have access to much more convenient and affordable transportation; and the physically and developmentally disabled, including my soon to be adult son on the autism spectrum, will have access to transportation options. There

is no doubt that safe, affordable, accessible, and convenient transportation is critical for everyone's quality of life.

While the technologies to enable self-driving are being rapidly developed, the desire to get these capabilities to market are highlighting profound shortcomings in our national approach to regulation. Specifically, the regulatory process is simply not keeping up with the pace of innovation. While this is not unique to self-driving, the rapid development of autonomous vehicles presents us with an opportunity to revisit our regulatory approach and offer reforms that are more suitable to the digital age. It is imperative. In this case the cost of delay is measured in lost members of our families, of pain and suffering, and the denial of economic, health and social opportunity for the elderly, disabled and the impoverished.

That said, in the Obama Administration, Transportation Secretary Anthony Foxx and Administrator Mark Rosekind of the National Highway Traffic Safety Administration (NHTSA) get it. It is clear that the administration has a profound understanding of the critical technologies that have rapidly developed during the President's tenure and have laid the groundwork for the next administration to propel us into the self-driving future. The path will not be easy. There are considerable and complex cultural and regulatory barriers that must be overcome, and industry, researchers, the public, and government at all levels will need to engage and collaborate.

In late September the Department of Transportation issued its much anticipated autonomous vehicle (AV) policy guidance in what we believe represented a well-intentioned and thoughtful first-step toward ensuring that the Department, and NHTSA specifically, is heading toward a more responsive regulatory approach that is more suitable for accelerating the safe deployment of highly autonomous vehicles on our Nation's roads.

While these initial guidelines are not perfect, ATII21.org believes the Department of Transportation should be commended for recognizing a number of critical issues that must become priorities for industry and government to safely deploy autonomous vehicles. We also commend the Department for its clear willingness to engage with both the traditional auto industry and technology sectors. We believe such an open and productive dialogue with all interested parties is the first step to evolving toward a much more responsive and effective regulatory framework than the existing model.

Specifically, there are several positive provisions included in this initial version of the AV policy. First, the Department's 15-point safety assessment covers all the major key areas that are critical to the safe design of highly autonomous vehicles. Second, the Department rightfully asserted its appropriate and exclusive role as the Nation's vehicle safety regulator and offered a model policy that can help guide States in formulating appropriate regulatory frameworks. Lastly, the Department was quite clear that it intended this process to be iterative and recognized the need to evolve and even adopt new regulatory models that could keep pace with the innovation cycle. We believe these are all excellent first steps in developing an appropriate regulatory framework.

There are however two sections of the AV Policy document that gave us pause. Specifically, the section on the use of existing regulatory tools and the examples given as possible future regulatory approaches is no better and potentially worse than the existing tools.

Although the policy includes language about revising and streamlining processes related to interpretations and waivers, we believe the underlying Federal Motor Vehicle Safety Standards (FMVSS), while arguably effective for traditional motor vehicle design approval, will prove to be an unworkable foundation for accelerating the design and deployment of highly autonomous vehicles. As was highlighted in the March 2016 report by the Volpe National Transportation Research Center, there are considerable challenges in applying these standards to SAE level 4 and 5 autonomous vehicles.^{1,2} For example, the FMVSS makes more than 250 individual references to human drivers, and eliminating traditional design features such as steering wheels and pedals, which can be anticipated in level 4 and 5 vehicles, would violate roughly a third of the standards and half of the Series 100 crash avoidance requirements.

¹John A. Volpe National Transportation Systems Center, Review of Federal Motor Vehicle Safety Standards (FMVSS) for Automated Vehicles, Preliminary Report-March 2016, prepared for the Intelligent Transportation Systems Joint Program Office, NHTSA.

²Levels of driving automation are defined in the SAE International Standard J3016. It identifies six levels of driving automation from "no automation" (0) to "full automation" (5), with level 4 being "high" and Level 5 being "full."

While we commend the Department for beginning what we believe is a long overdue conversation on the need to create a much more responsive and timely regulatory approach, we believe the examples offered such as pre-approval of designs based on the FAA model or the FDA medical device approach are neither particularly efficient nor applicable or fitting.

Data is the key to reforming the regulatory process in a manner that will allow the creation of a regulatory approach that is rapid, efficient, and effective. Specifically, a central repository for collecting, storing, and analyzing all operational and testing data from across the industry is necessary to create a responsive regulatory environment. Neither the NHTSA nor any existing industry group is positioned to perform this task. Consequently, we are recommending the establishment of an independent, federally chartered organization to securely and confidentially collect and analyze all operational and test data from across industry that will include simulation data. By collecting real-time data and applying modern analytical methods, we are confident that, if properly established, this organization can rapidly inform industry and NHTSA of real and potential issues. We recommend that this effort be funded from existing dollars. We would be happy to consult with the Subcommittee on the specific details of this recommendation.

The second area we would like to highlight in our testimony this morning is our call for a National Strategic Framework to Advance Life-Saving Self-Driving Vehicles. We created this document calling for presidential level leadership on self-driving.

Accelerating the path to self-driving is an enormously complex undertaking that will go beyond the responsibility of the U.S. Department of Transportation. While there are major roles and policy levers that both the Federal Government as a whole and U.S. Department of Transportation can take to accelerate deployment and ensure that only safe vehicles make it to market, it is critical that all levels of government work together, that industry and the research community continues to drive innovation and has a path to market, and perhaps most importantly that citizens are informed, engaged and welcoming of what will prove to be a major cultural shift.

Not unlike past transitions to transportation-related innovation, success will depend on high levels of cooperation and engagement across government, industry, and the public. This was true of steamships, railroads, motor vehicles and aviation. The disruptive transition to self-driving will require similar coordination, cooperation, and support.

As is true with all disruptive innovation throughout history, we can expect to experience both positive and negative effects as we begin integrating autonomous vehicles onto the Nation's roads. It is critical that we thoughtfully consider the obvious consequences, both good and bad, that will undoubtedly arise from our transition from what we refer to as the "crash economy" to a new mobility paradigm.

As I mentioned earlier, the major reason for making this transition is to save lives and reduce injuries. Last year, over 35,000 Americans died in car crashes. This year that number is expected to climb and may exceed 40,000. Millions more are injured including many with life-changing debilitating injuries. We know that crashes cost the U.S. economy almost \$1 trillion annually. Let us be clear, we would not tolerate such cost and carnage in any other mode of transportation, and now, the tools are arriving to make these tragedies preventable.

Autonomous features and ultimately self-driving vehicles hold promise to dramatically reduce fatalities and injuries as NHTSA estimates that more than 94 percent of these crashes are the result of human error. We simply should not allow more than 90 of our fellow citizens to die every day when we can create the conditions to prevent it. The sooner we fully integrate autonomous vehicles onto our highways, the sooner we will realize a dramatic reduction in the number of preventable fatalities and injuries.

Getting this transition right will not be easy. Moving from the crash economy to a dramatically safer, accessible, affordable, and convenient mobility paradigm is a complex undertaking requiring unprecedented cooperation and coordination among industry, associations, and research and government institutions at all levels.

We believe such an effort will require presidential leadership and that the incoming administration and Congress should work in concert to create the conditions necessary to accelerate the development, testing, and deployment of these capabilities as well as proactively address some of the anticipated consequences of transition.

At ATI21.org, we announced the publication of our initial framework for accelerating the deployment of self-driving vehicles last month. The framework is not a prescriptive list of recommended actions but rather an outline of key challenges areas that must be addressed in order to accelerate the integration of autonomous vehicles on our Nation's highways.

Between now and Inauguration Day, we will be soliciting reaction to the challenge areas and hosting a series of expert panels to explore and produce recommendations on each challenge area. We intend to update the framework based on panel input and host a final review and input session for the entire document on January 4th with the Consumer Technology Association in advance of the Consumer Electronics Show.

In short, ATI21.org is calling for a National Strategy to Advance Self-Driving (NSAS) and urging the next president to issue an executive order that would describe the challenges and create a Program Management Office (PMO) within the Office of Science and Technology Policy (OSTP). We recommend funding the activity as a government-wide technology initiative through existing Office of Management and Budget (OMB) authority under a provision in the Clinger-Cohen Act. The PMO would operate under a 4-year charter to collaborate with relevant stakeholders, assemble experts, develop outcome-focused and actionable strategies, and identify funding streams to address each of the challenge areas.

We have identified the following challenge areas:

- Earning public trust
- Increasing confidence in self-driving technology
- Ensuring robust cybersecurity
- Developing standards and regulations that encourage self-driving
- Creating the legal, liability, and insurance framework for accelerating the deployment of self-driving vehicles
- Adopting reasonable data and privacy policies
- Accelerating the transition to a fully self-driving fleet
- Understanding and planning for economic disruption and labor transition

As we say in the framework, accelerating the path to self-driving will not be easy. The incoming president by leading us through this ambitious effort early in the new term can ensure dramatic progress toward creating a new mobility paradigm that will create safe, convenient, resilient, and accessible transportation options to all Americans regardless of their ability, age, or economic condition. ATI21.org believes this is a transportation legacy that we can be proud to leave to future generations.

In the coming months, we look forward to working with the Subcommittee and Congress to work on creating the conditions necessary to speed integration of autonomous vehicles on the Nation's highways.

Thank you. I look forward to answering your questions.

Senator COLLINS. Thank you.

Dr. Kalra.

STATEMENT OF DR. NIDHI KALRA, CO-DIRECTOR, RAND CENTER FOR DECISION MAKING UNDER UNCERTAINTY

Dr. KALRA. Chairman Collins, Ranking Member Reed, members of the subcommittee, thank you for the opportunity to testify today on the future of autonomous vehicles.

My name is Nidhi Kalra, and I'm an Information Scientist at the RAND Corporation. RAND is a non-profit, non-partisan research institution committed to improving public policy through objective research and analysis. I have a Ph.D. in robotics and have been studying autonomous vehicles for 10 years. And in the interest of full disclosure, my spouse is the co-founder of an autonomous vehicle start-up in Silicon Valley, though his work has no bearing on my testimony, or vice-versa.

Now, there are three issues I'd like to discuss today, the safety of autonomous vehicles, their benefits for mobility, and the urgency of addressing distortions in the transportation market so we can harness their benefits and mitigate their drawbacks.

So first let's talk about safety. Will autonomous vehicles be safe before they're allowed on the road for consumer use? We may not know. Real-world driving is currently the only method of demonstrating their safety. But suppose a fleet of autonomous vehicles has a 20 percent lower fatality rate than human drivers. They would have to be driven 5 billion miles to prove it, and a fleet of

test vehicles, 100 test vehicles would have to be driven 225 years to cover this distance. It's impossible if we ever want them on the road for consumer use.

But now let's consider two things. First, Americans as a whole drive more than this every day. We drive 8 billion miles every day. So once autonomous vehicles are widely deployed for consumer use, we may know very quickly how safe they are. And consider that autonomous vehicles will improve over time. So when a human driver makes a mistake, only that person, at best, is able to learn from the experience, but that's not with autonomous vehicles. When one vehicle makes a mistake or has an experience on the road, that information can be used to improve the entire fleet.

So experience may be one of the most important tools for both demonstrating and improving autonomous vehicle safety. So I think an important question is how do we enable autonomous vehicles to get experience while mitigating the safety risks they pose? And I suggest two things—strategic pilot studies and data sharing—that can help.

Pilot studies could start with real-world testing in lower-risk conditions like operating vehicles in well-maintained areas and at low speeds, and then could be expanded as safety is demonstrated.

As for data sharing, developers are already using the experiences of one vehicle to improve their fleet, but data sharing across the industry could mean that the experiences of every vehicle can improve the entire industry.

Second, let's talk about mobility. Autonomous vehicles could improve mobility for millions of Americans who are elderly, young, have disabilities, or live in poverty. But policies may be needed to make them affordable, available, and accessible. Policymakers can incentivize developers to bring these technologies to those markets sooner than they might otherwise, or to integrate them with transit and para-transit. Policymakers may need to work with developers to help make sure they're accessible, meaning that they comply with ADA guidelines and use different forms of payment, for example.

And while the cost of shared autonomous vehicles is expected to be low, policymakers could extend transit and para-transit reduced fares to these other technologies to make them all the more affordable for these vulnerable populations.

Third, let's talk about market distortions. Autonomous vehicles could also significantly affect traffic congestion, energy pollution and land use, maybe for the better, but maybe for the worse. So to harness their benefits and mitigate their drawbacks, policymakers should address the existing distortions in the transportation market that lead to undesirable outcomes and subsidize desirable outcomes.

Now, there are many policy options to address distortions, like strengthening the auto insurance market to encourage safety, implementing congestion pricing to reduce congestion, and offering rebates for fuel-efficient vehicles to reduce pollution.

Now, I can't today give each policy the discussion it warrants, but now is the time to address these distortions, because autonomous vehicles could improve our transportation system tremendously if the right market signals are in place. And there is cur-

rently a window of opportunity to send those new market signals because consumer expectations about autonomous vehicle performance and cost aren't yet set.

So, let me conclude. In the 1990s, we couldn't forecast the impact that the Internet has now had. Similarly, today we can't forecast the impact that autonomous vehicles will have on our future, but we can shape that future, and I would like to leave you with two recommendations.

First, as I noted, widespread experience may be the key to figuring out both how safe autonomous vehicles are and how they get better. So it's important to get them that experience as safely as possible.

And second, correcting market distortions will be critical to encouraging better outcomes for our transportation system and for our society.

Chairman Collins, Ranking Member Reed, and members of the subcommittee, thank you for allowing me to appear before you today, and I look forward to your questions.

[The statement follows:]

PREPARED STATEMENT OF DR. NIDHI KALRA

Chairman Collins, Ranking Member Reed, and distinguished members of the subcommittee, my name is Nidhi Kalra of the RAND Corporation.¹ Thank you for the opportunity to testify on important emerging opportunities and risks related to autonomous vehicles. Autonomous vehicles have the potential to change transportation profoundly, in the United States and around the world. There is much opportunity for improvement, but also potential for added risks and harms. How autonomous vehicles ultimately shape our future is not foretold; it depends on many technology and policy choices we make today.

Today, I would like to discuss three important questions about the future of autonomous vehicles and how policies can shape it. First, will autonomous vehicles be safe before they are allowed on the road for consumer use? Second, how can autonomous vehicles improve mobility for Americans who currently may have limited mobility? Third, what mechanisms can help realize the benefits and mitigate the drawbacks of autonomous vehicles? I will focus most of my remarks on fully autonomous vehicles—those that can operate without a human driver some or all of the time—rather than on vehicles that require continuous human oversight.

WILL AUTONOMOUS VEHICLES BE SAFE BEFORE THEY ARE ALLOWED ON THE ROAD FOR CONSUMER USE?

In the United States, roughly 32,000 people are killed and more than 2 million are injured in motor vehicle crashes every year.² Although safety has generally improved over the past several decades, 2015 saw 35,000 road fatalities, the largest increase in fatalities in this country in more than 50 years. This occurred partly because Americans drove more and partly because they drove worse.

U.S. motor vehicle crashes as a whole can pose enormous economic and social costs—more than \$800 billion in a single year.³ And more than 90 percent of crashes are caused by human errors,⁴ such as driving too fast and misjudging other drivers' behaviors, as well as alcohol impairment, distraction, and fatigue.

¹The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest.

²Bureau of Transportation Statistics, Motor Vehicle Safety Data, Table 2-17, Washington, D.C.: Research and Innovative Technology Administration, U.S. Department of Transportation, 2015.

³Lawrence Blincoe, Ted R. Miller, Eduard Zaloshnja, and Bruce A. Lawrence, *The Economic and Societal Impact of Motor Vehicle Crashes 2010 (Revised)*, Washington, D.C.: National Highway Traffic Safety Administration, DOT HS 812 013, 2014, revised May 2015.

⁴National Highway Traffic Safety Administration, *Traffic Safety Facts, A Brief Statistical Summary: Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Cau-*

Continued

Autonomous Vehicles Present Benefits and Risks to Safety

Autonomous vehicles have the potential to significantly mitigate this public safety crisis by eliminating many of the mistakes that human drivers routinely make.⁵ To begin with, autonomous vehicles are never drunk, distracted, or tired; these factors are involved in 41 percent, 10 percent, and 2.5 percent, respectively, of all fatal crashes.⁶ Autonomous vehicles could perform better than human drivers because of better perception (e.g., no blind spots), better decisionmaking (e.g., more-accurate planning of complex driving maneuvers), and better execution (e.g., faster and more-precise control of steering, brakes, and acceleration).

However, autonomous vehicles might not eliminate all crashes. For instance, inclement weather and complex driving environments pose challenges for autonomous vehicles, as well as for human drivers, and autonomous vehicles might perform worse than human drivers in some cases.⁷ There is also the potential for autonomous vehicles to pose new and serious crash risks—for example, crashes resulting from cyber attacks.⁸ Clearly, autonomous vehicles present both enormous potential benefits and potential risks to transportation safety.

When the National Highway Traffic Safety Administration released much-anticipated guidelines intended to outline best practices for autonomous vehicle safety, many looked to that guidance to answer the key question: Will autonomous vehicles be safe? I believe the answer is “maybe.” Answering the question requires considering two issues. First, how should autonomous vehicle safety be measured, and second, what threshold of safety should be required before autonomous vehicles are made publicly available? In essence, what test do autonomous vehicles have to take and what constitutes a passing grade? Both are genuinely open questions, so it is understandable that Federal guidelines have not yet answered them.

There Is No Proven, Feasible Way to Determine Autonomous Vehicle Safety

There are no road tests that could demonstrate how safe an autonomous vehicle is—there are too many conditions and scenarios to test them all. (A road test that a person takes at the Department of Motor Vehicles also does not prove that he or she will be a good driver; rather, the road test determines whether the person can perform a specific set of driving skills under regular traffic situations. While this type of evidence is viewed as adequate for licensing human drivers, it is not generally viewed as adequate for robot drivers.)

A logical alternative is to test-drive autonomous vehicles extensively in real traffic and observe their performance before making them commercially available. Although this is a helpful first step, it is not sufficient to prove safety. Even though the number of crashes, injuries, and fatalities from human drivers is high, the rate of these failures is low in comparison with the number of miles that people drive. Americans drive nearly 3 trillion miles every year.⁹ The 35,092 fatalities and 2.44 million injuries in 2015 correspond to a failure rate of 1.12 fatalities and 78 injuries per 100 million miles driven. Given that current traffic fatalities and injuries are rare events compared with vehicle miles traveled, fully autonomous vehicles would have to be driven hundreds of millions of miles and sometimes hundreds of billions of miles to demonstrate their reliability in terms of fatalities and injuries. Under even aggressive testing assumptions, existing fleets would take tens and sometimes hundreds of years to drive these miles—an impossible proposition if the aim is to

sation Survey, Washington, D.C.: National Center for Statistics and Analysis, U.S. Department of Transportation, DOT HS 812 115, February 2015.

⁵James M. Anderson, Nidhi Kalra, Karlyn D. Stanley, Paul Sorensen, Constantine Samaras, and Oluwatobi A. Oluwatola, *Autonomous Vehicle Technology: A Guide for Policymakers*, Santa Monica, Calif.: RAND Corporation, RR-433-2-RC, 2014; and Daniel J. Fagnant and Kara Kockelman, “Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations,” *Transportation Research Part A: Policy and Practice*, Vol. 77, July 2015, pp. 167–181.

⁶National Highway Traffic Safety Administration, *Traffic Safety Facts: Crash Stats*, Washington, D.C.: National Center for Statistics and Analysis, DOT HS 811 449, March 2011; Bureau of Transportation Statistics, *Occupant and Non-Motorist Fatalities in Crashes by Number of Vehicles and Alcohol Involvement* (Updated July 2014), Table 2–20, Washington, D.C.: U.S. Department of Transportation, 2014; and U.S. Department of Transportation, *Fact Sheet: Enhanced Mobility of Seniors and Individuals with Disabilities Section 5310*, Washington D.C., 2015. This does not mean that 53.5 percent of all fatal crashes are caused by these factors because a crash may involve, but not be strictly caused by, one of these factors, and because more than one of these factors may be involved in a single crash.

⁷Lee Gomes, *Hidden Obstacles for Google’s Self-Driving Cars: Impressive Progress Hides Major Limitations of Google’s Quest for Automated Driving*, Massachusetts Institute of Technology, August 28, 2014.

⁸Anderson et al., 2014.

⁹Bureau of Transportation Statistics, 2015.

demonstrate their performance prior to releasing them on the roads for consumer use.¹⁰ And, in the meantime, human drivers would continue to cause avoidable crashes and enormous harms to people and property.

Developers of this technology and third-party testers need to develop innovative methods of demonstrating safety and reliability. These methods may include but are not limited to accelerated testing,¹¹ virtual testing and simulations,¹² mathematical modeling and analysis,¹³ scenario and behavior testing,¹⁴ and pilot studies,¹⁵ as well as extensive focused testing of hardware and software systems. This is a rapidly growing area of research and development. There are promising ideas but no demonstrated and accepted methods of proving safety. In sum, no one yet knows how autonomous vehicles should be tested. It is therefore reasonable that the current Federal guidelines have not specified a test either.

There Is No Consensus on How Safe Autonomous Vehicles Should Be

The second issue of how safe autonomous vehicles should be is worth considering, even if their degree of safety cannot yet be fully proven. Some will insist that anything short of totally eliminating risk is a safety compromise. They might feel that it is acceptable if humans make mistakes, but not if machines do. But, again, waiting for autonomous vehicles to operate perfectly misses opportunities to save lives because it leaves far-from-perfect human drivers behind the wheel.

It seems sensible that autonomous vehicles should be allowed on America's roads when they are judged safer than the average human driver, allowing more lives to be saved and sooner while still ensuring that autonomous vehicles do not create new risks. An argument can be made that autonomous vehicles could be allowed even when they are not as safe as average human drivers if developers can use early deployment as a way to rapidly improve the vehicles. The vehicles could become at least as good as the average human sooner than they would otherwise, and thus save more lives overall.

The lack of consensus on this point is not a failure of sound thinking. It is not a failure at all, but rather a genuine expression of Americans' different values and beliefs when it comes to humans versus machines. It is therefore reasonable that the Federal guidelines also do not draw a line in the sand.

While these are difficult decisions, our differences in values and beliefs can be informed by thinking not only about safety today but also about the arc of safety in the coming decades. Our discourse on the question of how safe the vehicles need to be focuses on the safety of autonomous vehicles at the time that they are first introduced for consumer use. But this thinking should be expanded to consider the evolution of autonomous vehicle safety over time, not just at the start of vehicle deployment. When a human driver makes a mistake on the road, typically only that individual can learn from that experience to improve his or her driving habits. The other drivers on the road are largely unaffected. This is not the case with autonomous vehicles, which can use experience and learning to improve performance, not just of the individual vehicle but of the entire fleet. This is because, when an algorithm or software is updated and improved for one vehicle, it can be updated for

¹⁰Nidhi Kalra and Susan M. Paddock, *Driving to Safety: How Many Miles of Driving Would It Take to Demonstrate Autonomous Vehicle Reliability?* Santa Monica, Calif.: RAND Corporation, RR-1478-RC, 2016.

¹¹Wayne B. Nelson, *Accelerated Testing: Statistical Models, Test Plans, and Data Analysis*, Hoboken, N.J.: John Wiley & Sons, 2009.

¹²Suren Chen and Feng Chen, "Simulation-Based Assessment of Vehicle Safety Behavior under Hazardous Driving Conditions," *Journal of Transportation Engineering*, Vol. 136, No. 4, 2010, pp. 304–315; Siddhartha Khastgir, Stewart A. Birrell, Gunwant Dhadyalla, and Paul A. Jennings, "Development of a Drive-In Driver-in-the-Loop Fully Immersive Driving Simulator for Virtual Validation of Automotive Systems," paper presented at IEEE 81st Vehicular Technology Conference, Glasgow, Scotland, May 11–14, 2015; and Stephanie Olivares, Nikolaus Rebernik, Arno Eichberger, and Ernst Stadlober, "Virtual Stochastic Testing of Advanced Driver Assistance Systems," in Tim Schulze, Beate Müller, and Gereon Meyer, eds., *Advanced Microsystems for Automotive Applications 2015: Smart Systems for Green and Automated Driving*, New York: Springer, 2015.

¹³Khashayar Hojjati-Emami, Balbir Dhillon, and Kouroush Jenab, "Reliability Prediction for the Vehicles Equipped with Advanced Driver Assistance Systems (ADAS) and Passive Safety Systems (PSS)," *International Journal of Industrial Engineering Computations*, Vol. 3, No. 5, 2012, pp. 731–742; and R. Kianfar, P. Falcone, and J. Fredriksson, "Safety Verification of Automated Driving Systems," *IEEE Intelligent Transportation Systems Magazine*, Vol. 5, No. 4, Winter 2013, pp. 73–186.

¹⁴California Department of Motor Vehicles, *Express Terms Title 13, Division 1, Chapter 1 Article 3.7—Autonomous Vehicles*, 2015; and Michael Sivak, and Brandon Schoettle, *Should We Require Licensing Tests and Graduated Licensing for Self-Driving Vehicles?* University of Michigan: Transportation Research Institute, Technical Report UMTRI-2015-33, 2015.

¹⁵ANWB, *Experiments on Autonomous and Automated Driving: An Overview 2015*, 2015.

all vehicles. For this reason, experience may be one of the most important tools for improving autonomous vehicle safety and, by extension, transportation safety.

Policymakers Can Promote Autonomous Vehicle Safety

This raises an important question: How do we enable autonomous vehicles to improve as quickly as possible while lowering the risks they pose? There are several tactics policymakers could consider to accelerate autonomous vehicles' improvement.

A first step is to conduct real-world but lower-risk pilot studies of autonomous vehicles. Risk can be lowered first by operating autonomous vehicles in conditions in which crashes are less likely. This can include limiting autonomous vehicle pilots to areas with less-complex terrain, to routes that are well maintained and easier to navigate, to nondangerous weather conditions, or to some combination of these controls. It can also include educating communities about safe behavior in and around autonomous vehicles. Furthermore, risk can be lowered by designing and operating vehicles so that when crashes occur, the consequences of the crash to passengers and bystanders are fewer. This could be accomplished by limiting vehicle speed, ensuring that all pilot-study passengers wear seatbelts, and so forth. These strategically limited pilot studies can then be expanded as safe operation of autonomous vehicles is demonstrated.

A second consideration is the role of sharing driving data across the industry and with policymakers. Autonomous vehicle developers already use the experiences of a single vehicle to improve the safety of their individual fleets. This improvement could occur even faster if the experiences of each vehicle in each fleet could be used across all developers to improve the entire industry. There are certainly nontrivial concerns about protecting trade secrets, but these concerns could be addressed and must be balanced with the societal need for safe autonomous vehicle technology.

In sum, it may not be possible to know what the safety risk of autonomous vehicles is, and Americans may not agree on what it should be. All the same, there are ways of lowering that risk that deserve careful consideration.

HOW CAN AUTONOMOUS VEHICLES IMPROVE MOBILITY FOR AMERICANS WHO CURRENTLY MAY HAVE LIMITED MOBILITY?

For almost all Americans, the ability to get around is essential for living a rich, productive, and healthy life: being able to get to a place of work, to visit friends and family, to access healthcare and other services, to participate in civic activities, and to be connected to the external world in all other ways. Even with the increasing ability to interact and transact online, the importance of mobility in today's world remains vital. Despite its importance, many Americans have limited, and sometimes very limited, mobility as a result of advanced age, disabilities, or lack of means. Whatever the reason, limited mobility has significant negative consequences. Autonomous vehicles could help.

Autonomous Vehicles Could Help Many Older Americans Who Face Limited or Declining Mobility

The experiences of older Americans, especially those over 75, are emblematic of the challenges of limited mobility. The number of Americans 65 and older will increase from 48 million in 2015 (15 percent of today's population) to 74 million in 2030 (23 percent of the population). The number of Americans 75 and older will increase from 20 million in 2014 (6 percent of today's population) to 35 million in 2030 (10 percent of the population.)¹⁶ Older Americans are living longer and working longer than ever before. The labor force participation of those over 65 is expected to be 21.7 percent in 2024, up from 12.4 percent in 1994.¹⁷

Driving is important to their quality of life. Of adults over 65, 80 percent live in car-dependent areas and 90 percent say they intend to age in place.¹⁸ Eighty-five percent of adults aged 65 to 84 hold licenses, and almost 60 percent of adults over 85 hold licenses.¹⁹

¹⁶ U.S. Census Bureau, Projections of the Population by Sex and Age for the United States: 2015 to 2060 (NP2014-T9), spreadsheet, December 2014. As of November 8, 2016: <http://www.census.gov/population/projections/files/summary/NP2014-T9.xls>.

¹⁷ Bureau of Labor Statistics, "Civilian Labor Force Participation Rate by Age, Gender, Race, and Ethnicity," web page, December 2015. As of November 8, 2016: http://www.bls.gov/emp/ep_table_303.htm.

¹⁸ David Dudley, "The Driverless Car Is (Almost) Here," AARP The Magazine, December 2014/January 2015. As of November 8, 2016: <http://www.aarp.org/home-family/personal-technology/info-2014/google-self-driving-car.html>.

¹⁹ Policy and Governmental Affairs Office of Highway Police Information, "Distribution of Licensed Drivers—2014 By Sex and Percentage in Each Age Group and Relation to Population,"

Driving is risky for many older Americans. A recent study found that, when compared with drivers aged 55 to 64, drivers over 75 were more than 2.5 times as likely to die in a car crash, and drivers over 85 were almost four times as likely.²⁰ This is due both to increased likelihood of getting into crashes and greater vulnerability to injuries.

But giving up driving has risks as well. Driving cessation almost doubles the risk of increased depressive symptoms and is correlated with (though not strictly a cause of) cognitive, social, and physical declines and higher rates of entry into long-term care.²¹

Geography can further affect mobility. Approximately 18 percent of the rural population is 65 years or older, compared with 13.5 percent in non-rural areas.²² Compared with their counterparts in urban areas, older adults in rural areas must take longer trips for healthcare and other services and have fewer alternatives to driving.²³

Autonomous vehicles offer a promising solution. Fully automated vehicles that do not require human intervention would allow many older adults to travel by car, without having to drive. It could increase their mobility, with all of the associated social and economic benefits, while mitigating much of the safety risk. This, in turn, may allow more people to age in place, remaining in their homes for much longer than they might otherwise be able to.

Autonomous Vehicles Could Improve Mobility for Many Others

Older adults are just one group of Americans that could benefit from increased mobility from autonomous vehicles. Many people with disabilities, young people, and people living in poverty face mobility challenges that could be alleviated by autonomous vehicles.

In 2010, 56.7 million individuals (18.7 percent of the population) identified as having a disability.²⁴ Only 65 percent of individuals with disabilities drive, compared with 88 percent of individuals without disabilities.²⁵ In spite of the Americans with Disabilities Act, which mandates that transit authorities operating a fixed route system provide paratransit or a comparable service to individuals with a disability,²⁶ individuals with disabilities often have limited mobility because of a lack of availability or access to services. One survey showed that 12 percent of persons with disabilities reported having a harder time obtaining the transportation they need to be independent, compared with 3 percent of others, the top two reasons being no or limited public transportation (33 percent) and not having a car (26 percent).²⁷

There are also 25 million young Americans between the ages of 12 and 17 who have mobility needs but are not yet old enough to drive or are novice drivers.²⁸ Getting to school and academic enrichment opportunities, social and extracurricular activities, and even first jobs can be a challenge. Many depend on buses (principally to school) or their parents—or forgo travel. For many working parents, there is a trade-off between supporting their own and their children’s mobility needs.

web page, U.S. Department of Transportation, September 2014. As of November 8, 2016: <https://www.fhwa.dot.gov/policyinformation/statistics/2014/dl20.cfm>.

²⁰ AAA Foundation for Traffic Safety, “Drivers Over 65 Almost Twice as Likely as Middle-Aged Drivers to Die in Car Crashes, According to AAA Foundation Study,” February 18, 2004. As of November 8, 2016: <https://www.aaafoundation.org/sites/default/files/DriversOver65.pdf>.

²¹ Stanford Chihuri, Thelma J. Mielenz, Charles J. DiMaggio, Marian E. Betz, Carolyn DiGuseppi, Vanya C. Jones, and Guohua Li, “Driving Cessation and Health Outcomes in Older Adults,” *American Geriatric Society*, Vol. 64, 2016, pp. 332–341.

²² U.S. Census Bureau, “Percent of the Total Population Who Are 65 Years and Over—United States—Urban/Rural and Inside/Outside Metropolitan and Micropolitan Area,” *American FactFinder*, 2014. As of November 8, 2016: http://factfinder.census.gov/bkmk/table/1.0/en/ACS/14_5YR/GCT0103.US26

²³ J. E. Burkhardt, A. T. McGavock, C. A. Nelson, and C. G. B. Mitchel, *Improving Public Transit Options for Older Persons Transit Cooperative Research Program*, Washington D.C.: Transport Research Board, 2002.

²⁴ Matthew W. Brault, *Americans with Disabilities: 2010*, U.S. Census Bureau, July 2012.

²⁵ U.S. Department of Transportation, *Freedom to Travel*, Washington D.C.: Bureau of Transportation Statistics, 2003.

²⁶ U.S. Department of Justice, *Information and Technical Assistance on the Americans with Disabilities Act*, 2016.

²⁷ U.S. Department of Transportation, 2003.

²⁸ Federal Interagency Forum on Child and Family Statistics, “POP1 Child Population: Number of Children (in millions) Ages 0–17 in the United States by Age, 1950–2015 and Projected 2016–2050,” 2016. As of November 8, 2016: <http://www.childstats.gov/americaschildren/tables/pop1.asp>.

Americans living in poverty also face mobility challenges. About 43.1 million people (13.3 percent of the population) live in poverty.²⁹ This includes older adults and many individuals with disabilities. In 2014, 10 percent of older adults and 28.5 percent of individuals with a disability had a yearly income below the poverty line.³⁰

About 24 percent of households below the poverty line do not own a vehicle, compared with just 2 percent of households with incomes over \$100,000. Individuals living in poverty are about three times as likely to take transit and 1.5 times more likely to walk.³¹ While these are desirable ways to get around for environmental and physical health reasons, they can take much more time and limit travel to destinations that are accessible by these modes. This is important because research shows that access to efficient transportation is important for escaping poverty (via access to education, training, and work) and achieving upward economic mobility.³² In sum, there are millions of Americans with limited mobility, and autonomous vehicles could help them.

Affordability, Availability, and Accessibility Are Keys to Realizing These Benefits

Simply bringing autonomous vehicles to market might not fully solve the mobility challenges Americans face. Autonomous vehicles, like other transportation options, must also be affordable, available, and accessible. Fortunately, autonomous vehicles may have advantages over conventional transit, taxi, or vehicle-sharing services.

For many older adults, individuals with disabilities, and other people living below the poverty line, the costs of a personally owned vehicle are prohibitive. The costs of a privately owned autonomous vehicle are expected to be much higher, particularly initially. Shared autonomous vehicles will be the key to affordability. Shared vehicles are vehicles that are not personally owned but instead are available for many people to use, either on demand or through a reservation system, and are typically pay-per-use. Some estimates suggest that the per-mile cost of using a shared autonomous vehicle service could be 30 percent to 90 percent less than owning a conventional vehicle or using conventional taxis, depending on the nature of the service.³³ In other words, the per-trip costs could be comparable to transit, but with greater convenience and speed.

Second, shared autonomous vehicles must be available where people live. Car-sharing vehicles and taxis are not readily available in most small towns and rural communities because there are too few people to support the services. Furthermore, those who live in poor urban areas are another underserved segment in today's mobility market. Transit may not offer complete solutions, and taxis have historically been scarce because of the low demand compared to wealthier urban areas.³⁴ The lower cost of shared autonomous vehicles may increase the availability in underserved regions where other transportation solutions are limited.

Third, shared autonomous vehicles need to be accessible. This includes vehicle design, websites, and technology interfaces that are consistent with Americans with Disabilities Act and other accessibility standards and guidelines. It also includes implementing diverse payment systems that do not require smart phones or credit cards. Meeting these design goals can be expensive. For example, the National Highway Traffic Safety Administration estimates that the cost of a new vehicle with adaptive equipment (e.g., mechanical hand controls, power transfer seats, and lifts and ramps) can be \$20,000–\$80,000.³⁵ The cost for accessible autonomous vehicles

²⁹ Bernadette D. Proctor, Jessica L. Semega, and Melissa A. Kollar, *Income and Poverty in the United States: 2015*, U.S. Census Bureau, September 2016. As of November 8, 2016: <http://www.census.gov/library/publications/2016/demo/p60-256.html>.

³⁰ C. DeNavas-Walt and B. D. Proctor, *Income and Poverty in the United States: 2014*, Washington D.C.: U.S. Census Bureau, 2015.

³¹ Federal Highway Administration, "Mobility Challenges for Households in Poverty: 2009 National Household Travel Survey," FHWA NHTS Brief, 2014.

³² Raj Chetty and Nathaniel Hendren, "The Impacts of Neighborhoods on Intergenerational Mobility: Childhood Exposure Effects and County-Level Estimates," Harvard University, 2015.

³³ Lawrence D. Burnes, William C. Jordan, and Bonnie A. Scarborough, *Transforming Personal Mobility*, The Earth Institute, Columbia University, January 27, 2013; and Tasha Keeney, "What If Uber Were to Adopt Shared Autonomous Vehicles (SAVs)?" ARK Invest, June 22, 2015.

³⁴ Mark W. Frankena and Paul A. Pautler, *An Economic Analysis of Taxicab Regulation*, Bureau of Economics, No. 1103, May 1984; Nelson Nygaard, *Boston Taxi Consultant Report*, 2013; and Hara Associates Inc., *Best Practices Studies of Taxi Regulation: Taxi User Surveys*, prepared for San Francisco Municipal Transportation Agency, 2013. Today's ride share services may be helping provide better service in these underserved populations (see the Uber-funded study by Rosanna Smart, Brad Rowe, Angela Hawken, Mark Kleiman, Nate Mladenovic, Peter Gehred, and Clarissa Manning, *Faster and Cheaper: How Ride-Sourcing Fills a Gap in Low-Income Los Angeles Neighborhoods*, BOTEC Analysis Corporation, July 2015).

³⁵ National Highway Traffic Safety Administration, *Adapting Motor Vehicles for People with Disabilities*, June 2015.

may be lower because the vehicle only needs to be modified for passenger use; it does not need to be modified to enable driving.

Policymakers Can Promote Affordability, Availability, and Accessibility

All of this suggests that autonomous vehicles may increase mobility for historically underserved populations in a way that is more affordable, available, and accessible than existing transportation options. However, there is a clear and essential role for sound policy in realizing these benefits.

First, policymakers can create incentives for manufacturers to prioritize these markets and reach them sooner than they might otherwise. Incentives can include cost-sharing programs, subsidies, or other financial levers. They can also include partnerships to integrate both public and private shared autonomous vehicles into existing transit and paratransit services so that they are complementary rather than competing. This may involve making payment seamless across modes, providing transfer benefits across modes, and integrating scheduling. Private ride-share services are already working with transit agencies to provide connections to existing transit services, but primarily in urban areas.

Second, policymakers may need to incentivize technology developers to ensure that accessibility for diverse populations is a priority when designing these vehicles. This includes facilitating collaboration between developers, healthcare providers, independent living centers and other facilities, and, most importantly, the users themselves. Participatory design will be key.

Third, while the cost of shared autonomous vehicles is expected to be lower than many alternatives, public assistance may still be warranted. In many regions, seniors and individuals with disabilities ride transit at a discounted rate or even for free. Policies would be needed to extend these discounts to shared autonomous vehicle services.

In sum, autonomous vehicles present an enormous opportunity to improve mobility for millions of Americans who are currently underserved by our existing transportation system. The social, health, and economic benefits could be enormous. Policymakers can play an important and distinct role in prioritizing and enabling the technology so that autonomous vehicles can help democratize America's transportation system.

WHAT MECHANISMS CAN HELP REALIZE THE BENEFITS AND MITIGATE THE DRAWBACKS OF AUTONOMOUS VEHICLES?

In addition to transforming safety and mobility, autonomous vehicles may also shape other areas of transportation, including congestion, energy and pollution, and land use. Some potential impacts will be positive while others will be negative. All of the impacts are complex and difficult to predict, but despite the uncertainty, policymakers can help nudge the free market in the right direction.

The Impacts of Autonomous Vehicles on Congestion

Congestion has enormous societal costs. Travel delays resulting from traffic congestion caused drivers to waste more than 3 billion gallons of fuel and kept travelers stuck in their cars for nearly 7 billion extra hours—42 hours per rush-hour commuter.³⁶ The total cost to the United States was \$960 per commuter, or \$160 billion for the Nation as a whole.

Even if autonomous vehicles had no impact on the incidence of congestion, they could reduce the cost of congestion. If individuals can work in their cars, the cost of the time spent in traffic could be reduced substantially, even if the time itself is not reduced.

Nevertheless, the potential impact of autonomous vehicles on traffic congestion itself could be substantial but is uncertain. Traffic congestion could be significantly reduced because more vehicles can fit on a given stretch of roadway if they are autonomous. In the near term, autonomous vehicle platooning (where cars drive close together to reduce air resistance and increase fuel economy) can enable greater throughput; in the longer term, if a large number of vehicles are autonomous, lanes could be made narrower, creating more usable road space. If autonomous vehicles are much safer, they could significantly reduce crashes, which are a major source of congestion. Shared autonomous vehicles could provide better connections to main transit lines, leading to increases in use.³⁷

³⁶David L. Schrank, Bill Eisele, and Timothy J. Lomax, *The 2015 Urban Mobility Scorecard*, College Station, Tex.: Texas A&M Transportation Institute, 2015.

³⁷Johanna Zmud, Jason Wagner, Richard T. Baker, Ginger Goodin, Maarit Moran, Nidhi Kalra, and Dan Fagnant, *Policy and Planning Actions to Internalize Societal Impacts of CV and*

However, there is a flip side. Because autonomous vehicles will lower the costs of driving by car—by enabling productivity in the vehicle, reducing fuel costs through greater fuel economy, avoiding parking fees, and lowering insurance costs through greater safety—they could also increase the amount of driving. Improvements in mobility for underserved populations would also add to the amount of driving. If people can do the same things from the comfort of their own cars, fewer people might take public transit.³⁸

Accurately predicting the net effect on transportation demand is impossible because of the disruptive nature of autonomous vehicles. Just as we could not predict in 1990 how the Internet would change how and how much we would communicate 20 years later, we cannot confidently predict today how autonomous vehicles will change how and how much we will travel 20 years from now.

The Impacts of Autonomous Vehicles on Energy

Autonomous vehicles could increase fuel efficiency, but the net effect is unclear because they may increase travel demand, which could negate those gains. To the extent that fossil fuels remain the primary source of transportation energy, this would have knock-on effects in foreign oil dependence, air pollution, and greenhouse gas emissions.

The way people operate and maintain vehicles is inefficient. Aggressive driving alone can drop fuel economy by 25 percent, and not using cruise control on highways can drop it another 7 percent.³⁹ Autonomous vehicles can avoid these behaviors and thus reduce fuel consumption. Adding to this, even relatively simple levels of automation can enable platooning.

In the longer term, if autonomous vehicles that crash less are widely used, they could be built lighter, which will further reduce fuel consumption and emissions. Less obviously, fully autonomous vehicles might be able to jump-start alternative transportation fuels. One of the key obstacles to both plug-in electric and hydrogen fuel cells, which have zero tailpipe emissions and can use renewable energy, is the lack of refueling or charging infrastructure. This becomes much less of a problem if cars can drive themselves to refueling or recharging stations because far fewer stations are needed.⁴⁰ One recent study showed that electric shared autonomous vehicles could reduce greenhouse gas emissions in 2030 by 87–94 percent relative to current conventional vehicles and 63–82 percent below projected model year 2030 hybrid vehicles because of decreases in future carbon intensity of electricity, “right sizing” of vehicles, and higher miles traveled per vehicle.⁴¹

On the other hand, passengers may prefer larger autonomous vehicles to allow them to take better advantage of the opportunity to do things other than driving, resulting in lower fuel economy and greater emissions.⁴² And, of course, they may drive more.

The Impacts of Autonomous Vehicles on Land Use

Automobile use has influenced the form and extent of land development in the United States, leading in large part to sprawl (that is, low-density, inefficient land-use patterns).⁴³ The land allocated to automobile infrastructure poses a cost to society: It could otherwise be used for farms, open space, homes, businesses, and other facilities, with associated environmental, economic, and public health effects.⁴⁴

Autonomous vehicles may affect land use in two opposite ways, and both could take place. Commute time and distance are among the key factors households consider in deciding where to live. While areas farther away from central business districts offer many benefits, particularly in housing size and cost, a longer commute may be too costly, both in terms of travel and time costs. However, given the ability

AV Systems in Market Decisions, interim deliverable to the National Cooperative Highway Research Program, Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine, May 2016.

³⁸Zmud et al., 2016; Anderson et al., 2014.

³⁹Michael Sivak and Brandon Schoettle, “Eco-Driving: Strategic, Tactical, and Operational Decisions of the Driver That Influence Vehicle Fuel Economy,” *Transport Policy*, Vol. 22, July 2012, pp. 96–99.

⁴⁰Anderson et al., 2014.

⁴¹Jeffery B. Greenblatt and Samveg Saxena, “Autonomous Taxis Could Greatly Reduce Greenhouse-Gas Emissions of U.S. Light-Duty Vehicles,” *Nature Climate Change*, Vol. 5, No. 9, 2015, pp. 860–863.

⁴²Anderson et al., 2014.

⁴³Robert Burchell, George Lowenstein, William R. Dolphin, Catherine C. Galley, Anthony Downs, Samuel Seskin Katherine Gray Still, and Terry Moore, *Costs of Sprawl-2000 TRCP Report 74*, Federal Transit Administration, 2002.

⁴⁴M. A. Delucchi and J. J. Murphy, “How Large Are Tax Subsidies to Motor-Vehicle Users in the U.S.?” *Transport Policy*, Vol. 15, 2008, pp. 196–208.

to engage in other activities while in an autonomous vehicle, the opportunity cost of transportation declines. This could increase the willingness of households to locate farther away from the urban core, increasing urban sprawl.⁴⁵

On the other hand, autonomous vehicles could also lead to greater density in core urban areas. Driving remains the dominant mode of passenger travel in the United States, even in large cities with good transit options, but the typical automobile is parked for about 95 percent of its lifetime.⁴⁶ As of a decade ago, the total area devoted to parking spaces in major central business districts was, on average, about 31 percent of the district area.⁴⁷ The emergence of autonomous vehicles could sharply reduce the amount of parking needed in core urban areas in several ways. First, after dropping off its passenger or passengers in a downtown location, an autonomous vehicle could pilot itself to a remote lot in a peripheral area, reducing the amount of parking needed in the densest urban areas where land values are highest. Second, as described earlier, autonomous vehicle technology might lead to a new model for urban mobility in the form of driverless taxis. Under such a system, autonomous vehicles would not need to park after every trip; rather, after dropping off one passenger, they would simply travel to pick up the next passenger. Third, the convenience and low cost of such a system might induce many urban dwellers to forgo car ownership, or at least to reduce the number of cars owned. Thus, driverless taxis could reduce the number of parking spaces needed in residential buildings, as well as at commercial centers.⁴⁸ These effects, emphasizing the service character of transportation, could free up substantial amounts of space in urban areas for other valuable uses: homes, businesses, parks, hospitals, and so on.

Driving Externalities May Prevent the Benefits from Being Realized

While the effects of autonomous vehicles are complex, some outcomes are clear wins. If safe autonomous vehicles are developed and used widely and responsibly, the current public safety crisis in the U.S. transportation system could be mitigated. If safe and usable autonomous vehicles are developed, mobility could increase for millions of Americans who currently have limited mobility. In addition, if the potential increase in transportation demand created by autonomous vehicles were mitigated or decoupled from fossil fuels, there could be enormous energy security, public health, and environmental benefits. Related to this, if shared autonomous vehicles are widely available and widely used, this could reduce private vehicle ownership and the need for road infrastructure, allowing repurposing of land to more economically productive uses.⁴⁹

Yet these outcomes may not actually be realized because many benefits accrue to society rather than to either the producers or consumers of autonomous vehicles. Consumers may be unwilling to pay for expensive technology if much of the benefits go to others, and consequently, producers may be less willing to develop them. Thus, there is less incentive for producers and consumers to take actions that would achieve beneficial outcomes.⁵⁰

Safety is a good example of this phenomenon, with significant consequences for autonomous vehicles. When an individual drives unsafely or operates an unsafe vehicle, he not only puts his own well-being at risk but also the well-being of all other road users around him, including pedestrians and bicyclists. However, in our current transportation and legal system, an individual is responsible for only a fraction of the full cost of being unsafe. In many States, motorists are required to carry only \$30,000 (or less) worth of liability insurance—far less than is necessary to compensate someone for a serious injury, much less a loss of life. This leaves a huge gap between the harms that are regularly inflicted by drivers and the amount available for legal recovery. In essence, society subsidizes dangerous vehicles and driving behavior, creating less incentive for safer vehicles and behaviors.

Economists call this an externality. An externality is an effect that one party imposes on another party without compensating them for the effect if it is negative or charging them for it if it is positive.⁵¹ The free market does not allocate resources well in the presence of externalities because the true costs and benefits of actions are distorted.

Consider how the safety externality dampens the market for safe vehicles, including safe autonomous vehicles. First, buyers' incentive to purchase safe autonomous

⁴⁵ Anderson et al., 2014.

⁴⁶ Donald C. Shoup, *The High Cost of Free Parking*, Chicago: Planner's Press, 2005.

⁴⁷ Shoup, 2005.

⁴⁸ Zmud et al., 2016.

⁴⁹ Zmud et al., 2016.

⁵⁰ Zmud et al., 2016.

⁵¹ James M. Buchanan and Wm. Craig Stubblewine, "Externality," *Economica*, Vol. 29, No. 116, 1962, pp. 371–84.

vehicles (which we can expect to be expensive, at least at first) is less than it would be if full social benefits of safe vehicles were reflected in a lower price tag. Second, and related, auto manufacturers' incentives to create as-safe-as-possible autonomous vehicles are less than they should be, because safety is undervalued in the marketplace.⁵² The result is that very safe autonomous vehicles could be technologically feasible, but fewer firms will develop them and fewer individuals will buy them because many of their benefits accrue to the public rather than the purchaser.

Safety is just one externality. Many of the benefits and the costs of autonomous vehicles (and vehicles in general) are external. If a buyer's car is energy efficient, it helps the buyer somewhat, but most of the benefits go to other people (e.g., the people who breathe the air in the area where that vehicle is driven). Those costs (e.g., of poor air quality) are real and are borne by society. If the benefits of reducing pollution are not factored into the buyer's cost of the vehicle, there is little incentive for them to buy it, particularly if the vehicle is more expensive than less-efficient alternatives.

Policymakers Can Promote Beneficial Outcomes by Internalizing Externalities

So, how can we solve the externality problem? The key is to use policy tools to "internalize" externalities so that market prices reflect the true costs and benefits of private-sector actions. This can be done with subsidies, user fees, mandates, and privileges to ensure that producers and consumers of autonomous vehicles receive the benefit from (and are thus incentivized toward) making choices that benefit society.

As just one example, when a driver uses a busy road, he adds to congestion that other travelers experience, but he does not have to pay for the cost of that extra congestion—the lost productivity of others as they sit in traffic, the delay in goods movement, and the local increase in pollution. But congestion is a problem that could be solved. Nearly all passenger vehicles in this country have space for at least four people, but on average, there are just 1.67 passengers.⁵³ Those unused seats are extra, already-built transportation capacity. But that capacity is not used because, in large part, the costs of carpooling are internal (the driver bears the cost of the effort and hassle) but the benefits of carpooling remain external (the driver does not benefit from reducing society's congestion). High-occupancy-vehicle (HOV) lanes are one partial remedy: They help internalize the positive externalities of carpooling by enabling carpoolers to themselves bypass congestion and get to their destinations faster.

There are many policy options to internalize not only the congestion externality but also the other driving externalities related to safety, pollution, oil dependence, and mobility. These include creating insurance requirements that strengthen the market for road safety, offering transit incentives that reduce congestion, and offering rebates for using fuel-efficient vehicles, among others. Each option has a long history of research and discussion, and these and other options have been implemented to varying degrees.

It is not possible today to give each policy the discussion it warrants. Nevertheless, now is the time to revisit the impact of driving externalities and the policies to internalize them, because autonomous vehicles could improve our transportation system tremendously, provided the right market signals are in place. In other words, because so many of the benefits and costs of autonomous vehicles would accrue to people other than the buyer, internalizing externalities is a key step to ensuring that society minimizes their disadvantages and maximizes their benefits.

There is also a current window of opportunity to send those new market signals because consumer expectations about autonomous vehicle costs, performance, and other characteristics are not yet set. For instance, congestion pricing requires drivers to pay a fee to travel during peak rush hour, because driving during rush hour imposes higher congestion costs on everyone than driving at other times does. Although congestion pricing is widely recognized as an effective means of internalizing the cost of congestion and thereby reducing congestion, it has been difficult to implement, partly because drivers are unaccustomed to paying different prices based on when they travel. However, today, many private ride-sharing companies charge an extra fee for their services during rush hour, analogous to congestion pricing. Because these services are new and the reasons for the charge are understandable to

⁵²This externality explains, in part, why there is little market for vehicles that are designed to better protect individuals outside of the vehicle in the event of a crash. The technology exists, but the societal benefit of protecting others does not reach the buyer in the form of a relatively lower-priced vehicle.

⁵³Federal Highway Administration, Summary of Travel Trends: 2009 National Household Travel Survey, June 2011. As of November 8, 2016: <http://nhts.ornl.gov/2009/pub/stt.pdf>.

consumers (greater demand for a limited supply of goods), these fees have been generally acceptable. Similarly, consumers may be more amenable to new policies that internalize the externalities of driving now, before autonomous vehicles are available, rather than later, once expectations about autonomous vehicles are set. Of course, these policies must apply to all auto travel, not just autonomous vehicle travel, for the market signals to be clear.

In sum, it is not possible to fully predict what a future with autonomous vehicles will look like. However, by using the current window of opportunity to internalize the externalities of driving, it is possible to send the right market signals, paving the way for a future transportation system that maximizes the potential advantages while minimizing the potential disadvantages. This is an exciting future of increased mobility and economic growth and greater transportation safety, efficiency, equity, and sustainability.

[Conflict of Interest Statement: Nidhi Kalra's spouse, David Ferguson, is co-founder and president of Nuro, an autonomous vehicle startup. He previously served as a principal engineer for Google's driverless car project. This written testimony was carefully reviewed by subject-matter experts within the RAND Corporation; the research quality assurance team for the RAND Justice, Infrastructure, and Environment division; and the RAND Office of Congressional Relations. However, the opinions and conclusions expressed in this testimony are the author's alone and should not be interpreted as representing those of the RAND Corporation or any of the sponsors of its research.]

Senator COLLINS. Thank you very much for your testimony, and I am going to start my questions with you.

MOBILITY FOR SENIORS

As a senator representing a State with the oldest median age in the country, I can see tremendous potential for seniors whose vision has diminished to the point where they no longer can safely drive being able to use these autonomous vehicles so that they can maintain a measure of independence and not be dependent on others. So I see that, in addition to the safety benefits, and really the two are linked, as being a tremendous advantage.

Another advantage which I wondered whether you had analyzed at all is whether there would be an impact on the insurance market and the rates that individuals would pay for insurance if they are driving cars with either limited safety features that have been added to it or are fully autonomous.

Dr. KALRA. I appreciate the note about seniors. My grandparents are in that same boat, so I understand that very clearly.

In terms of insurance, yes, in the long run we might expect insurance rates to go down because fewer crashes mean lower costs for personal injury and damage, and eventually they may be needed for declining auto insurance. But in the short run, it's actually hard to say what the effect of insurance is going to be, for a few reasons.

First, it may take many years or many decades for the fleet to become largely autonomous, so the risks may not change as quickly as we anticipate.

Second, because at least for some types of autonomous vehicles there's going to be shared control between the human and the machine, there may be over-reliance on the technology, which is one of the things we've seen with Tesla. So it may not necessarily translate into lower crashes or crash rates. That remains to be seen.

And third, the car repair costs for a crash could actually increase, because right now if I rear-end someone, it's a few hundred

dollars to bang out that bumper, but in the future it could be much more expensive.

Now, there's a different issue with people who are insured at the minimum insurance rate, but that's a little more complicated. We can go there if you want to.

Senator COLLINS. Thank you.

EXISTING VEHICLE TECHNOLOGIES

Administrator, we heard Ms. Hersman say that three technologies, if they were mandated, could save some 10,000 lives. Now, whenever the Federal Government mandates, there is obviously cost involved. But I am curious whether NHTSA has considered mandating proven safety technologies that are available right now on new vehicles as they're manufactured. I should make that clear.

Mr. ROSEKIND. In fact, I think as soon as anybody says to any of you "We need to regulate to get safety," the first thing you need to ask is what are we going to regulate? Because for regulation we need performance criteria, testing, we need to know that there's enough penetration that we have sufficient data, cost/benefit analyses, et cetera.

I say that because the last technologies that we have seen come through rulemaking are things like electronic stability control, that rear visibility camera that you like so much, advanced air bags. Those took 6, 8, and 10 years to actually get through the regulatory process. That's really important because in these new technologies, by the time those rules would come out it would be irrelevant for the new technology that would have evolved.

And I say that because, quickly, in September of 2015 we actually challenged the auto industry: how do you take automatic emergency braking and make it standard on all vehicles? This is called democratizing safety. So it's not just on high-end or an option. Basically what they did was in March come back, and 20 automakers are going to make AEB standard by 2022 on all vehicles in our country. That will beat regulation by 3 or 4 years. We can count the lives saved.

So there are ways to do this besides regulation, and I think we have to use the right tool. For the moment, this policy is the right tool at the right time.

STATE REGULATIONS OF AUTOMATED VEHICLES

Senator COLLINS. Well, let me ask you the other side of that coin. The guidance the Department has put out said a 15-point safety assessment is voluntary, but as you're well aware, States like California are already proposing to make it mandatory for companies that want to test or deploy automated vehicles. What can you do, what can NHTSA do to ensure that States do not arbitrarily mandate various aspects of your guidance document, thereby creating a patchwork of ever-changing State laws that would stymie innovation and the deployment of these vehicles?

Mr. ROSEKIND. Really, a huge part of including that piece, the model state policy, was to differentiate the Federal versus State roles. In fact, directly to your point, we make it absolutely clear that States actually have to do nothing in this area. They can actu-

ally support the advancement of these safety technologies with no policy or regulations. If they choose to, we identify some areas where they can move forward. Everyone on the State level that we've interacted with is absolutely interested in seeing a consistent framework and trying to avoid the patchwork. This is an area I think we need to watch and see it develop.

And California, as you mentioned, if you look at their early, sort of recommended policies, they've changed dramatically in their latest proposals because they waited for this policy.

So I think everybody is seeing an effort and an interest right now in trying to prevent that patchwork, and we're going to have to wait and see how it actually develops.

Senator COLLINS. But should the States even be involved in this area, or should it be left up to the Federal Government so that there is a nationwide standard and approach?

Mr. ROSEKIND. In the policy we make that explicit, here's what the Federal Government is concerned about, standards for the vehicles, defects, et cetera, and the States, they still stay responsible and they don't have to do anything. We make that explicit.

Senator COLLINS. You do, but if California is moving forward to implement your guidance and make it mandatory, isn't that contrary to the goal of your guidance?

Mr. ROSEKIND. Two things. One is we are explicit in there saying that this policy was not intended to codify, and at the same time I think right now California has not actually put their regulations out. They've put a proposal out. They've talked about other aspects, that they want to evaluate it, and they're even questioning the language that's being used, and that's what I'm saying. I don't think we even know what their final stance is going to be, because they have continually emphasized the need for consistent framework.

Senator COLLINS. Senator Reed.

CYBERSECURITY

Senator REED. Well, thank you, Chairman, very much.

I agree with Mr. Brubaker; computers don't get tired, they don't get road rage, but they open a whole new dimension of cyber security which we have to deal with. I know, Administrator, the FAVP encourages information sharing on cyber security, but we've seen incidents in which systems have been hacked recently, vulnerabilities in automobiles, GPS systems, insurance plugins have been used.

So can you give us an idea of what you're doing in terms of ensuring that we can reassure the public that these vehicles will not be subject to cyber attacks?

Mr. ROSEKIND. Thank you for emphasizing this issue because, as you've heard from pretty much everybody, without public confidence in these vehicles, it's just not going to happen.

So specifically to cyber security, NHTSA has actually been on this for many years. In 2012 we formalized that with a group, an office within the agency. Just recently we have had a roundtable with 300 people, pulling them together. We had an intra-government meeting after that, which has resulted in everything from urging and supporting an agency, Auto ISAC, Information Sharing and Analysis Center, within the industry. The industry has come

out with their own best practices. Just a few weeks ago, NHTSA came out with its own cyber security best practices. Just yesterday the Department of Homeland Security actually highlighted our cyber security best practices, a model for other industries to go after.

So the good news is all of this has been done before an incident has actually occurred within the auto industry. One that everybody knows about, about a year ago in July Wired Magazine, that was planned. That was a researcher demonstrating it could be done. I'd point out that even with the authorities and tools we had, within 3 days the defect was called and 1.4 million vehicles basically were already under remedy at that point.

So I would just say it's a constant vulnerability. It clearly is a threat that needs to be addressed. But for the moment there's a lot of action going on in that arena.

Senator REED. Let me just quickly follow up with Ms. Hersman, and thank you. How do you think outside expertise could assist in combatting these cyber threats and regulating advanced technologies like HAVs?

Ms. HERSMAN. I think there's a tremendous opportunity to call on experts, just like this committee does. Things change very quickly, and when it comes to technology, we certainly can't expect NHTSA to always stay on the cutting edge. Potentially having advisory groups, organizations that will assist them in evaluating new cutting-edge technology is an opportunity that they should consider and take advantage of going forward. We're going to ask so much of this agency when it comes to looking at the evolution of technology that we need to support them and give them opportunities to get the best and the brightest to weigh in on it.

Senator REED. Thank you very much.

IMPACT ON LABOR

Dr. Kalra, I seem to be emphasizing the potential challenges rather than the golden opportunities, but we should do that. And one of them, as I mentioned in my statement, is employment, roughly 3 to 4 million jobs that are good jobs. You've done some work, I believe, on this. You made some comments in your discussion.

Can you just comment upon the implications of the labor market, both positive and negative, for these vehicles?

Dr. KALRA. Absolutely. So you're absolutely right that there are millions of Americans who make their living behind the wheel, and there's no question that autonomous vehicles do threaten those jobs. I think we have to stare that back in the face. The question is what to do about it.

This transition to full autonomy is going to take time, so time can be an advantage in this respect in that we are ahead of the curve. We can start thinking now about how to develop an alternative job market, where that's possible. We also know that freight may be one of the areas that is first hit because of the private nature of the industry and because we're talking about goods movement rather than people movement. So the technology may make its way there faster. One aspect of that is that many freight ex-

perts project a lack of supply of drivers in the future, so there may be a little cushion in there.

In terms of on the flip side, autonomous vehicles will create new kinds of jobs or increase the technical nature of existing jobs. An auto body shop is not going to look the same as it does today. So we need to prepare our young people especially, people in community colleges, for those high-tech jobs.

The broader issue is that autonomous vehicles could and, I believe, will democratize transportation and give mobility to people who currently don't have it. Important to that is physical mobility. Being able to get around is one of the most important things to help people out of poverty, getting them access to training, getting them to jobs. The unfortunate part is people who have the least access to transportation often are the ones who struggle to get jobs, people who are in poverty who can't afford their cars.

So there's two sides of this coin. I think we need to do everything we can to bring mobility to people who are currently underserved by our transportation system, while providing cushion to people who will be negatively affected.

Senator REED. Your comments seem to be there has to be a conscious, deliberate planning process because this is coming.

Dr. KALRA. That is right.

Senator REED. And your best guess at when we'll see, for example, significant autonomy in freight delivery? Is it 5 years? 10 years? Too far to guess?

Dr. KALRA. I can only guess. I would be surprised if we don't have it in 10 years. I would be surprised if we do have it in the next two to three.

Senator REED. Okay. Anybody else want to take a wild guess, like the lottery?

Senator REED. Okay. Thank you, Madam Chairman.

Senator COLLINS. Thank you, Senator.

Senator Daines.

DATA SECURITY

Senator DAINES. Thank you, Madam Chair and Ranking Member Reed. And thank you for testifying here today. This is a topic that covers many issues I care deeply about. As a 5th generation Montanan, we have a lot of open space, a lot of roadways. In fact, we just wrapped up the election season, and one of the candidates running for governor traveled 64,000 miles during the course of the campaign on the roads. So that kind of puts in perspective that we're not as big as Texas or Alaska or California, but we have to drive a lot more. So I care very much about what you're talking about, saving lives, to improve passenger and freight mobility, very important for us in a State that requires moving our products, ag products particularly, around the world.

I'm very excited about these new technologies. I spent 12 years in the cloud computing business, executive capacity, before I came to politics.

So I wanted to follow up on Senator Reed's question on the cyber piece here, Mr. Rosekind. You said in your testimony that the quickest way to slam the brakes on innovation is for the public to lose confidence. I think that's well said. I was a private employee

for 28 years, and the best was when I didn't have my information compromised, until I became a Federal employee. Then I got the letter from OPM. Thank you, Federal Government here. I never had that issue in the private sector.

Mr. ROSEKIND. I got that letter, too.

Senator DAINES. Many of us did. I'm sure if we polled the audience here, there would be a lot of hands going up. Clearly, we want to make sure we're protecting privacy and hardening our systems.

Many consumers no longer have confidence in the government. I appreciate the fact that you're bringing some advisory groups in to bring that perspective. Going fast, at the speed of business out there, sometimes I think government needs to.

How is NHTSA gaining the public's confidence with this latest guidance that you're looking at here as it relates to cybersecurity?

Mr. ROSEKIND. I think in the policy, one of the ways actually that we're trying to do that is through the innovation approach. I think, just like when people talk about regulation, when you talk about cyber security, if someone were to say regulate that, as you know, the speed that this stuff is changing, by the time you get through a 6- to 10-year regulation it's not going to be relevant anymore.

So, one of the 15 safety assessment items is cyber security. Everybody has to tell us how they're addressing that particular issue, and our intent here is to see as many different forms of innovation coming to us as we can, and the data will drive the safest and best way to protect these systems. In fact, at some point, if there are best practices, it should be based on that data. In the future if there's rulemaking, it should probably be based as a foundation on whatever those best practices were.

Senator DAINES. I know industry has been working collaboratively to address cyber and published some best practices in July. How did NHTSA's guidance incorporate their experiences and expertise?

Mr. ROSEKIND. We had a lot of interaction with them. We knew what was coming. In fact, I would highlight not just this policy but our own best practices came out just a few weeks ago, and they complement exactly what we know the industry was doing.

Senator DAINES. So I guess my understanding is they didn't go through a notice and comment process before being issued. Afterwards DOT solicited comments, and I think they're due next week. So my question, I guess, is why wasn't there more consultation with industry before the guidance was issued?

Mr. ROSEKIND. Well, let's keep them separated. The best practices came out a few weeks ago, and the policy came out September 20th. We actually have an extensive amount of open time. So the policy is under a 60-day comment period right now. That closes November 22nd. And what was already identified in here is 23 next steps. So we actually have a whole new set of public meetings that are coming up to talk about all the different elements. We just did that last week. We had a meeting on the letter, which includes the cyber security part. So there's all kinds of other opportunity for people to add input.

Senator DAINES. And that's helpful, and I know Senator Collins was talking with us a bit about some of this guidance, which be-

comes quasi-regulation. You touched on the time required to go through the formal rulemaking process, and the guidance allows you to be more nimble, but it may not always be as transparent. I think that's one of the political concerns we hear.

RULEMAKING PROCESS

Should voluntary guidance policies be used to expedite the rule-making process or Federal enforcement action?

Mr. ROSEKIND. I think what we're trying to do is continue our enforcement and regulatory tools. We have those authorities. We're not giving any of them up. All we've done is try and complement those with the way to support innovation at this time. It is absolutely possible, if you come in with the right data, that we will use that data to create best practices and rulemaking. We actually identify potential rulemaking in here as well. So that is just one more tool that's being included to deal with this fast-paced technology.

Senator DAINES. Thank you. I'm running out of time.

DRIVING IN RURAL AREAS

Dr. Kalra, a question. You discussed lowering the risk to pilot programs and raised questions about the ability of this technology to function better than humans in complex conditions. I come from a State that has a lot of rural roads. Fifty-four percent of automobile fatalities occur on rural roads despite the fact that just 19 percent of Americans live in rural areas.

How do you incorporate issues like we have in Montana of unmapped roads, gravel, snow, wildlife, where 95 percent of the roads are rural? As we know, accidents often happen when things we don't anticipate occur. How do we lower the risk of these technologies in rural settings?

Dr. KALRA. By testing them in those environments. And I'll point to the University of Michigan's testing center for autonomous vehicles, where they are committed to testing on different kinds of road surfaces, in different kinds of weather conditions. We need to get autonomous vehicles not only in sunny Southern California but also in Montana, and I think that has to be a priority.

Senator DAINES. The sun shines a lot in Montana, but we also have ice and big elk out there at times.

Dr. KALRA. I'm from North Dakota. I know that ice.

Senator DAINES. Oh, you do understand that.

Dr. KALRA. I do.

Senator DAINES. You might understand ice better than I understand it, I think.

Anyway, thank you. I'm out of time.

CYBERSECURITY RISKS

Senator COLLINS. Thank you for raising that very important issue, which is one that concerns me as well.

Mr. Brubaker, both of my colleagues have brought up the cyber security issue, which is also of great concern to me as we've seen we have rogue States and terrorist groups that seem to be able to hack into virtually any database. What is the industry doing to ad-

dress the cyber security risks of autonomous vehicles, and do you think that there's more that NHTSA could do to proactively address such a risk?

Mr. BRUBAKER. Yes, I do. The one thing I would caution is you want to be very careful in regulating cyber security and establishing cyber rules because you tend to lock in a solution that's relevant for that time period, but it's not timeless.

But to answer your specific question about what NHTSA can do, I would actually start by going across the river to the five-sided building and start talking to the people who have been doing embedded system cyber security for years who are really good at it. One of the key elements of the third offset strategy the Department is pursuing right now—and I know both you and the ranking member have a strong defense background, so you would get this—is really focusing in on automation and robotics, advanced robotics. So they're doing the kind of cyber security strategy and employing the kind of tactics that you need to really lock down these embedded systems, and they've been doing it pretty successfully for years.

So I think the one thing that we could do is look across the river, look to the IC, the intelligence community, for lessons learned on how they do encryption, how they do authentication. I know that the industry has issued its best practices but, frankly, when I look at it, I think it's a lot of reinventing the wheel, a lot of things that have already been done.

I would also say, again, the caution on the regulatory piece is we've had the Federal Information Security Management Act, FISMA, for a number of years, but it didn't prevent the OPM hack. So you can issue the regulations, and you can comply with those regulations, and you can go down a cyber security checklist, but unless it's substantive, and unless it's moving, because it's a constant game with the adversaries, and you need to understand their motives and what they're about and do the risk assessment accordingly and structure your systems from the ground up.

The one area that I think industry has really got to pay very close attention to is supply chain integrity, where they're securing the components, they know where those components come from, they have visibility end to end, and there are a handful of companies out there who are focused on it, automakers that are focused on it. But by and large, the industry is having a very difficult time adjusting its culture to harden its systems.

Senator COLLINS. Thank you.

DISTRACTED DRIVING

Ms. Hersman, yesterday's New York Times quoted you in the area of distracted driving, and you pointed out that new technologies that are intended to allow the driver to keep his or her hands on the wheel may actually be preventing the driver from paying attention to his or her driving environment, and the article quotes you as saying it's the cognitive workload on your brain that's the problem.

Are you concerned that automated and self-driving vehicles—well, self-driving vehicles are not a problem if we really get to that stage. But the semi-automated, if you will—you have your scale for

the degree of automation—are going to produce even more distracted drivers and thus more crashes?

Ms. HERSMAN. I would say there are always unintended consequences when we introduce new things. We do know that people are very distracted today. People are addicted to their devices that they bring into the car with them. The challenge with moving to things like hands-free is that people think that the distraction is in their hands, but the distraction is really in your brain. We would have outlawed stick-shift cars a long time ago if it was our hands that were the problem.

So when we look at automating vehicles further, what that does is potentially has the human being stepping back a little bit, and human beings typically are not good monitors. When everything works according to plan 99 times out of 100, it's hard for the human being to pay attention 100 percent of the time. In aviation we call this over-reliance on automation. We saw pilots' skills deteriorate as airplanes performed more functions for the pilot.

One of the challenges is how do you compel the human being to pay attention so that when they need to take over or when they need to intervene, they're ready and they're prepared to do so? If you could text, if you could read the newspaper, if you could do other things, 99 percent of the time it might work well. It's that one time that you need to intervene that you're not prepared to, and we haven't even touched on impaired drivers and drivers who might be sleeping, who might be fatigued or not paying attention.

So there definitely are some risks and some tradeoffs. I think a number of the panelists have touched on these. That's why we talk about the messy transition between Level 1 and Level 5 and having to keep that human in the loop, how can you compel them when they need to be engaged to do it.

Senator COLLINS. Thank you.

LESSONS FROM VOLVO DEMONSTRATION

Administrator, last month the world's first shipment by a self-driving truck was made by an auto Volvo truck. I watched the video of that. There was a professional driver on board but, in fact, the truck was driving itself 120 miles along Interstate 25, and it was operating fully autonomously without that driver's assistance. It was very exciting to watch, but I'll have to admit to you it also made me a bit nervous as I watched it.

Are there any lessons from that test that NHTSA has learned so far, and would it have any effect on where you're going with your future guidance?

Mr. ROSEKIND. Absolutely. Let me just add a little bit to that confidence. That was actually at 2:00 a.m. in the morning with a patrol car behind them, so there was a lot more protection there than just what you see in the video, which was very promotional.

Having said that, there is a lot of lessons learned, and part of the reason to have the policy out is so that people are basically handling all these safety issues before they're ever out testing or deploying these kinds of things. That's part of what we're trying to do, is be proactive instead of reactive, wait for something bad to happen and then react to it. We'd rather deal with all of these issues, not just with that truck example but what's going on in

Pittsburgh. You cited all of the exciting things that are happening, but we really need to make sure that safety is being addressed, at least for these 15 items, before these things get tested or deployed on the road.

Senator COLLINS. Senator Reed. Thank you.

IMPACT ON LABOR

Senator REED. Thank you very much, Ms. Chairman.

Mr. Brubaker, you in your testimony note also this potential labor shift and that we have to be prepared to respond to it. Could you just give us your advice or your thoughts on the type of coordination at the Federal level we have to take to anticipate this and deal with it?

Mr. BRUBAKER. Sure, absolutely. I want to commend the subcommittee for the language that they put in the report language last year asking the Secretary to devote funds to TRB (Transportation Research Board) to study the economic impacts of these self-driving technologies because, as we all know, there will be displacement, and we really need to understand it and get proactive.

So it's going to involve a number of different Federal agencies. I mean, the obvious one is the Department of Labor. They would be best poised to kind of understand where the shifts are. But I think even to the point where you're identifying the most vulnerable professions would be very, very helpful. And then even to the point where if people wanted to volunteer proactively for retraining and job placement in needed skill areas, we could coordinate that, and it's one of the areas that we lay out in our framework. It's the eighth area where we really need to be mindful of it and very sensitive.

I mean, I grew up in Youngstown, Ohio, and I saw what happens when people don't—and how they vote later—when people aren't treated with respect.

Senator REED. That's exactly right. I was in Niles a few months ago, right outside of Youngstown.

Mr. BRUBAKER. Near my hometown.

Senator REED. So I get it. We have to be very, very conscious of this.

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION GUIDANCE

Doctor, you and RAND published a guide on this technology in 2014. As you look at NHTSA's guidance, do you think they're addressing policy areas that need to be addressed at the Federal level? I have harped on employment and cyber security. Are there other issues?

Dr. KALRA. Can I ask, do you mean for NHTSA in particular, or the Federal Government in general?

Senator REED. NHTSA in particular, and then go big.

Dr. KALRA. Okay. For NHTSA, I think they need to continue the course that they're going on. Their guidance is admirable. It threads the needle well on how do you provide guidance and a framework for safety while allowing innovation to occur. But one of those items is, for example, ethics, and it asks developers to say how will the car handle ethical issues. Even if the reporting is done, it's not clear that reporting will lead to safety. So there's a

gap there because even though one can follow the guidelines, that doesn't mean autonomous vehicles will be safe, and that's because no one really knows how to prove safety in advance of getting these vehicles on the road.

So I think continuing in that direction is important.

For the Federal Government more broadly, in addition to the economic issues, I just want to reiterate that there are market distortions. I know this is wonky, this is what RAND does, but there are market distortions in our transportation system that mean that we don't take full advantage of the opportunity for cost savings.

I'll be very specific. When we have pollution, whether it's factory pollution or automotive pollution, that's a real cost to our society. It is paid in healthcare. It is paid. It's not an invisible cost; it's a real cost. The question is who pays for it? So as long as the market does not take into account the costs that we all bear for some of these activities, there isn't an incentive, a market incentive to reduce them.

So I think that is something that often gets overlooked as we talk about the safety of autonomous vehicles, which is understandable. But I would encourage us, if we want this future of sustainability and efficiency and mobility for everyone, to look at the other things in our transportation market that are preventing us already from achieving those goals.

Senator REED. Thank you.

Ms. Hersman, in terms of NHTSA's guidance, do you think it effectively addresses safety concerns from your perspective?

Ms. HERSMAN. I would say it's a good first step, and I think we can see the challenge that exists of not having anything and having a vacuum, and then the States are stepping in, there's a patchwork system. But I think we're also so in the early days here. There's so much that we don't know. If they were to put out regulations right now, they probably wouldn't be the right ones.

So I think when we look at the balance between the Wild West of doing nothing and saying nothing on this and letting everyone do whatever they want versus locking everything down with prescriptive regulations going into the future, I think they've really tried to achieve a fine balance there. I think there's more work to be done, absolutely. But I think this gives people something to react to. It gives us a framework to start from.

I do want to go back to the issue of workplace. We're a safety organization, so we track deaths and injuries. The transportation industry is one of the most dangerous when it comes to workers' health and their injuries and deaths. They're just behind the construction industry for absolute numbers of fatalities, and just behind agriculture and mining for the rates. So it's a very dangerous job. Forty percent of workplace fatalities are motor vehicle crash related.

So those folks, we want to make them safer too. So if we can have that path to figure out how to take care of them over the long run, I think this will be good for them as far as their safety.

ROLE OF GOVERNMENT

Senator REED. There are so many opportunities for safety, for improved productivity, for better health effects. But then there's

the other side of the equation of what about the drivers that have done a good job, the defined pension, et cetera, and suddenly there's an autonomous vehicles and thank you very much for your service. We have to deal with that.

And that goes to the question of there are some people that might prefer the Wild West, let the chips fall where they may and this will work itself out. But that goes to, Mr. Rosekind, the agency has to have a role here.

So can you just give us a sense of what that role is going forward as you deal with a very sophisticated industry that is conscious of these issues, the safety advocates of the cyber dimensions? Can you just give us assurance that it won't be the Wild West but it will be innovative and based on good experience?

Mr. ROSEKIND. You've just heard from pretty much everybody on the panel what a challenging arena to address. How do you make sure you don't clamp it down, all this great American entrepreneurial spirit that could save lives and make life so much better for everybody? Henry Claypool is over there. We talk about the elderly. He's representing the disabled community. Never had driver's licenses; don't need them. Autonomous vehicles can do it. We're just talking about great entrepreneurship and innovation being tremendous and not wanting the Wild, Wild West. That's why it's the right tool at the right time.

The policy is intended, we hope, to be literally as innovative for the government as it is for the technology companies. This is a first step. In fact, in there we make a commitment that in a year, with all of the different 23 next steps that are going on, on an annual basis this policy will be reviewed and updated. We can't do that with regulation in any kind of effective way.

So we're trying to strike for a very first effort that right balance, to support innovation and safety. People think they're at the opposite ends. We're trying to support that middle ground, safety and innovation, because we're talking about 32,092 lives, and we could save all of them. Autonomous vehicles should play a critical role in us getting there.

Senator REED. Thank you.

Thank you, Madam Chairman.

ENERGY AND ENVIRONMENT

Senator COLLINS. Thank you and I appreciate very much you bringing up the employment impact, which is certainly something for us all to think about as well.

I just have a couple more questions. One, Dr. Kalra, do you see any energy consumption and environmental benefits from the deployment of autonomous vehicles?

Dr. KALRA. Absolutely. There are tremendous benefits and risks. But the benefits include, for example, if we have a large number of autonomous vehicles, we can increase the throughput of vehicles on our roads, reduce congestion, because a lot of congestion is actually caused by crashes. So there's a reduction in congestion, which immediately translates into a reduction in fuel consumption.

But if we think big, one of the biggest challenges we have in getting real alternative fuels, like hydrogen, into our transportation system is the infrastructure problem, meaning the distribution

problem of how many hydrogen stations do you need. And if an autonomous vehicle, fully autonomous, can drive itself to a hydrogen station in the future, gas up at 2:00 in the morning, or maybe there are long lines but no one cares because there's no one in there, autonomous vehicles could actually make possible transportation fuels that right now are struggling to get off the ground because of these logistical issues.

So the opportunities, dare I say it, are limitless for improvement. But again, the market signals should also be in play.

Senator COLLINS. Thank you.

ETHICAL CONSIDERATIONS

I have one final question that I wanted to ask each of you, and that is as I have gotten more involved in this fascinating issue, there is a question that keeps occurring to me, and that is the ethical considerations that a human driver makes when faced with two unpalatable choices. I wonder how do you teach a fully autonomous vehicle judgment, the kind of judgment that that professional truck driver has because of his or her many years of experience.

I was thinking—and we've all been in these kinds of situations where you have to make a split-second judgment on whether you're going to swerve around a vehicle that suddenly stopped or has spun on an icy road and risk going off the road and hitting a tree, perhaps killing yourself and your passengers, or a pedestrian or a bicyclist has darted in front of you in the road, and yet if you slam on the brakes you're going to be back-ended.

I mean, driving is not a simple task. It requires complex judgments all the time. So how does a self-driving vehicle make those kinds of judgments?

We'll start with the Administrator, and I'd like to go right down the line.

Mr. ROSEKIND. I am going to use that to address two things. You've just raised a great example of all the unknowns that are out there still related to autonomous vehicles, and the questions you've just raised—and there are many, many more related to ethics—there are no answers right now. But we are taking hands off the wheel, human hands, and putting them into the hands of a coder, because that car will be programmed to make decisions, basically.

So I think that's why, for example, people have questioned us—it's part of our 15-item assessment. We put ethics in there, and people have questions. When you think about when people are really going to accept these and have confidence, and we know the ethics are going to be an issue people are going to ask about, there are no answers right now. That's why it's in there for us to really look at the innovation of what people bring to this.

But let me just add one element to that that nobody is really talking about. I've been fortunate over about the last decade to get to know Captain Gene Cernan, the Apollo 17 astronaut, the last man who walked on the moon. One of my favorite sayings at safety meetings with him is, you know, I'm never going to live long enough to make all the mistakes that could kill me, right? So why does he go to safety meetings? For just that reason.

So think about how all of us learned to drive a vehicle. Our experience is those ethical decisions we're going to make are based on

our personal experience. Now, with autonomous vehicles, if we collect all of this information and share those cases where somebody died in some unique edge or corner case, if that information were shared, no other person should ever lose their life in that same situation because that information gets shared with the entire fleet, with every vehicle that's out there. That's the future that we could look toward, including in these ethical issues. We get to make decisions at some point that we could share and make sure that everybody basically is allowed the same opportunity to be safe.

Senator COLLINS. Thank you.

Ms. Hersman.

Ms. HERSMAN. I would probably fall back on the 10 years that I spent at the NTSB and say that we've got to take care of the data. That means we've got to learn from the data. It's got to be accessible. We have to have standardized, accessible formats.

If you think about black boxes on airplanes, that's how we learn. We know what happened. When it comes to autonomous vehicles, or even something that's in-between, in order to understand those decisions or those outcomes that you talked about, who was in charge? The car, the human, or some combination of the two?

We've got to share that data. When we talk about mistakes that occurred or close calls or things that happened, if we don't have all manufacturers willing to share those lessons learned, we're going to have to have each provider learn the lesson anew every time. So we've got to look at this holistically and say there will be failures. Will there be deaths? Absolutely, as this technology rolls out. Will there be things that happen that we don't expect? I can't tell you how many investigations we went into and people said this was never supposed to happen. This scenario was 10 to the minus 9th. It was never going to occur, and it did.

So things will happen, but that data to me is incredibly important to how this rolls out and to maintain that confidence going forward. We've got to learn.

Senator COLLINS. Thank you.

Mr. Brubaker.

Mr. BRUBAKER. Yes. So these ethical issues when they get raised cause me to lose the rest of my hair here. Part of the issue is we're all thinking about this in a human context. We're all sort of applying that judgment that we have to make, and what we're not cognizant of or what we're really not thinking through is that the level of situational awareness that these vehicles are going to have far exceeds that of a human. You're talking about redundant sensors. You're talking about the ability to see far beyond what a human eye can see and have this 360-degree, 24/7 situational awareness.

The data is important. I agree with the two prior speakers. But the thing that we have to remember is that this is all about artificial intelligence. This is about instantly assessing the situation, constantly assessing it, calculating probabilities and reducing the risk of being in an emergent situation where you've got to make two really unpalatable choices.

So my whole view on this, and this is from having lots and lots of conversations with people in the AI world and people who are looking at this and building the sensor suites and mashing up this technology, that those ethical considerations are—I don't want to

call them a red herring, but in many cases the whole notion is to create the kind of technology that will avoid those emerging situations in the first place.

Senator COLLINS. Thank you.

Dr. Kalra.

Dr. KALRA. I agree with the other speakers in almost every regard. I do want to say that when we raise these vivid examples of swerve or do this, people don't actually make ethical judgments when they decide what to do. They make snap judgments. They don't have time. They barely react. It's just a knee-jerk thing that you do without thinking about the consequences. The ethical things that we do when we drive, or the unethical things, are driving when we're intoxicated, or texting while we drive, and autonomous vehicles won't make those kinds of ethical mistakes.

But the ethical judgments that autonomous vehicles will have to make I don't believe are the pedestrian versus the driver but really about how the autonomous vehicle distributes risk on the road at every moment of driving. The example I'll give is when I'm driving and there's a bicyclist next to me, I'll drive in the middle of the lane because I want to distribute the risk differently between the bicycle, myself, and the other people who might be on the road. Autonomous vehicles will have to make those judgments, and I think attention needs to be placed on how do autonomous vehicles ethically distribute regular risk on the road rather than in the sort of imminent crash cases, and there's no answers to this because even ethicists don't have the thing that's the right thing to do. But I would urge us to put our attention on those everyday kinds of ethical problems.

Senator COLLINS. Thank you very much.

Senator Reed, do you have anything else?

Senator REED. No.

Senator COLLINS. I want to thank you all for testifying today. This was a superb panel.

This technology is so fascinating and moving so quickly, and the fact that it could substantially reduce or perhaps one day even eliminate the 94 percent of crashes that are attributable to human error is truly an astonishing fact, and that's one fact that prompted me to call this hearing.

I appreciate your advancing our understanding of the issues, the technology, and the policy considerations that we will have to face.

SUBCOMMITTEE RECESS

The hearing record will remain open until next Wednesday, November 23rd, 2016. There may be additional questions submitted by us or by our colleagues for the record. We very much appreciate your cooperation, and we look forward to continue to working with you.

This hearing is now adjourned.

[Whereupon, at 3:53 p.m., Wednesday, November 16, the subcommittee was recessed, to reconvene subject to the call of the Chair.]

MATERIAL SUBMITTED SUBSEQUENT TO THE HEARING

[CLERK'S NOTE.—The following outside witness testimonies were received subsequent to the hearing for inclusion in the record.]

PREPARED STATEMENT OF JOHN BOZZELLA, PRESIDENT AND CEO, ASSOCIATION OF GLOBAL AUTOMAKERS

On behalf of the Association of Global Automakers (“Global Automakers”), I am pleased to provide the following statement for the record of the Senate Committee on Appropriations Subcommittee on Transportation, Housing and Urban Development, and Related Agencies hearing entitled “The Automated & Self-Driving Vehicle Revolution: What Is the Role of Government?” Global Automakers represents international automobile manufacturers that design, build, and sell cars and light trucks in the United States. These companies have invested \$52 billion in U.S.-based facilities, directly employ more than 100,000 Americans, and sell 47 percent of all new vehicles purchased annually in the country. Combined, our members operate more than 300 production, design, R&D, sales, finance and other facilities across the United States.

The automotive industry is in the midst of an unprecedented wave of technological innovation that is redefining how we think about transportation. Advancements in connected and automated vehicle technology promise to enhance mobility, help save lives, improve transportation efficiency, and reduce fuel consumption and associated emissions. Over the past several decades, our members have made tremendous strides in safety by improving vehicle crashworthiness; today, automakers are deploying crash avoidance technologies to help prevent crashes from occurring altogether. Our members are at the forefront of this innovation, as they have made, and continue to make, substantial investments in the research and development of automated vehicle systems and other advanced automotive technologies.

With the introduction of advanced sensors such as cameras and radar, a number of vehicles on the road today already provide automated functionality through advanced crash-avoidance and convenience features like automatic emergency braking, lane keeping assist, and adaptive cruise control. These systems, which are foundational to the development of more highly automated systems, are designed to provide support to the driver only in certain situations. As these systems become more advanced, a vehicle’s capability to operate without active control by the driver will increase.

The next breakthrough in vehicle safety, and a critical technology for realizing the benefits of automated driving, is Dedicated Short Range Communications (DSRC) connected car technology. This technology supports vehicle to vehicle communications (V2V) allowing cars to have greater 360-degree situational awareness. Through DSRC, vehicles can speak to each other and to surrounding infrastructure at the rate of ten times per second to avoid crashes and improve mobility. This technology is on the road today; pilot projects and deployments around the country are using DSRC supported applications to demonstrate the value of connected mobility to the traveling public. Soon, and increasingly into the future, we will share our roads with automated vehicles; V2V has the ability to connect all vehicles, regardless of mode or level of automation.

While we are indeed at the cusp of a transportation revolution through connected automation, these transformations are not inevitable nor accidental. Public policy can either spur investment and innovation, or hinder them, depending on which policy choices are made. Effective public policy on connected and automated vehicles should have two components. First, it should be flexible and provide room for innovators to develop, test and sell new technologies. Overly prescriptive and rigid regulation would slow and limit innovation. Second, manufacturers should be able to build vehicles and systems that can be sold in all fifty States. A patchwork of inconsistent laws and regulation would be unworkable.

The National Highway Traffic Safety Administration (NHTSA) Federal Automated Vehicle Policy, released in September 2016, provides a policy framework that is more flexible and nimble than the formal rulemaking process, and recognizes that technology can advance more rapidly than regulation. Last month, NHTSA issued its Cybersecurity Best Practices for Modern Vehicles to complement the important efforts already underway within the Automotive Information Sharing and Analysis Center (Auto-ISAC) to develop industry-led best practices to enhance vehicle cybersecurity as systems become more electronic and connected. Issues of consumer

privacy have also been addressed through the automakers' consumer privacy protection principles. These actions, by Federal regulators and industry, help spur the development of live-saving technologies and ensure that the public has confidence in them.

The NHTSA's Federal Automated Vehicle Policy is intended to address a number of key policy questions and is a positive first step to demonstrate Federal leadership. The Policy is divided into four main sections. First, the Vehicle Performance Guidance for Automated Vehicles outlines recommended practices for the safe pre-deployment design, development and testing of highly automated vehicle systems prior to the sale or operation on public roads. The Guidance was designed to be flexible and dynamic; it is intended by NHTSA to highlight important areas that manufacturers should consider and address as they design and test their systems. The Guidance provides for a "Safety Assessment Letter," a voluntary tool by which developers would communicate to the agency how it addresses fifteen key safety areas in designing their vehicles and systems. NHTSA is in the midst of developing a template for the Letter, and we believe NHTSA should establish a clearly defined and practicable approach that does not create an undue administrative burden that could slow innovation. It is also our expectation that NHTSA will not use the Guidance and the Safety Assessment Letter as a mechanism for "premarket approval" (or "premarket disapproval") of automated vehicle technology, as this would extend beyond the agency's current authority.

Second, the agency has developed a Model State Policy which seeks to provide guidance to the States in order to help support a more uniform nationwide approach to automated vehicle policy. While the Policy cannot in itself preempt State action, it does set a clear marker in defining the roles of State government in addressing issues related to vehicle automation. We support the strong statements in the Policy that affirm that "[t]he shared objective is to ensure the establishment of a consistent national framework rather than a patchwork of incompatible laws," and that "[the] Guidance is not intended for States to codify as legal requirements for the development, design, manufacture, testing, and operation of automated vehicles."

However, despite the guidance in the Model State Policy, several States are in the process of establishing their own regulatory programs for automated vehicles. In some instances, State departments of motor vehicles would assume the responsibility of determining whether a particular automated vehicle or system is safe and thus may be sold or operated in the State. Such State-by-State regulations would present a significant obstacle to the future testing and deployment of automated vehicles. While the Model State Policy clearly delineates the Federal roles and States' roles, it does not clearly limit or prevent State regulation of automated vehicle design and performance.

Additionally, we have some concerns with certain recommendations in the Model State Policy that encourage States to regulate automated vehicle test programs. Already, we have seen State proposals to require manufacturers to obtain an ordinance authorizing testing from each local jurisdiction in which testing will be conducted. However, Federal law authorizes original manufacturers to conduct on-road test programs and authorizes NHTSA to regulate test programs. Allowing a patchwork of State and local test requirements for automated vehicle testing would significantly obstruct the development of these vehicles. We are open to working with NHTSA and Congress to ensure there is a path forward for automated vehicle deployment without unnecessary obstacles at the State level.

Third, the Federal Policy provides a useful description of the agency's current regulatory tools, which includes issuance of safety standards, interpretations of the meaning and application of standards, and exemptions from standards, as well as the agency's ability to take enforcement action regarding safety related defects. Each of these tools could have a valuable application in facilitating and regulating the entry of automated vehicles into U.S. commerce. At the same time, we must consider the long-term efficacy of these tools in determining whether other regulatory and non-regulatory policies may be appropriate and necessary in the future. It is important that any action be data driven and technology neutral.

Finally, the agency discusses the potential new tools and authorities that may be necessary in addressing the challenges and opportunities involved in facilitating the deployment of automated vehicles. We agree with NHTSA's assessment that new authorities could assist the agency in facilitating the development and introduction of automated technology. However, imprudent legislation in this area could have the opposite effect and delay technology development. For example, we see no basis at all for any change to the self-certification system for vehicles. The Federal Policy's discussion of the Federal Aviation Administration (FAA) process of "premarket approval" is not practical given the structural differences between the automotive industry and aviation sector, and implementation of such an approach could signifi-

cantly slow innovation. Similarly, the Safety Assessment Letter should not be used as a means to prohibit testing or deployment of technology without adequate data to support an unreasonable safety risk.

We believe that NHTSA's Federal Automated Vehicle Policy is an important first step in the development of a flexible and nimble approach that can adapt to the pace of technology. However, the document requires further clarification and refinement to achieve these goals. Global Automakers is currently preparing comments on the NHTSA guidance and will provide a copy to the Committee upon submission to NHTSA. Additionally, we agree with NHTSA that the agency should update its Federal Automated Vehicle Policy and regularly review the Policy, as it is designed to never be frozen or final. Global Automakers and its members remain committed to working with Federal, State, and local governments to ensure there is a flexible, consistent framework for automated vehicle technologies so consumers can fully realize the benefits as quickly as possible.

In addition, the Federal Government must move expeditiously to establish a framework for the deployment V2V communications through DSRC connectivity. NHTSA is developing a new vehicle safety standard that would require vehicles to be equipped with DSRC technology. Global Automakers looks forward to the release of the proposed rule, and will continue to work with the Federal Communications Commission to ensure that the 5.9 GHz Safety Spectrum remains free from harmful interference to support DSRC technology.

The automobile industry continues to provide innovative technologies with demonstrable safety, mobility, and environmental benefits. To achieve these benefits, there must be close collaboration and coordination among and between government, industry, academia, and other stakeholders. Global Automakers and our member companies believe that connected and automated vehicles represent the next giant leap towards our shared long-term goal of safer and cleaner, and more efficient vehicle transportation.

PREPARED STATEMENT OF PROPERTY CASUALTY INSURERS ASSOCIATION OF AMERICA

There are public perceptions that auto accidents and insurance costs are decreasing. In fact, our roads are becoming increasingly dangerous and auto repair and medical costs are increasing. According to the National Highway Transportation Safety Administration (NHTSA), 17,775 people died on our Nation's roads in the first half of 2016. Traffic deaths are increasing at the fastest rate in 50 years, with a 10.4 percent increase in the first 6 months of this year. Even adjusted for the increase in vehicle miles traveled (VMT), the fatality rate increased 6.6 percent to 1.12 per 100 million VMT. Non-fatal injuries are on the rise as well, increasing 28 percent since 2009, according to the National Safety Council. Someday, self-driving cars may reduce the number of accidents and deaths. However, the potential of automated vehicle technology stands in sharp contrast to what is happening on our roads today.

The Property Casualty Insurers Association of America (PCI) is composed of nearly 1,000 member companies, representing the broadest cross section of insurers of any national trade association. PCI members write \$202 billion in annual premium, 35 percent of the Nation's property casualty insurance. That figure includes over \$97 billion, or 42 percent, of the auto insurance premium written in the United States. PCI's analysis has found that since 2013, auto claims frequency has increased nearly 5 percent, increasing the overall cost of claims by more than 18 percent. PCI has analyzed the recent increase in auto insurance claim frequency and found strong correlations with traffic congestion and distracted driving, weaker correlations from increasing populations of novice and older drivers, and some correlation with liberalized marijuana laws.

While it is important to prepare for the automated vehicle of the future, we urge policymakers to continue to focus on the auto safety challenges that face us today, such as distracted and impaired driving. H.R. 22, the FAST Act, provides for increased public awareness, improved enforcement, and establishing an enforceable impairment standard for drivers under the influence of marijuana. These provisions are critical to reducing accidents, injuries and deaths on our Nation's roads. The importance of addressing these issues was also the subject of a bipartisan letter from 23 members of Congress to Transportation Secretary Foxx urging prompt implementation of these FAST Act provisions.

[The bipartisan letter is attached.]

NHTSA recently unveiled its "Federal Automated Vehicle Policy," which is intended to provide guidance for States on the testing and deployment of highly automated vehicles (HAVs). While mentions of insurance are few, the new policy raises

issues that are important to the automobile insurance market as it seeks to adapt and develop new products to meet consumer needs.

RECOGNITION OF STATE REGULATION OF INSURANCE AND LIABILITY ISSUES

NHTSA's policy identifies the following as Federal responsibilities: setting and enforcing safety standards for motor vehicles, recalls, promoting public awareness and providing guidance for the States. NHTSA's policy also recognizes that it is the State's role to license drivers and vehicles, enforce traffic laws, regulate motor vehicle insurance, and legislate regarding tort and criminal liability issues pertaining to automated vehicles. PCI shares the view that the States should continue to have primacy on motor vehicle insurance and liability issues as they do today, and we support NHTSA's recognition of that role.

NHTSA's policy also repeats the recommendation from its 2013 guidance that entities testing automated technology should provide proof of financial responsibility coverage of at least \$5 million. PCI has not taken a position on this coverage requirement. However, as HAVs are deployed for public use, States will need to consider what, if any, changes need to be made to existing State motor vehicle financial responsibility laws.

DATA COLLECTION AND ACCESS

As policymakers consider what data should be collected and retained by automated vehicles, it is essential that insurers have reasonable access to the data for providing customer service for claims handling and underwriting purposes. In many auto accidents, apportionment of liability is likely to hinge upon whether or not a human driver or the vehicle itself was in control and what actions either the driver or the vehicle took or did not take immediately prior to the loss event. Access to data for insurers will speed claims handling and potentially avoid disputes that could delay compensation to accident victims. Access to historical anonymized data on the different automated vehicle systems will also be important to help insurers innovate and develop new insurance products as the nature of the risk changes.

CONCLUSION

Automated driving technology holds great promise for the future. Implementing clear policies on the Federal and State roles in regulating automated vehicle technology and ensuring that insurers have access to vehicle data on reasonable terms to efficiently handle claims, develop products and underwrite are essential to that future. However, policymakers must not lose sight of the auto safety issues that face us today. We look forward to working with policymakers at the Federal and State level to reduce accidents on our roads today and in the future.

ATTACHMENT

Congress of the United States
Washington, DC 20515

May 18, 2016

The Honorable Anthony Foxx
Secretary
U.S. Department of Transportation
1200 New Jersey Ave, SE
Washington, DC 20590

Dear Secretary Foxx,

Auto accidents and road fatalities are on the rise in the United States. In January, the National Highway Traffic Safety Administration (NHTSA) reported that in the first nine months of 2015, fatalities increased by more than 9 percent over the same period in 2014. Statistics from the National Safety Council (NSC) paint an even bleaker picture. The 38,000 people who died on U.S. roads in 2015 represent the largest increase in highway fatalities in the last 50 years. And early last year, before the increase in fatalities, NHTSA's estimate of auto accident costs totaled \$836 billion per year.

According to the NSC, there are a number of potential causes for this increase in accidents, including distracted driving on increasingly congested roads and a rise in drug impaired driving. These trends point to the need for the Department of Transportation (DOT) to promote awareness and provide leadership and guidance to the states on these auto safety issues.

Congress has already taken the first step with the passage of H.R. 22, The FAST Act, which contains important initiatives to address these issues. With your leadership and guidance, we can do more to help keep motorists and pedestrians safe. DOT can increase public awareness of these issues by implementing the "High Visibility Enforcement Program", intended to reduce alcohol and drug impaired driving and to increase seat belt usage. In addition, the Department's management of "National Priority Safety Program" will be critical in helping to reduce highway deaths and injuries by allocating funds among states that reduce impaired driving, distracted driving and deaths and injuries among unrestrained vehicle occupants.

The FAST Act also directs DOT to study the feasibility of establishing an impairment standard for drivers under the influence of marijuana, and develop recommendations on how to implement such a standard.

Recent trends indicate the need for urgent action on these and other auto safety initiatives. On behalf of our constituents, we urge DOT to promptly implement the "High Visibility Enforcement Program" and "National Priority Safety Programs" and expedite the completion of the marijuana impairment study to provide critical guidance to combat marijuana impaired driving.

Sincerely,



Rodney Davis
Member of Congress



Daniel Lipinski
Member of Congress



Patrick Tiberi
Member of Congress



Brad Sherman
Member of Congress



Steve Stivers
Member of Congress



Joyce Beatty
Member of Congress



Mimi Walters
Member of Congress



Julia Brownley
Member of Congress



Ryan Zinke
Member of Congress



Judy Chu
Member of Congress



Mike Bishop
Member of Congress



Denny Heck
Member of Congress



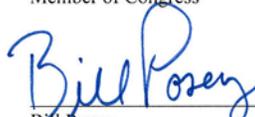
Peter King
Member of Congress



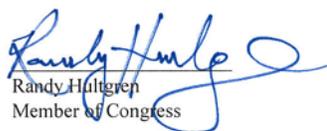
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Member of Congress



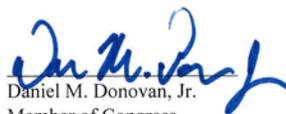
Robert J. Dold
Member of Congress



Bill Posey
Member of Congress



Randy Hultgren
Member of Congress



Daniel M. Donovan, Jr.
Member of Congress



Frank Guinta
Member of Congress



Steve Israel
Member of Congress



Tom Emmer
Member of Congress



Barry Loudermilk
Member of Congress



Tom MacArthur
Member of Congress