HOW AUTONOMOUS VEHICLES WILL SHAPE THE FUTURE OF SURFACE TRANSPORTATION

(113–42)

HEARING

BEFORE THE

SUBCOMMITTEE ON
HIGHWAYS AND TRANSIT

OF THE

COMMITTEE ON
TRANSPORTATION AND
INFRASTRUCTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

FIRST SESSION

NOVEMBER 19, 2013

Printed for the use of the
Committee on Transportation and Infrastructure

Available online at: http://www.gpo.gov/fdsys/browse/
committee.action?chamber=house&committee=transportation

U.S. GOVERNMENT PRINTING OFFICE

85–609 PDF WASHINGTON : 2014

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE

BILL SHUSTER, Pennsylvania, *Chairman*

DON YOUNG, Alaska
THOMAS E. PETRI, Wisconsin
HOWARD COBLE, North Carolina
JOHN J. DUNCAN, JR., Tennessee, *Vice Chair*
JOHN L. MICA, Florida
FRANK A. LOBIONDO, New Jersey
GARY G. MILLER, California
SAM GRAVES, Missouri
SHELLEY MOORE CAPITO, West Virginia
CANDICE S. MILLER, Michigan
DUNCAN HUNTER, California
ERIC A. "RICK" CRAWFORD, Arkansas
LOU BARLETTA, Pennsylvania
BLAKE FARENTHOLD, Texas
LARRY BUCSHON, Indiana
BOB GIBBS, Ohio
PATRICK MEEHAN, Pennsylvania
RICHARD L. HANNA, New York
DANIEL WEBSTER, Florida
STEVE SOUTHERLAND, II, Florida
JEFF DENHAM, California
REID J. RIBBLE, Wisconsin
THOMAS MASSIE, Kentucky
STEVE DAINES, Montana
TOM RICE, South Carolina
MARKWAYNE MULLIN, Oklahoma
ROGER WILLIAMS, Texas
TREY RADEL, Florida
MARK MEADOWS, North Carolina
SCOTT PERRY, Pennsylvania
RODNEY DAVIS, Illinois
MARK SANFORD, South Carolina

NICK J. RAHALL, II, West Virginia
PETER A. DEFAZIO, Oregon
ELEANOR HOLMES NORTON, District of Columbia
JERROLD NADLER, New York
CORRINE BROWN, Florida
EDDIE BERNICE JOHNSON, Texas
ELIJAH E. CUMMINGS, Maryland
RICK LARSEN, Washington
MICHAEL E. CAPUANO, Massachusetts
TIMOTHY H. BISHOP, New York
MICHAEL H. MICHAUD, Maine
GRACE F. NAPOLITANO, California
DANIEL LIPINSKI, Illinois
TIMOTHY J. WALZ, Minnesota
STEVE COHEN, Tennessee
ALBIO SIRES, New Jersey
DONNA F. EDWARDS, Maryland
JOHN GARAMENDI, California
ANDRÉ CARSON, Indiana
JANICE HAHN, California
RICHARD M. NOLAN, Minnesota
ANN KIRKPATRICK, Arizona
DINA TITUS, Nevada
SEAN PATRICK MALONEY, New York
ELIZABETH H. ESTY, Connecticut
LOIS FRANKEL, Florida
CHERI BUSTOS, Illinois

SUBCOMMITTEE ON HIGHWAYS AND TRANSIT

THOMAS E. PETRI, Wisconsin, *Chairman*

DON YOUNG, Alaska
HOWARD COBLE, North Carolina
JOHN J. DUNCAN, JR., Tennessee
JOHN L. MICA, Florida
FRANK A. LOBIONDO, New Jersey
GARY G. MILLER, California
SAM GRAVES, Missouri
SHELLEY MOORE CAPITO, West Virginia
DUNCAN HUNTER, California
ERIC A. "RICK" CRAWFORD, Arkansas
LOU BARLETTA, Pennsylvania
BLAKE FARENTHOLD, Texas
LARRY BUCSHON, Indiana
BOB GIBBS, Ohio
RICHARD L. HANNA, New York
STEVE SOUTHERLAND, II, Florida
REID J. RIBBLE, Wisconsin, *Vice Chair*
STEVE DAINES, Montana
TOM RICE, South Carolina
MARKWAYNE MULLIN, Oklahoma
ROGER WILLIAMS, Texas
SCOTT PERRY, Pennsylvania
RODNEY DAVIS, Illinois
BILL SHUSTER, Pennsylvania *(Ex Officio)*

ELEANOR HOLMES NORTON, District of Columbia
PETER A. DEFAZIO, Oregon
JERROLD NADLER, New York
EDDIE BERNICE JOHNSON, Texas
MICHAEL E. CAPUANO, Massachusetts
MICHAEL H. MICHAUD, Maine
GRACE F. NAPOLITANO, California
TIMOTHY J. WALZ, Minnesota
STEVE COHEN, Tennessee
ALBIO SIRES, New Jersey
DONNA F. EDWARDS, Maryland
JANICE HAHN, California
RICHARD M. NOLAN, Minnesota
ANN KIRKPATRICK, Arizona
DINA TITUS, Nevada
SEAN PATRICK MALONEY, New York
ELIZABETH H. ESTY, Connecticut
LOIS FRANKEL, Florida
CHERI BUSTOS, Illinois
NICK J. RAHALL, II, West Virginia *(Ex Officio)*

CONTENTS

Committee on Transportation and Infrastructure
U.S. House of Representatives

Bill Shuster
Chairman

Washington, DC 20515

Nick J. Rahall, II
Ranking Member

Christopher P. Bertram, Staff Director

James H. Zoia, Democrat Staff Director

November 19, 2013

SUMMARY OF SUBJECT MATTER

TO:	Members, Subcommittee on Highways and Transit
FROM:	Staff, Subcommittee on Highways and Transit
RE:	Subcommittee Hearing on "How Autonomous Vehicles Will Shape the Future of Surface Transportation"

PURPOSE

The Subcommittee on Highways and Transit will meet on Tuesday, November 19, 2013, at 10:00 a.m. in 2167 Rayburn House Office Building to receive testimony related to autonomous vehicles and the surface transportation system. At this hearing, the Subcommittee will hear from the National Highway Traffic Safety Administration (NHTSA), General Motors, Nissan North America, Inc., Carnegie Mellon University, the American Association of State Highway Transportation Officials (AASHTO), and the Eno Center on Transportation on how autonomous vehicles will shape the future of transportation.

BACKGROUND

From the time Henry Ford rolled the Model T off the assembly line, the automobile has continued to profoundly impact Americans. After the automobile became commercially viable, millions of citizens purchased automobiles for daily use, in turn altering American's living patterns, leisure activities and mobility. As Americans drove more, the societal need for better transportation infrastructure was undeniable. On June 29, 1956, President Dwight D. Eisenhower signed into law the *Federal-Aid Highway Act of 1956,* which established the Interstate Highway System comprised of 46,876 highway miles, 55,500 bridges, 104 tunnels and 14,750 interchanges.[1] The Interstate Highway System gave American's unprecedented access to businesses, goods and services, and jobs and has remained largely unchanged for the past 50 years. Advances in computer technology, however, are beginning to revolutionize the automobile and the way Americans travel.

[1] The Eisenhower Interstate Highway System. *Federal Highway Administration.* http://www.fhwa.dot.gov/interstate/faq.htm. Accessed: October 7, 2013.

Function-specific automation, such as automatic breaking systems and automatic parallel parking, is already available in vehicles rolling off the assembly line today. More advanced automation combines these functions with integration of braking, throttle, and steering control and will begin to reduce the need for driver control of the vehicle. The lesser the degree to which a human driver is required to control the vehicle, or is expected to resume control after a period of time, the more autonomous the vehicle.

Fully autonomous vehicles are at the end of the automation spectrum. These vehicles are capable of navigating the road without human input by sensing their environment through electronic sensors and computer software algorithms. Their electronic sensors are usually comprised of radar, lidar, global positioning systems and optical cameras that feed sensory data from the environment into an on-board computer processor; the computer is then able to control and maneuver the vehicle based on the sensory data. Although research and development on autonomous vehicles has been decades ongoing, recent advances in computer and in-vehicle driver assist technologies have brought commercial availability of autonomous vehicles closer to reality.

On August 7, 2012, the internet conglomerate Google announced it had logged over 300,000 accident-free miles with a dozen autonomous vehicles, a milestone in the development and deployment of autonomous vehicles on the Nation's highway system.[2] Google has not announced plans to sell autonomous vehicles to consumers but automobile manufacturers are working on their own autonomous vehicles. On August 27, 2013, Nissan Motor Company announced plans to deliver the first commercially-viable autonomous vehicle system by 2020.[3] Other automobile manufacturers that claim to have a working autonomous vehicle prototype include General Motors, Mercedes-Benz, Ford, Toyota, and Audi. These companies envision offering consumers greater productivity while driving and, more importantly, a safer driving experience.

By current estimates, the potential safety benefits from autonomous vehicles cannot be ignored. NHTSA estimates that 34,080 fatalities occurred in the United States as a result of vehicle crashes in 2012, with human error as a primary cause of vehicle crashes. One study estimates human error is the probable cause for 93 percent of vehicle crashes.[4] If the factor of human error could be reduced through the adoption of autonomous vehicles, vehicle crashes and fatalities could be significantly reduced in the future. NHTSA estimates economic costs from vehicle crashes in the United State at $230 billion per year, based on year 2000 data. These safety benefits can only be realized, however, if federal, state and local policies are in place to ensure autonomous vehicle integration with the existing vehicle fleet and infrastructure.

In 2011, Nevada passed a law to authorize the state's department of transportation to develop rules and regulations governing the use of driverless cars on its roads, making it the first

[2] R. Rosen. "Google's Self-Driving Cars: 300,000 Miles Logged, Not a Single Accident Under Computer Control," *The Atlantic*, August 9, 2012, Retrieved from: http://www.theatlantic.com/technology/archive/2012/08/googles-self-driving-cars-300-000-miles-logged-not-a-single-accident-under-computer-control/260926/.

[3] A. Ohnsman. "Nissan Sets Goal of Introducing First Self-Driving Cars by 2020," *Bloomberg*, August 27, 2013, Retrieved from: http://www.bloomberg.com/news/2013-08-27/nissan-sets-goal-of-bringing-first-self-driving-cars-by-2020.html.

[4] National Highway Traffic Safety Administration (2008). National Motor Vehicle Crash Causation Survey. U.S. Department of Transportation, Report DOT HS 811 059.

state to adopt an autonomous vehicle law. The law charges the Nevada Department of Transportation with setting safety and performance standards and requires designated areas where driverless cars may be tested. Florida and California soon followed Nevada's lead by enacting autonomous vehicle laws of their own. Legislatures in several other states are considering similar legislation.

On May 30, 2013, NHTSA announced its preliminary statement of policy concerning autonomous vehicles. The new policy includes plans for research on related safety issues and recommendations for states related to the testing, licensing, and regulation of autonomous vehicles. NHTSA plans to continue autonomous vehicle research activities regarding human factors, electronic control system safety, and system performance requirements. NHTSA will also offer its expertise to states seeking autonomous vehicle legislation in regards to licensing, driver training, and conditions for operation. NHTSA and the Research and Innovative Technology Administration are also researching connected vehicle technology which allows vehicles to communicate, via wireless radio signals, driving information such as speed, lane departure, and environment information to other vehicles on the highway. Connected vehicle technology would complement autonomous vehicle systems to create greater situational awareness for equipped vehicles.

The potential introduction of autonomous vehicles into the market on a larger scale raises many policy questions and challenges. Without proper planning for the integration of autonomous vehicles into existing infrastructure and vehicle fleet, operating constraints may restrict the efficiency and safety benefits of these vehicles. Design of the driver-vehicle interface, which will need to balance the automated benefits to a driver while ensuring a driver remains alert if suddenly required to take control of the vehicle, is key to reaping the potential safety benefits of this technology. The interaction between vehicle and driver will require some oversight, as this will result in ultimate responsibility for the safe operation of the vehicle. What, or whom, is responsible for the safe operation of the vehicle, will impact liability in the event of a crash. With connected vehicle technology, there must also be enough market penetration for the technology to be utilized effectively. In other words, a connected vehicle is only useful if there are other connected vehicles and the appropriate infrastructure with which it can communicate.

Autonomous vehicles present a unique opportunity to improve highway safety, decrease congestion, lower emissions, expand mobility, and create new economic opportunities for jobs and investment. Automobile manufacturers have undertaken significant research and development activities, with the goal of one day offering an autonomous vehicle to the average consumer. Federal, state and local governments have begun laying the groundwork for a future where autonomous vehicles may integrate with the existing vehicle fleet and infrastructure. With careful research and planning, autonomous vehicles could one day revolutionize American mobility.

WITNESS LIST

The Honorable David Strickland
Administrator
National Highway Traffic Safety Administration

Mr. Kirk Steudle
Director
Michigan Department of Transportation
On behalf of the AASHTO

Mr. Mike Robinson
Vice President of Sustainability and Global Regulatory Affairs
General Motors

Mr. Andrew Christensen
Senior Manager of Technology Planning
Nissan Technical Center North America

Dr. Raj Rajkumar
Carnegie Mellon University

Dr. Joshua Schank
President and CEO
Eno Center for Transportation

HOW AUTONOMOUS VEHICLES WILL SHAPE THE FUTURE OF SURFACE TRANSPORTATION

TUESDAY, NOVEMBER 19, 2013

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON HIGHWAYS AND TRANSIT,
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE,
Washington, DC.

The subcommittee met, pursuant to notice, at 10 a.m., in Room 2167 Rayburn House Office Building, Hon. Thomas E. Petri (Chairman of the subcommittee) presiding.

Mr. PETRI. The subcommittee will come to order.

Today's hearing will focus on how autonomous vehicles will shape the future of surface transportation. These vehicles have the potential to offer incredible safety and mobility benefits to drivers and fundamentally transform transportation infrastructure as we know it.

It is important to understand exactly what autonomous vehicles are. Some vehicles currently available to consumers have computer technology that performs some driving functions, such as automatic parallel parking and adaptive cruise control. These features are considered a basic level of autonomy, but the purpose of today's hearing is to discuss the impacts of more advanced levels of autonomy that could be available to the public in the next 10 to 20 years.

More advanced autonomous vehicles are capable of alerting drivers to danger and controlling of vehicles' brakes and steering during certain situations where the driver reacts too slowly. These vehicles will blend human control with autonomous systems to make for a more convenient and a safer driving experience.

The most advanced level of autonomous vehicle is capable of navigating roads with limited or no action from the driver by utilizing a variety of optical sensors, radar, and computer algorithms. The sensors deliver environmental data of the road and surrounding vehicles into the computer algorithm which then determines the appropriate driving maneuver.

These vehicles do not suffer from intoxicated or fatigued driving, and are able to react to dangerous driving situations faster than can a human being. Many auto manufacturers have developed prototypes that one day could be offered to consumers.

Carnegie Mellon University has developed and tested one such vehicle at the University Transportation Center, and we will hear from the director of their program today.

Autonomous vehicles could significantly reduce traffic fatalities and crashes by reducing or eliminating driver error, which is a contributing factor to over 90 percent of all crashes. These crashes cost the United States economy over $200 billion per year in medical, property and productivity losses.

Crash reductions would also have the added benefit of reducing congestion since a high percentage of congestion is due to vehicle crashes. While safety is the most important benefit, autonomous vehicles could reduce congestion and improve fuel economy through better utilization of existing highway capacity and more efficient operation of the vehicle's acceleration and braking control.

Seniors and persons with disabilities could be afforded greater mobility options that are not available to them today. Some researchers think autonomous vehicles could be offered to consumers on a service-based contract, which would provide a vehicle whenever the consumer requests one, but these benefits can only be realized if Federal and State authorities carefully prepare for their arrival and adopt policies that help autonomous vehicles assimilate into the transportation network.

States have just started to address some of these challenges through laws allowing autonomous vehicles to operate on public roads and their licensing procedures. The U.S. Department of Transportation is conducting a pilot program on connected vehicle technology which could one day play a role in the autonomous vehicle system by communicating safety information to other vehicles on the road.

Liability and cybersecurity concerns are significant barriers to autonomous vehicle adoption. Who is at fault in a crash between a vehicle operated by a human and one operated by a computer system?

Are proper encryption technologies in place that protects autonomous vehicles from unwanted intrusion?

All of these concerns must be addressed before benefits from autonomous vehicles can be realized. Vehicles and infrastructure that they utilize are becoming increasingly integrated with computer technology, which has the potential to revolutionize highway safety and mobility in our country. In order to see these benefits come to fruition, Federal and State officials should begin planning for the benefits and the challenges that autonomous vehicles will bring to the future of our Nation's surface transportation system.

So I hope today's hearing will provide our committee members with insight into this important issue, and before I conclude my remarks I would like to commend Staff Director Jim Tymon for his 11 years of service and dedication to our committee. Jim is leaving the committee to join the American Association of State Highway and Transportation Officials as their director of management and program finance, and he has been a key staffer on the last two surface transportation authorizations and sacrificed countless hours away from his beautiful family to improve our Nation's transportation system.

So on behalf of the committee, I wish you the best luck in your future endeavors, and thank you for your service over the many years to this committee.

[Applause.]

Mr. PETRI. I look forward to hearing our witnesses, but before that I turn to my ranking member, Eleanor Holmes Norton, for any opening statement she might wish to make.

Ms. NORTON. Well, thank you, Mr. Chairman, and I certainly want to thank you for calling this hearing on autonomous vehicles. This is my first hearing as ranking member. I am honored to serve with you and look forward to working closely with you and with the other members of the subcommittee on the opportunities and the challenge facing the Nation's infrastructure programs.

I particularly look forward to today's testimony. I want to learn how manufacturers and those who are involved in the research are working to develop and test autonomous and connected vehicle technology, and perhaps we will speak a bit about the role of the States and the localities on the Federal Government in regulation for the safety of all involved.

I expect that this hearing will spur a robust discussion, perhaps the kind of discussion we are not yet having in the United States about the policy and economic and the legal challenges and the opportunities presented as we embark into increasing levels of automation in vehicles just as we have in other forms of transportation.

Just last week I had the opportunity to ride in an electric car, but unlike Chairman Petri, who has ridden in a connected vehicle, and Chairman Shuster whose ride in a driverless car has been widely reported, I have yet to have a car drive me. I am looking forward to that opportunity.

Technology, of course, is already common in vehicles today. So we should not be surprised that driverless vehicles are already envisioned. After all, we are living with driverless vehicles. The Metro here used by Members, staff, and Federal employees has long used automatically driven cars, and automatic pilots are common in both planes and on rail.

It is worth noting, however, that after a serious Metro crash here in 2009 that killed nine residents, Metro has been riding manually, and that is the case, although that accident was not directly attributed to the driverless nature of the trains. Manual deployment now is used as a safety precaution.

The technology for driverless cars, of course, must cope with the risks and the dangers and the congestion that are far more complicated on the road than in the air or on rail. Perhaps, however, and this is how I would like to envision the technology that will lead to driverless cars, perhaps the technology applied to our transportation infrastructure on the ground has the power to actually reduce our accidents and risks, and the chairman has spoken of some of them. I will not reiterate them.

But mass deployment of technology is already ushering in dramatic gains in safety by significantly reducing vehicle crashes and saving lives. I have a strong interest in facilitating the use of technology-based solutions in a number of ways to address our surface transportation challenges.

This hearing, therefore, is not futuristic. I believe that understanding and preparing for the future of our surface transportation system now is important so that technological advances can turn into benefits for highway users as they become commercially available.

There are, of course, even more immediate issues this subcommittee must resolve in the near term. Our subcommittee must grapple with the looming insolvency of the Highway Trust Fund at the end of fiscal year 2014. I hope that the subcommittee seizes every opportunity to find a solution to our Nation's surface transportation funding woes, about which we hear so much daily. We can ill afford to wait until next year to solve that problem.

I know you share my concerns, Chairman Petri, and I look forward to working with you to develop sensible solutions to keep our Nation moving forward as we begin to think through reauthorization of a new surface transportation bill. Then perhaps we will really be ready to move forward and utilize the new technology that we will hear about at today's hearing.

I want to thank today's witnesses for joining us in advance and to thank you for your testimony, and I wanted to apologize, Mr. Chairman, to you and to our witnesses that a subcommittee hearing in another subcommittee of this committee is considering revitalization of a site near the Wall in my district. So I will be traveling by foot between this very important hearing and that hearing.

Thank you very much, Mr. Chairman.

Mr. PETRI. Thank you. I am on that subcommittee and am playing hooky, but I certainly understand why you would want to be there.

I would like to welcome our witnesses and to ask unanimous consent that their full statements be included in the record.

Without objection, so ordered.

The panel consists of the Honorable David L. Strickland, who is the Administrator, National Highway Traffic Safety Administration; Mr. Kirk Steudle, director of the Michigan Department of Transportation, on behalf of the American Association of State Highway and Transportation Officials; Michael J. Robinson, vice president, Sustainability and Global Regulatory Affairs for the General Motors Corporation; Mr. Andrew Christensen, senior manager for Technology Planning, Nissan Technical Center North America; Dr. Raj Rajkumar, who is a professor, Electrical and Computer Engineering Department of Carnegie Mellon University; and Dr. Joshua L. Schank, president and CEO of the Eno Center for Transportation.

Gentlemen, thank you very much for attending this hearing and for the effort that you and your staff put into the prepared statements which will be made a part of the record, and I would invite you to summarize them in approximately 5 minutes and give the committee a chance to ask questions as well.

We will begin with Mr. Strickland.

TESTIMONY OF HON. DAVID L. STRICKLAND, ADMINISTRATOR, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION; KIRK STEUDLE, DIRECTOR, MICHIGAN DEPARTMENT OF TRANSPORTATION, ON BEHALF OF THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS; MICHAEL J. ROBINSON, VICE PRESIDENT, SUSTAINABILITY AND GLOBAL REGULATORY AFFAIRS, GENERAL MOTORS; ANDREW CHRISTENSEN, SENIOR MANAGER, TECHNOLOGY PLANNING AND STRATEGIC TECHNOLOGY COMMUNICATION, NISSAN TECHNICAL CENTER NORTH AMERICA; RAJ RAJKUMAR, PH.D., PROFESSOR, ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT, CARNEGIE MELLON UNIVERSITY; AND JOSHUA L. SCHANK, PH.D., PRESIDENT AND CEO, ENO CENTER FOR TRANSPORTATION

Mr. STRICKLAND. Thank you, Mr. Chairman, and good morning. I also want to thank and recognize Ranking Member Holmes Norton and members of the committee for this opportunity to testify on automated vehicles and the implication for the future of surface transportation.

The future of the automobile is extremely bright. Increasingly a car's capabilities are determined more by its electronics than by its mechanics. This is bringing countless innovations and improve driver comfort, provide useful information and entertainment, and most importantly, advanced safety.

According to our estimates, there were 33,561 people that lost their lives on America's roadways in 2012. In addition to the devastation that their crashes caused to these families, the economic cost to society reached into the hundreds of billions of dollars. Automated vehicles can potentially help reduce these numbers significantly.

Traditionally, we have improved survivability by advancing the vehicle's crash worthiness along with a number of people that are sitting with me at this table and other manufacturers across the globe. With those technologies, such as seat belts and air bags, occupants are more likely to survive a crash than they were more than 20 or 30 years ago. Today there are new, exciting prospects for advancing safety through new crash avoidance technologies that could prevent a crash from occurring in the first place.

To that end, I am pleased to highlight the Significant and Seamless initiative that the National Highway Traffic Safety Administration recently announced. The Significant and Seamless initiative addresses the areas in highway safety where industry can fast track existing safety technology.

One major component is forward collision avoidance and mitigation, a sensor-based vehicle technology that can detect the imminent crash and alert the driver to take corrective action and automatically apply the brakes.

We have greatly accelerated our efforts to initiate and complete research of the Connected Vehicles Program. V2V, which depends on the 5 gigahertz spectrum, is designed to give drivers situational awareness to improve safe decisionmaking on the road.

Chairman Petri, I would like to thank you for taking time to visit our demonstration at RFK Stadium earlier this year.

I think the Connected Vehicles Program is a critical evolution of crash avoidance technology.

Recently traditional and nontraditional auto companies have unveiled research projects to develop self-driving cars. Unsurprisingly, people find this fascinating. With all the discussion surrounding automated driving, we find it helpful to think of these emerging technologies as part of a continuing of vehicle control.

To that end, NHTSA has issued a preliminary statement of policy concerning automated vehicles where we define levels of automation starting from your basic 1957 Chevy at level zero with no automation at all, all the way to full automation requires no input or control from the driver.

Automated driving is an exciting frontier for the industry, and we have identified three key areas for preliminary research: human factors and human-machine interface; initial system performance requirements; and electronic control system safety. Our research will inform agency policy decisions and assist in developing an overall set of requirements and standards for automated vehicles.

Several States, including the great State of Michigan, have enacted legislation expressly authorizing the operation of autonomous vehicles within their borders under certain conditions. Generally, these laws seem to contemplate partially self-driving or fully autonomous operation.

We offer recommendations to the States considering legislation or regulations governing licensing, testing and operation of self-driving vehicles on public roads in order to encourage the safe development of automated vehicles. In general, we believe that States are well suited to address issues such as licensing, driver training, and conditions for operation related to the specific types of vehicles.

We do not at this time recommend that State permit operation of self-driving vehicles for purposes other than testing. Any greater State regulation at this time may stifle innovation needed to improve safety, reliability, and the collection of data.

The promise of advanced vehicles is very exciting. While certainly there is a risk with any emerging technology, I firmly believe that when the risk is properly identified, understood and mitigated, we can help minimize it and reap the potential benefits.

One additional note, Mr. Chairman, as a point of personal privilege. I just also wanted to acknowledge Jim Tymon's fantastic service. I had the opportunity to work with him on SAFETEA–LU, oh, so many years ago as I was working on the Senate side, on Senate Commerce Committee, and Jim was a fantastic colleague, occasional adversary, but overall a great friend, and one of the best policy minds in Washington, DC, and I just want to thank you for all of his years of friendship and expertise, and God bless you, and have all of the best opportunities at AASHTO.

Thank you very much, Mr. Chairman.

Mr. PETRI. Thank you.

He is moving on up to AASHTO.

[Laughter.]

Mr. PETRI. Mr. Steudle.

Mr. STEUDLE. Good morning, Chairman Petri and distinguished members of the subcommittee. Thank you for the opportunity, on behalf of AASHTO and the State departments of transportation, to share our views on how autonomous vehicles will shape the future of transportation.

I have three points for you. First, the ultimate goal is the safest and most efficient transportation system imaginable, and it may be possible to achieve this goal with accident free vehicles, vehicles that can drive themselves, and vehicles, drivers, and transportation infrastructure that safety, securely and reliably share real time information.

Second, widespread acceptance and deployment of driverless vehicles and of interconnected vehicles and infrastructure will be challenging and evolutionary.

Third, there are actions that you can take today to move forward with these technological advances and effectively prepare us for the future.

Now, allow me to elaborate on these three points. First, the big picture. In reality, autonomous and interconnected vehicles, drivers, and infrastructure are a means to achieving our society's larger goals of an accident free transportation system.

Mr. Chairman, as you noted in the beginning, the safety benefits are huge. They are enormous. You also noted that the driver was at error in most crashes. If we can take the driver out of the equation, we have the potential to reduce the severity of crashes and crash rates significantly.

Some of the technology is already available, such as traffic signal overrides for emergency vehicles and buses, and automatic braking that reacts more quickly than humans can. Autonomous vehicles could significantly improve the mobility for those who are permanently or temporarily disabled and our aging population.

Vehicles that can communicate in real time with other vehicles, drivers and infrastructure can enable vehicles to drive closer together, allowing the transport system to operate more efficiently. Ultimately the deployment of connected and autonomous vehicles could fundamentally change the way we design and build roads and bridges.

For example, with crashless cars the need for a 12-foot-wide lane, guard rails, rumble strips, wide shoulders and even stop signs could decrease and be replaced with the need for sensors and next-generation traffic signals.

But achieving this vision will not happen overnight, which leads me to my second point. Additional research, development, testing and evolution will be needed before there will be widespread acceptance and deployment. This will take many years.

This evolution will include the deployment of many enabling technologies ranging from sensor-based information to wireless communications between vehicles and vehicles with the infrastructure and even technologies that we have not thought of yet. During this evolutionary period, we do not want to limit our options or impede further significant advances in technology. We need to be very cautious.

However, we have substantial deployment challenges that must be addressed, and here are a few things to consider. The hardware investment needed to equip vehicles and to retrofit roadways with new technologies and materials will add to the substantial roadway preservation deficit we already face.

Privacy concerns associated with data sharing could prove to be a significant hurdle in the development. Electronic security risks, as you noted earlier, such as viruses and hacking could threaten widespread acceptance.

Our fleet turnover rate of vehicles is currently at about 20 years, meaning you introduce new technology today and it will take 20 years for the full fleet to be completely converted.

Connected vehicle technology must have a secure and fast communications network to work, faster than is currently available with traditional cellular communications. The FCC has reserved 5.9 gigahertz bandwidth for this use. They are now considering sharing this use with other wireless communications providers, and we think that that needs to be done very cautiously.

And lastly, there will be a range of operational challenges during this transition period when both autonomous and nonautonomous vehicles will be sharing the roadways.

Finally, we have recommendations to advance autonomous vehicle technology today. First of all, encourage NHTSA to make its decision this year on requiring vehicle technology for all new passenger vehicles.

Second, protect the 5.9 gigahertz bandwidth for the connected vehicle program.

Third, fund research to more fully understand the breadth of possible operating scenarios and implications that autonomous and connected vehicle technology will have.

And, fourth, support the continuing collaboration between the U.S. Department of Transportation, the State departments of transportation, and the global automakers and suppliers. This collaboration will be essential for the successful deployment of autonomous vehicles into the future.

Finally, Mr. Chairman, I would like to commend the committee for taking on this issue and for your leadership to make sure that our Nation's transportation system continues to be the envy of the world. Thank you.

Mr. PETRI. Thank you.

Mr. Robinson.

Mr. ROBINSON. Good morning, Mr. Chairman and members of the committee. Thank you for the opportunity to participate this morning in this very important hearing.

The idea or autonomous driving has captured our collective attention and imagination, but in reality many of the future building blocks upon which it rests are already here. The role technology is already playing to assist the drivers or our vehicles in managing the conditions and circumstances they encounter on the highways today is providing the foundation for future breakthroughs.

It should not be surprising that GM is investing in technologies that ultimately will provide even greater levels of driver assistance and vehicle management, and importantly, we are working on systems that do not require dramatic upgrades or modifications to the national highway infrastructure network.

To the greatest degree possible, our goal is to keep the systems we are talking about contained within the vehicles and between the vehicles. However, we do have one low-tech need: clearly marked lanes and shoulders. This will enhance the capabilities of these technologies that we are already using to sense the road, such as radar, ultrasonic sensors and cameras, along with, of course, GPS location capabilities.

Over the past 2 years, the media has devoted much time and attention to the idea of a self-driving car. For the most part, as the name implies, people assume that an autonomous vehicle will take you to your destination without any personal involvement after simply issuing a command, without any oversight by the driver. It is easy to understand why this captures our imagination.

However, these types of driverless systems are a significant distance into the future. Realistically and for the foreseeable future, the driver will still need to be engaged and in control. Simply put, this is because driving is a very complicated business, and it will take some time for the computer driven systems to be capable of managing an reacting to all of the situations and road conditions that drivers do encounter.

That said, we are quickly forging ahead in a very thoughtful way to enhance safety by reducing driver workload. We consider these systems to be like having an extra set of eyes available for the driver. For example, today GM offers adaptive cruise control, ACC, on variety of our vehicles, an example of the building blocks that I just mentioned that will move us to the more automated systems of the future.

ACC is an intelligent form of cruise control that slows down and speeds up a vehicle automatically at pace with the traffic ahead. Like normal cruise control, the driver sets the speed, but also sets a distance gap setting. ACC is typically paired with a collision warning system that alerts the driver of a potential collision ahead and may also be equipped with a system that begins braking before the driver might have time to react. This system is already on various Cadillac vehicles and our new Chevrolet Impala.

GM has talked publicly about taking this very type of system to the next level, for example, adding the ability of the vehicle to maintain lane control. We call this more advanced system Super Cruise and expect it will provide even greater driver assistance, including hands free capability on certain freeway drives.

This system, too, though will require a driver's supervision. We believe this type of technology can realistically be brought to market before this decade ends.

Beyond that, the definition of what constitutes autonomous and automated vehicles and automated technology is being discussed and can be interpreted in various ways. The document that David Strickland referred to, "Preliminary Statement of Policy Concerning Automated Vehicles," really starts to frame that discussion and will provide a good basis for our collaborative work that needs to be done among the various players down the road.

At the same time a number of States are also becoming involved in defining, guiding or even regulating autonomous technology implementation. We think this is a bit premature, but to the extent States do decide they need to be involved, quite frankly, the approach the State of Michigan has taken to carefully make sure current systems and the building blocks I mentioned are not in peril as we test these future vehicles.

In addition to the obvious highway safety benefits of more automated vehicles, wide implementation of these systems could offer potentially significant benefits for improved fuel economy and CO2 reduction. Also eliminating or virtually eliminating crashes could have profound impact on how we engineer vehicles for future occupant safety and crash worthiness. It will give us the opportunity to take a fresh look at how we design body structures that manage crash energy. Fewer crashes means easier engineering.

Consequently, there may be opportunities to further reduce vehicle mass.

Finally, the ability to sense other cars, traffic congestion and even pedestrians would allow for smoother traffic flows, reduced noise and less pollution. Everybody wins in that scenario.

So you may ask how can we get this technology to the road faster. What can you do as a committee. We have three suggestions. Let the market work. Let manufacturers like GM do what we do best and compete for customers with features that add real value to the drive today and to the future generations of vehicles tomorrow.

Two, support a Federal approach to addressing these issues. We need a regular standard that can be adopted across all 50 States, not a patchwork of 50 different standards.

And, three, I would suggest respectfully that we need to provide an environment that promotes the development and implementation of these technologies here in the United States rather than in other countries, for example, reasonable protection for automakers and dealers from frivolous litigation for systems that meet and surpass whatever performance standards are established by the Government.

I have run out of time, Mr. Chairman, but in conclusion, I want to let you know that we are committed to these technologies. We are moving full steam ahead and look forward to your questions.

Mr. PETRI. Thank you.

Mr. Christensen.

Mr. CHRISTENSEN. Thank you, Chairman Petri and members of the committee.

I am the senior manager of Technology Planning at Nissan's Technical Center located in Farmington Hills, Michigan. Nissan has established ambitious goals for the development of autonomous vehicles. So I am particularly honored to testify about how autonomous vehicles will shape the future of transportation.

Carlos Ghosn, the CEO of the Renault-Nissan Alliance, recently announced the goal for Nissan to have an affordable autonomous drive vehicle ready by 2020. This timeframe is challenging, but we believe achievable.

Autonomous drive technologies can be classified by the level of automation ranging from emerging active safety technologies, such as forward emergency braking, to more autonomous vehicles and ultimately driverless cars. While many advantages are often cited for each level of autonomous technology, the potential safety benefit is the most important reason to pursue its development.

It is estimated that human error is involved in over 90 percent of the more than 6 million accidents occurring annually in the United States. Typically those crashes involve some level of driver inattention. We believe that autonomous driving technology has the potential to successfully address these types of situations resulting in these accidents.

Nissan's work on autonomous drive is a continuation of over 10 years of crash avoidance technology development inspired by our safety shield concept. This proactive development philosophy has enabled Nissan to introduce technologies designed to help drivers avoid a variety of risks from the front, side, and rear of the vehicle, including the world's first backup collision intervention and predictive forward collision warning systems.

It is the exact safety systems that will form the foundation of our autonomous drive technologies. Nissan's efforts are focused on technology that operates within the available roadway infrastructure. In the future additional benefits could be achieved if autonomous technology is fully integrated with the transportation infrastructure, including traffic control and road systems.

While some of the technologies that will act as the foundation for autonomous drive are already being introduced and we believe in their potential, the development of autonomous technology remains a challenging task which will require careful planning and resource allocation.

From an engineering standpoint, Nissan is already investing in the future of autonomous driving. In the United States, Nissan has teams working at our Technical Center in Michigan, and we have also opened a research facility in Silicon Valley to integrate the rich IT knowledge available there.

We are also creating a dedicated autonomous vehicle proving ground. Although Nissan is developing most of this technology in house, we will also partner with others as needed. For example, we will continue to collaborate with top level universities, such as Oxford, Stanford, MIT and Carnegie Mellon.

However, a successful introduction of autonomous drive will require more than careful engineering development. Autonomous driving may significantly alter the way society views driving, making social acceptability an important factor that should be carefully managed in parallel with the technical development. An ongoing and open dialogue among stakeholders is critical to help address the social framework needed to support autonomous technology deployment.

The necessary technical achievements and the maturing of social acceptance will be fostered gradually, step by step. Nissan conducted an autonomous driving demonstration at an event in California this summer and we are ready to conduct field operational tests in the United States and in other countries.

Nissan has also received the first license plate for an autonomous vehicle in Japan, authorizing us to test vehicles on public roads.

These demonstration events and field tests are important not only from a technology development perspective, but also to educate the public and help us understand social opinion. With the potential societal benefit that can come with autonomous driving, Nissan believes the United States can take a leading role in helping to promote safe and dynamic development of the technology.

Such leadership may include the consideration of appropriate legislative action, funding for research and development, and studying the need for investment in wireless communication infrastructure to support future advancements.

We hope that road traffic safety in the United States will be dramatically improved with the advent of autonomous driving, and we believe Nissan's commitment will contribute significantly to its progress.

We look forward to working with Members of Congress as we move toward this challenging goal.

Mr. Chairman and the committee, I thank you for your time and interest in this important issue.

Mr. PETRI. Thank you.

Dr. Raj Rajkumar.

Dr. RAJKUMAR. Thank you, Chairman Petri and Ranking Member Norton, for convening this important hearing.

I am honored to share my views as a researcher working with my colleagues at Carnegie Mellon University and the University of Pennsylvania at our U.S. DOT National University Transportation Center for Safety which is dedicated to developing technologies that target the holy grail of zero traffic fatalities.

Our work is also supported by the National Science Foundation through the Cyber-Physical Systems Program and by General Motors.

There is tremendous excitement building around autonomous vehicle capability in industry, academia and among the public. Today, we can envision a future of driving that is dramatically safer, more energy efficient, more sustainable, more productive and less congested, all without abrogating the role of the automobile in American life.

Autonomous driving is a prospective and realistic solution to the challenges of traffic fatalities, congestion and loss of mobility. Indeed, as Chairman Shuster recently showed by his willingness to experience a seamless driverless vehicle first-hand on a 33-mile autonomous ride on September 4 in Pittsburgh, autonomous vehicles have already been shown to be feasible in real-world street and highway traffic conditions.

Autonomous driving is an emerging and welcome result of the rich foundation of Federal investments in basic research and engineering, computer science and robotics. The seminal turning point in the pursuit of a grand vision of autonomous driving was the Urban Grand Challenge sponsored by the Defense Advanced Research Projects Agency, DARPA. This 2007 competition, won by our team from Carnegie Mellon University, clearly demonstrated the feasibility of autonomous driving in an urban, though restricted, setting.

Continued basic research is required to address the challenges presented by bad weather, poor road conditions, different lighting conditions and to ensure safe recovery from any failures of subsystems.

Fundamental advances are needed to successfully verify and validate the correct and secure operations of these cyber-physical systems. We at Carnegie Mellon University are addressing these core scientific challenges.

One pivotal research thrust which will accelerate the safety and reliability of autonomous driving capabilities involves connected vehicle technologies. The accurate and reliable operation of autonomous vehicles will be significantly improved with the seamless integration of automation and connectivity.

Carnegie Mellon has developed a 1.8-mile test-bed with 11 instrumented traffic lights near Pittsburgh. A much larger test-bed will be developed next year.

We are also exploring communication systems for use by bicyclists and pedestrians. Similarly, the big data opportunities in this domain will yield innovations in mobility analytics to identify and resolve traffic bottlenecks, to help emergency responders and to better integrate different modes of transportation.

The following are some considerations for policymakers. First, we should exercise caution in rushing to deploy technologies before ensuring that they can be fully trusted. For the foreseeable future, a human must continue to be in the driver's seat even if the vehicle is capable of driving itself.

Secondly, we must recognize that the pace of advances and adoption will depend on the level of support for continued research. Advances will still require serious R&D investments in both basic research and applied test-beds linking industry, universities, companies and communities.

Thirdly, we must be sure that policy and regulatory innovations evolve along with this technology.

Fourthly, we must ensure that adequate privacy and cyber-physical security safeguards are developed and integrated.

Finally, these challenges should not deter policymakers from pursuing the goal of autonomous vehicles because this technology holds tremendous promise to reduce highway spending in the 2030–2040 timeframe.

In closing, I thank the members of this committee for the opportunity to speak to you on an area of research that can profoundly transform our economy, our highways, and our lives. These investments will keep our Nation as the global leader in intelligent transportation systems.

Thank you.

Mr. PETRI. Thank you.

Dr. Schank.

Dr. SCHANK. Good morning and thank you for having me here today. Thank you, Chairman Petri and members of the committee. I appreciate the opportunity to talk to you about autonomous vehicles.

I am Joshua Schank. I am the president and CEO of the Eno Center for Transportation. We are a nonpartisan, objective, neutral transportation policy think tank based here in Washington, DC, and we were founded by William P. Eno 92 years ago. Mr. Eno was stuck in a traffic jam at the age of 9 in a horse and buggy in New York City and devoted the rest of his life to dealing with traffic and safety issues and founded the Eno Center for Transportation. So we have been working on this for a long time.

This paper, "Preparing a Nation for Autonomous Vehicles, Opportunities, Barriers and Policy Recommendations," was authored by Eno Fellow Dan Fagnant and his advisor Kara Kockelman at the University of Texas, and the paper sought to look at the barriers that exist to integrating autonomous vehicles and to understand how Federal policy can smooth the transition.

First we looked at some of the big benefits that could come from autonomous vehicle introduction. These include safety, reduce congestion, fuel savings, and greater mobility for those who cannot drive themselves. We found that over 40 percent of fatal automotive crashes involve some kind of alcohol distracted driving or fatigue. So we could save potentially at least 10,000 lives per year with just a 50 percent market penetration for autonomous vehicles, which is pretty substantial.

We also found that a cooperative adaptive cruise controls could potentially increase lane capacity on our existing highways by 21 percent, cutting fuel consumption by 224 million gallons per year, for a savings of approximately $37.4 billion annually. That is very substantial, and that is, again, with a 50 percent market penetration.

And then, of course, these vehicles will provide increased mobility for the disabled, for children, for the elderly, segments of the population that did not previously have access to this level of mobility, and that could provide tremendous economic benefits for society.

And so we estimate that with simply a 50 percent market penetration, comprehensive costs will save approximately $3,320 annually per vehicle, and of course, there are over 250 million vehicles in the United States today. So those numbers add up pretty quickly.

However, there are substantial barriers to implementing autonomous vehicles and achieving that 50 percent market penetration. The cost is going to be the biggest one. We estimate an initial cost will be approximately $100,000 per vehicle upon market entry. That is obviously beyond the reach of the average America. That cost is going to have to come down for us to achieve these benefits.

Second, there are no current standards in place for licensing and liability for these vehicles. We are going to have to get that done in order to achieve these benefits.

And then, third, the security and privacy concerns need to be addressed. You need to make sure that no one can hack into the system and potentially create problems that way, and of course, privacy is always an issue for people who are driving or riding in autonomous vehicles.

Therefore, we propose the following policy recommendations:

One, we need to expand autonomous vehicle research in order to figure out how to get that cost down. That is probably the number one priority.

Number two, we need to begin developing Federal guidelines for licensing of autonomous vehicles. That has to happen now because these vehicles could potentially be on the road by the end of the decade, and we want to be able to take advantage of them as quickly as possible in order to capitalize on these benefits.

Number three, we need to being determining appropriate standards for liability, security and data privacy. That also is something that we can start on right away.

So in conclusion, the benefits from autonomous vehicles are substantial, but the barriers that exist are also substantial. We do feel that these can be overcome. However, even before full automation, there are substantial benefits that can be achieved from simply adopting many of these technologies that we have talked about today.

And through expanding research and creating effective standards and regulations for autonomous vehicles, we have the opportunity to take advantage of these benefits sooner rather than later, but we must seize that opportunity or otherwise we could potentially let these economic benefits slip away.

Thank you so much for having me here today, Chairman Petri and members of the committee. I appreciate the opportunity to testify.

Mr. PETRI. Thank you. Thank you for your testimony. Thank you all for your testimony.

I guess I will start off the questioning. One issue that I wanted Administrator Strickland to address, we engaged in a little correspondence earlier, and it has to do with the statutory authority of NHTSA to issue regulations. It clearly has the authority to issue regulations concerning the safety of autonomous vehicles, but I understand it is considering guidelines regarding portable electronic devices, such as GPS navigation systems and other smartphones and other mobile communication devices which are not integrated into the vehicle but are used in the vehicle and out of the vehicle.

Do you have legislative authority to do that now or do we need to address that to figure out how that works within our congressional division of responsibility?

Questions are being raised in the industry, and I wondered if you have a response or are preparing one to that.

Mr. STRICKLAND. Yes, sir. We are actually preparing a formal response for your letter, but I am happy to sort of give you an outline of the agency's authority in this area.

The core is through the Motor Vehicle Safety Act where we have the statutory authority to clearly regulate, you know, the full automobile on road, public road automobiles, as well you know, and including medium-duty and heavy-duty trucks.

But it also reaches to motor vehicle equipment. Now, that would cross a span of devices and technologies. More specifically, your letter asked the question regarding portable devices, things such as, you know, a Samsung Galaxy or an iPhone, and our authority does reach to those applications on those devices that can be classified as motor vehicle equipment, and, Mr. Chairman, that is actually a very broad scope of issues. I mean things like, you know, navigation on an iPhone.

If you see the iPhone application has three tabs. One has a person walking for walking navigation. One has one for transit for transit directions, but there is also one for a car. That is a piece of motor vehicle equipment. I think we have very strong precedent to be able to make that extension.

In addition to that, there are applications that may not be specifically designed or intended for use in the vehicle, but can be reasonably expected to be used in a driving environment. Those are also motor vehicle equipment. While, you know, that authority is not limitless in that area, it is very broad, and we plan to work collaboratively not only with the manufacturers, which we already have, but with those device manufacturers, application manufacturers through our work in guidelines in order to make sure that all of these things are working in the proper zone of safety.

Mr. PETRI. Well, it is an interesting area that is a little bit new because of the way computer technology has evolved and things being small and multipurpose, and so on. We want to obviously be sensitive to this. The primary requirement is safety of the vehicle, but to have too broad a regulation where it is inappropriate because something might be carried on a vehicle raises issues as well.

So I am glad you are taking an interagency approach and have to be doing a lot of consulting with the industry and other experts to figure out how to prevent us from snarling things up.

Mr. STRICKLAND. Absolutely, Mr. Chairman. Just as one follow-on, I just want to actually thank not only some of the witnesses here at the table and their companies, but a lot of others. The goal for us ultimately in the fight against distracted driving in the opinion of the agency is a technological breakthrough, being able to identify the driver from the passenger, having the driver have to interlock their device or pair their device with the vehicle with a good, safe driving, you know, display that follows our in-vehicle guidelines, and allowing the passenger to play as many games of Angry Bird as they want.

Once we get there, I think that we have the opportunity to have a tremendous safety breakthrough, but if it is achievable, we all need to work together on that, and I appreciate your support and your question on that, Mr. Chairman.

Mr. PETRI. Thank you.

Mr. Robinson, you mentioned one concrete thing we could do is to make sure that to the extent we can, working with the States, that there is good marking on highways, and that is obviously of importance for safety in any event. But could you explain why that is important or how soon that needs to be done so far as these innovations are concerned?

Mr. ROBINSON. Certainly, Mr. Chairman. Thank you for the question.

When you realize that many of these systems cue off of visuals that are provided by cameras, the lane markings become very important to your operation of these systems. So the better the markings, the more effective the systems are.

And for that reason if you have older roads that do not have markings that have been painted in anyone's recent memory or you have weather conditions that get in the way of being able to track the markings, you can have difficulty. That is why the driver is so important at all times.

But it is a basic matter of being able to see the lines by the cameras that are on the vehicles.

Mr. PETRI. Thank you.

I have other questions, but I think I will submit them for the record and call on Mr. Sires.

Mr. SIRES. Thank you, Mr. Chairman. Thank you for holding this very interesting meeting.

I have so many questions. First, it is hard for me to fathom a car in New York City being without a driver. I mean, it is hard enough with a driver.

[Laughter.]

Mr. SIRES. So you know, trying to visualize this is very difficult.

The other question that I had is, you know, I worked on the fixing up of the E–Z Pass in New Jersey, and people were concerned that they were being tracked. I assume that with this car it is a lot easier to be tracked, and I think that is one of the questions that you are going to have to address because it was big issue trying to deal with the E–Z Pass and finding this thing.

The other thing is I am interested in the retrofit of the highways. Mr. Steudle, you said you would have to do some work there. Can you just talk a little bit about that?

What does it entail? You know, how much money is it going to cost? You know, do we have to place signals on the highway?

Mr. STEUDLE. Actually, there is an analysis underway. AASHTO is developing what is called a footprint analysis. What would the need for highway retrofit look like? Frankly, it depends on what the final technology looks like.

If we had done this 6 or 7 years ago, the estimate would have been significantly higher because at that point they were talking about roadside units every quarter mile, which was, frankly, just not possible to do.

So I think now you are looking at basically traffic signals that have some form of technology in them that can communicate with the vehicles as they are driving down the road.

I think once the technology standard is set, some of the prices will come down. It is very difficult to tell you that it is going to cost this much money today because the technology is changing so fast. We are learning through the model deployment safety pilot, which the U.S. DOT has underway in Ann Arbor, Michigan, is about what the infrastructure needs are really, how far these traffic signals can actually communicate, and we are finding that they actually are more efficient at a distance twice as far as what we originally intended them to be.

So it is a work in progress, but I suspect that where you are going to see the initial technology is in traffic signals where you have a communications backbone that links back into our traffic management systems.

Mr. SIRES. Are these any sensors that you are going to have to put on the highway? Do you know what I mean?

Mr. STEUDLE. The traffic signal is a dedicated short-range communication radio. It is a transmitter that would receive. It is the same frequency that vehicles-to-vehicles use, but then it is from the vehicle to the infrastructure and back to the vehicle. So, it basically is a receiver and a transmitter in the traffic signal.

The reason you select a traffic signal is because that is where the collision points are located most frequently.

Mr. SIRES. You know, I used to have a 1965 Mustang that I did a lot of work on, you know, many years ago. I cannot imagine anybody doing any work on these cars that are so sophisticated, and to me I think it is just going to put people out of work. You are going to have to send these cars back to the shop. I cannot see anybody doing work on these things. I mean you have to be so sophisticated, and I guess that is where we are headed.

Can anybody tell me if we are going to put people out of work?

Mr. STEUDLE. Well, I definitely would defer to the OEMs on the panel——

Mr. SIRES. You can pass that around.

Mr. STEUDLE [continuing]. To speak to the ability of shade tree mechanics. However, the one great thing about electronic systems, they do actually create efficiencies and improve safety in all vehicles. Yes, it may be beyond an individual shade tree mechanic today to change your oil and take a look at your braking system—the type of thing you could do on a 1965 Mustang. But, we do have the ability, frankly, to achieve improvements in fuel economy, improvements in safety, and reduction of costs for all of these things, which are enabled by new electronic systems.

Mr. SIRES. All that stuff just tells me it will put more people out of work. But, you know, I get it. It is the future. That is where we are headed. You know, I am just trying to figure it in the next few decades what is going to happen.

Can you just talk about it a little, Mr. Robinson?

Mr. ROBINSON. Certainly, Congressman Sires.

And, by the way, I suspend disbelief whenever I am in New York City, too. I close my eyes a lot in the back of a cab. It is not autonomous driving, but it is close.

This is technology that, quite frankly, is going to be liberating, and I understand your concerns, but we are talking about a future state where I think the technology is actually going to have the reverse effect on the one you are concerned about. I think it is going to create jobs ultimately.

I think all of these technologies are going to require technicians. They are going to require people capable of working on these systems, and it is different than the state we have today or with the old cars that I have worked on as well. But I think this is actually going to be a liberating thing in the final analysis.

Mr. SIRES. Right. Thank you.

I mean, I think this is very exciting the more I read about it, but it is just scary to me anyway.

Thank you very much for being here today.

Thank you, Mr. Chairman.

Mr. PETRI. Thank you.

Mr. Ribble.

Mr. RIBBLE. Thank you, Mr. Chairman. And I want to thank everyone on the panel. This has been really interesting.

Mr. Christensen, I just want to talk a little bit about Wi-Fi and the amount of demand that, as we picture this in the future, how much demand there is going to be. I understand that efforts are underway to find a compromise so that Wi-Fi consumers can share the unlicensed band of a spectrum with Government transportation agencies and auto companies.

Since the DSRC technology is not yet on the road, there is an opportunity to develop both systems to allow efficient use of the band. Would you be open to accepting modifications to the industry's plans if this flexibility were to allow efficient use of the band and avoid interference?

Mr. CHRISTENSEN. So thank you for your question, Congressman.

This is a key area. The ban that was set aside for DSRC is critical. It was set aside for vehicle safety. So we feel that is very important to maintain that band. We understand that there are other uses out there, other individuals who would like to utilize that band. There may be a possible for some sharing opportunity, but that would require extensive testing and guaranteeing that there would be no interference or cross-talk across the band because, again, you are talking about Internet access for an individual or safety in a vehicle, and of course, we are prioritizing that safety.

Mr. RIBBLE. Yes, I mean, the FCC has identified 75 million hertz of spectrum, which is more than the amount used today by billions of Wi-Fi devices. It seems fairly large, and I am just curious if the automotive manufacturing industry is willing or interested in putting any ideas on the table to make the band use more equalized across all uses in the country.

Mr. CHRISTENSEN. We have been involved with the discussion and are very interested to understand more and, again, do this testing and understand what the possibilities may be, but we need to be very careful in this area and truly understand what type of cross-talk or what type of issues we could have in this area, and again, weigh those priorities and really understand before we move forward or before we make any changes or give up some of that spectrum to make sure that, yes, it is a significant amount of bandwidth, but we also need those protections on either side of the band that we are working to guarantee that the system is functional.

Mr. RIBBLE. OK. Good. Thank you for those comments.

Mr. Robinson, just a quick question for you. In your testimony you said that we need to provide an environment that promotes the development and implementation of these technologies in the U.S. rather than other countries. Can you expound on that a little bit?

Mr. ROBINSON. Sure. What I am specifically referring to, Congressman, is creating an environment where the risk associated with putting these systems on the road is not so prohibitive that it becomes a disabler so that we are not forced to go first to Europe or China or some other location where we have a better environment. That is all we are concerned about.

And I realize that presents some real challenges because it is new territory for all of us, but I think it really will be an enabler if we can find a balance with technologies that have been tested and regulated ultimately and that comply with those regulations to be used in this country without undue burden and risk associated with trying them here first.

Mr. RIBBLE. You speak specifically of your concern about frivolous litigation for systems that meet performance requirements and relevant Government operating standards. Are you looking for some type of assistance there?

If you build something that complies with the performance requirements and standards, that you want protection from the litigation; is that what you are looking for?

Mr. ROBINSON. Yes. I don't have all the answers, Congressman, but I think that some balance that would recognize the compliance with the regulated systems that we are talking about ultimately and not having to worry about frivolous litigation.

I do not want to sound cynical about this, but we are the most litigated industry you can find, and it should not shock anyone to know that that becomes a factor in the way we think about where to deploy and learn out these systems. So we are not looking for a pass. We are looking for being responsible and stepping up to our obligations, but at the same time of having a reasonable opportunity to not be overexposed, if you will, for building systems that are compliant with Federal standards.

Mr. RIBBLE. All right. Thank you.

And you are testifying before Congress. So your cynicism is warranted here. I thank you very much, and I yield back.

Mr. PETRI. Thank you.

Ms. Esty.

Ms. ESTY. Thank you, Mr. Chairman. I want to thank you for holding this hearing and for all of our witnesses for helping us with this very critical issue.

We have heard a lot about the benefits of this technology. So I would like to turn to the challenges that we face and how those of us here in Congress can be constructively part of addressing those challenges.

Broadly speaking, I see two major challenges. One has to do with affordability, and the other has to with consumer acceptance, and some of you have referenced both of those issues.

If consumers do not trust the technology, they will not adopt it, and if it is too expensive, they also will not adopt it. So we have some challenges around that.

So for Mr. Strickland, NHTSA has introduced some preliminary statements about the timeframe to achieve vehicle automation, and if you could talk a little bit more about what it is going to take between level zero and level five, do you have the resources to proceed through these stages?

What is going to be necessary for the timeframe to achieve the 2020 or into the 2020s, depending on which of our witnesses you are talking about, to achieve the level of confidence that we would need to have on the public's part?

Mr. STRICKLAND. Well, Congresswoman, we have laid out a research plan over the next 4 years to talk about preparing for the automated future at the various levels. While we at this point see level five of automation, which is a fully autonomous vehicle being far off in the future, clearly there are lots of components, including things that are on the road today, which are the foundations which can improve safety.

We do have adequate resources right now for us to do the research that is underway. Clearly, as more advances and, frankly, new innovations, new technologies come onboard, we will clearly have to always reevaluate our plans as to making sure that we are prepared, but the work plan, our new Office for Electronics that we have started at NHTSA, in addition to a number of other pieces of work that we are doing at the Vehicle Research and Test Center out in East Liberty, Ohio, we are very prepared to be able to work with the industry to be able to create a level playing field for safety and innovation so that we can see this automated future come to fruition.

Ms. ESTY. Anyone else with thoughts on this?

Mr. ROBINSON. Congresswoman, I guess I would like to address your observation about cost. It is true a lot of these systems initially are expensive. On our products, for instance, a lot of these have been introduced in Cadillacs—adaptive cruise control, crash mitigation braking—but it has not taken long for us to now introduce those same technologies in a Chevrolet. The new Impala has these same technologies.

These are the building blocks upon which the kinds of future state that we are talking about can be engineered. So I think while there is always initially a high cost with the introduction of these systems, I think over time, and by the way, the customers love these systems, they are very intuitive, and they work, and you do not have to learn over again how to drive a vehicle.

So I think part of the socialization process that you are concerned about is going to take place naturally as these become more and more mainstream building blocks that allow for the ultimate state that we are talking about.

Ms. ESTY. And I would like to turn for a moment, also having just come out of the Science Committee where we are spending a lot of time looking at cybersecurity. There has been a reference early already today about privacy concerns of which obviously we are hearing a great deal right now. If some of you could address the concerns about cybersecurity, what will we need to develop to ensure that no one can actually misdirect intentionally these systems?

Because obviously that will certainly shatter consumer confidence if we are not simultaneously thinking about how these interactive systems can protect against cyber attack.

Mr. STRICKLAND. I will begin, Congresswoman. We at NHTSA recognize this has to be bedrock. In order for us to have a reliable system, it has to be rigorous against electronic attacks. It also has to be beyond Six Sigma reliable as the auto industry already does. We are working very hard internally to be able to work with the automakers to figure out what that level of protection needs to be.

One issue which is new for us but clearly we are very capable of the task is that before we always set our performance standards, you know, here is the miles per gallon you have to achieve, you know, for the CAFE standard.

For electronics and cybersecurity, we are likely going to be looking at process standards. What are the processes the manufacturers have undertaken to test their systems to the certainty and reliability of what an anticipated attack would be?

And you know, while I would love to be able to say this is more of a futuristic notion, we are seeing it today. You know, there are automakers that now have the ability to actually change vehicle performance, you know, and actual mechanics through pushes from the Web, and so we have this today.

So clearly, the manufacturers from a liability and reliability standpoint have to address it in their own business plans, but for us as an agency, we clearly have to have a process to make sure that those standards are, you know, best for the driving public.

Ms. ESTY. Thank you very much. I have some other questions, but I will submit them, other than just to say to the doctor, please keep advocating for basic research and development, and I hope all of you will continue to sound the importance of that in order for these technologies to be able to be rolled out in the consumer sector.

Thank you.

Mr. PETRI. Thank you.

Mr. Hanna.

Mr. HANNA. Thank you, Chairman.

I have a basic question. I find all of this fascinating, and, Mr. Schank, you mentioned the $3,220 per car. You think maybe roughly $100,000.

Mr. Robinson, the automobile no matter how less expensive it becomes through whatever means, mass production, et cetera, growth in demand, it will never be less expensive than a basic automobile without this.

I guess I am interested in anybody's answer about what those incentives might be for an individual to spend more money on a car in which they have to be—maybe I am mistaken in this—but at least equally alert and engaged as they would with their normal car that we drive today.

I guess what I am asking you is: what are the demand dynamics in this?

Societal costs aside because for the moment we are not buying people automobiles; they buy their own. So it is fair to say they are not a big part of the component. So maybe, Mr. Robinson, since you are in the business.

Mr. ROBINSON. Well, Congressman, your observation that people buy what they need when they want is a fair one. You know, the average age of an automobile today is over 10 years. People, first of all, have high-quality vehicles for the most part, and so they are able to drive them longer, but the truth is, I mean, if we implement all of these technologies tomorrow, it would still take 10 or 11 years for the natural process if people were able to buy these vehicles right now.

I do not have the answer to your question about what the demand levels are going to be ultimately because, quite frankly, we are not smart enough today to know precisely in 5 or 6 or 7 years how these technologies are going to evolve and what the cost is likely to be.

Dr. Schank gave you some numbers from his research. I am in no position to talk to those numbers other than to tell you that as we look at other systems that have been put on vehicles over years, the cost will come down over time if it is a system that people value.

People have shown——

Mr. HANNA. Well, that is my point. What is your view of the value of this to anyone in this room?

Mr. ROBINSON. I look at it in building blocks. We are trying to bite this thing off in pieces because we are not looking at what are we going to price 10 years from now. We are looking at what systems do we have today that add value, and that is why we talk about things like adaptive cruise control, crash mitigation, braking, those types of things, because people value them. We can do them at a cost and provide a value that people are prepared to pay for it, and we have had great customer experience.

So I think that is the model on which we will build.

Mr. HANNA. So that is a marginal thing, but this is actually a big leap to go to automated vehicle.

Mr. ROBINSON. Sure. It is a leap built on many steps.

Mr. HANNA. Right. Mr. Schank is chomping at the bit there, I think.

Mr. SCHANK. Yes. Well, I think there are some real benefits to drivers from spending a little bit extra to potentially reduce the chances of being involved in a fatal crash and potentially reduce their fuel consumption, but maybe a more obvious one that we have not talked about is the potential for these vehicles to go and park themselves, which is something that I think all of us would find convenient if you are going somewhere and you do not have to worry about parking because the vehicle will just go off and park itself.

But then the second possibility is that the dependent populations that currently do not have access to automobiles will be very glad to adopt this technology, the elderly, disabled, and potentially even children.

But I would like to point out, and I do not know what the manufacturers think about this, but some of our research indicates that it is possible that the total number of vehicles on the road may decrease as a result of the introduction of autonomous vehicles because so many vehicles will be available for use when there is no driver in them. So you can have greater sharing of vehicles and people will not necessarily need to own as many vehicles as they currently do today. So that is another interesting question to think about.

Mr. HANNA. So I dial a number and the car shows up, and I get in and I leave it wherever I got out.

Yes, sir.

Dr. RAJKUMAR. It is very tempting to think of a driverless car as this revolutionary endpoint. It is an evolution when it happens. It is not a question of if, but when. But the progress towards the endpoint will consist of multiple intermediate milestones where a car is more aware of what is happening around it, and even if the driver is not paying attention for whatever reason, such as distracted driving, tiredness, sleepiness and so on, the car will basically be able to prevent an accident from happening rather than drifting off of the lane or going off of a cliff. All of those accidents will be prevented. So every driver will basically be able and willing to spend a few thousand dollars more to get those capabilities in place.

Humans can be very smart, of course, but they can also be very stupid at times. Basically this technology will prevent humans from hurting themselves.

Mr. HANNA. Thank you. My time has expired.

Mr. PETRI. Mr. Cohen.

Mr. COHEN. Thank you, Mr. Chair.

This has been an interesting hearing, and I kind of looked at it as "Star Wars" when I heard about it. I still think about it somewhat that way.

I remember back in the 1980s I was in the Tennessee Senate, and a fellow came up to me and he told me that this man named Frank Gorrell was representing this company and they were going to have phones like Dick Tracy, and everybody was going to have one, and I thought he was absolutely out of his mind.

Thinking back upon that, yes, I envision the day we will have these vehicles, like the Flintstones or something, but—who, the Jetsons? Yes, that is the opposite.

[Laughter.]

Mr. COHEN. Thank you.

I did not watch those things.

But I am kind of thinking about like you said it was great, you know, the car. I was thinking I go to Contral and you have to find a place to park, and you just get out and let the car go. How does the car know where it says "no parking from 4 o'clock to 6 o'clock" or all the myriad signs, Dr. Schank? How does the car know that, or which lot to go to?

Mr. SCHANK. Well, presumably you could have the vehicle go back to your house depending on how long you are planning on being there. So you cannot think about the constraints of the existing system necessarily being that way.

But also presumably we would have to change our parking policies to some degree in order to adapt to these technologies, and we are already moving in that direction. I mean, parking is becoming more automated. I usually pay for my parking by phone. I do not pay by coins at the meter anymore, and so as you continue to be able to do that, you are going to have more interaction between computers, and they are going to be able to communicate with each other about when you can park in a certain space.

Mr. COHEN. So they will just have to have some kind of governor so that there will be a beep and will know that you cannot park here because it is the wrong time?

How will it know an emergency vehicle?

They will all be coded, I guess.

Mr. SCHANK. Right. There is going to have to be a greater integration of these technologies with existing technologies so they can communicate with each other about that type of basic information.

Mr. COHEN. And just as Representative Sires was concerned about the loss of jobs, what are municipal governments going to do without being able to manufacture funds from parking tickets and traffic offenses?

[Laughter.]

Mr. COHEN. You are going to ruin the basic structure of municipal government. It is just a thought I had.

I got a ticket and I went to court on it, which was a mistake, I guess, for parking more than 12 inches from the curb, which I did not know was even the law, and I do not think I did it. But the car is going to know 12 inches?

I mean, how is the car going to know the Memphis City code?

Mr. SCHANK. These are all challenges that are interesting to think about, but certainly can be overcome. You could, for example, have the car to be programmed with the code. It could easily be programmed with the code of any city you might presumably go to, just like you have GPS systems that cover the entire country right now or the world, and you can drive your car anywhere and it knows exactly what the roads look like.

So it is plausible to introduce that kind of information.

Mr. COHEN. I guess it is, Doctor, but when you suggest that the car would go home to park, that mitigates against the idea of saving fuel, you know.

Did any of you all make Web sites maybe since you are working on this? Maybe you could kind of back off for a couple of months and help us with the Affordable Care Act.

Mr. SCHANK. The car might go home to park though because someone else needs to use it at home to go somewhere while you are at the restaurant. So it could be an efficiency as well.

Mr. COHEN. You mean I would give my car to somebody else?

Mr. SCHANK. In your family. Let us say your wife wanted to use it while you were at the restaurant, you know, and she needs to go somewhere.

Mr. COHEN. Who would I be at the restaurant with?

[Laughter.]

Mr. COHEN. You certainly have a futuristic society, Dr. Schank.

[Laughter.]

Mr. CHRISTENSEN. Congressman, if I could just interject real quickly, another area from a parking standpoint is with EVs and the proliferation of EVs. Obviously infrastructure is still going to be limited. We are trying to get more infrastructure for charging, but one of the areas we are looking at is having an EV be able to seek out that charging location and automatically charge itself in those conditions, again, with the limited funds that are going to be available for the proliferation of infrastructure. How can we make the cars seek out that infrastructure that it is looking at? So another area of research.

Mr. COHEN. I can see a lot of benefits, and the thing about the drunk drivers, I mean, that is 40 percent of them. The problem is those people do not know they are drunk when they get behind the wheel, and we have already got like ignition interlock devices and difficulty of getting judges to require those to be put on the vehicle.

I guess it would work, but some of these technologies will just help with driving in general. Do you not already have these braking systems and fuel saving mechanisms that would already work like on trucks now? Are they that compatible?

Like in New York, I cannot imagine what will happen with the immigrant population if you have automatic driving all the cabs. They do a great job. I do not see how they could be any better.

Anyway, I yield back the balance of my time.

Mr. PETRI. Mr. Davis.

Mr. DAVIS. How do you follow my good colleague, Mr. Cohen from Tennessee? There you go.

[Laughter.]

Mr. DAVIS. Thanks for being here, first of all. A very interesting discussion. I obviously agree with my colleague, Mr. Cohen, that some things that we may not be able to see as futuristic actually become reality like cell phones. I have some concerns representing a rural district similar to when cell phones became active in society. The rural areas fell behind. The rural areas did not have the new technology or access to new technology like we do now.

I hope that through testing, research and development, autonomous vehicles can get to the point where they can understand the Memphis City Code.

Now, I do not think Mr. Cohen understands the Memphis City Code, but that is OK. That is OK, but I do have some concerns. First off, while I have you here, Mr. Strickland, I know it does not necessarily have everything to do with the autonomous vehicles, but just a few years ago electric vehicles were discussed as new and innovative, and I saw a story come out today in Bloomberg about Tesla and about three electrical fires with Tesla.

I am concerned. I want to make sure that NHTSA holds Tesla's accountability standards to the same standards they have done with Chevy Volt in the past instance and also with Fisker's Karma plug-in.

Can you tell me what the next step is in NHTSA's investigation and process into Tesla's three fires?

Mr. STRICKLAND. Oh, certainly, Congressman. First and foremost, NHTSA holds all of our manufacturers, tier one supplies, and equipment supplies equal before the law. So we follow the same process in our defects investigations in the same way every single time.

This morning it was probably announced that we opened a formal investigation into the Tesla Model S. While there are three fires in total, there are only two that happened in the United States. One is in Mexico, and the reason why the agency moved forward to open a formal investigation is that we looked at, you know, the damage patterns and the issues for those two crashes.

The first crash in Seattle, Washington, looked anomalous, and that is why we at that point were pre-investigatory and took no formal action.

The second crash and fire in Tennessee had a number of similarities, therefore, two being a trend and we clearly saw some issues. We decided to open a formal investigation, which is we are going to look at whether or not the Tesla Model S countermeasures in dealing with road hazards are adequate, and whether or not it poses an unreasonable risk to safety. We are working very closely with Tesla.

My understanding is that Mr. Musk has already said he will be very happy to cooperate with our investigation, which we always appreciate. When we come to our final conclusions, we will definitely report them publicly and be happy to report back to the committee on what we found.

Mr. DAVIS. Thank you, Mr. Strickland.

A question not Mr. Robinson. Do you anticipate that with the progress in automated vehicles, that they would be all electric, hybrid, gasoline, or would it just be a piece of technology that would put on any vehicle that would sell out of a dealership?

Mr. ROBINSON. Thank you, Congressman.

I think it depends on how the vehicle is going to be used, quite frankly. To the point about being in a rural versus an urban area, a lot of the technologies that we have been talking about as building blocks, adaptive cruise control, automatic braking, those are on our new trucks. So it is not just urban vehicles that we are talking about here.

And, two, I think to your point about what this enables from an engineering standpoint down the road, I do think ultimately if you get to a point where you can take out further weight on vehicles because of the fact that the vehicles are not crashing anymore, it liberates the engineers to come up with all kinds of propulsion solutions to fossil fuels.

So down the road, sure, there are all kinds of opportunity for that to come into play. I think it is probably something we have not focused on so much here. We talk a lot about safety, which is a huge issue, but I think it does create more options for all of us in terms of how the vehicles are propelled down the roadways.

Mr. DAVIS. Well, thank you.

And I agree. I mean, I think we already have this technology in many of the large pieces of farm machinery. In Illinois where I live, they are out in our fields on a regular basis. So the potential is here. I just want to make sure that a lot of that potential is further researched and developed; that we take into consideration not just the congested cities.

Because like my colleague, Mr. Sires, I, too, will be amazed when an automated vehicle goes through New York City, but I think we would all be more amazed for an automated vehicle to go through my home town of Taylorville, Illinois, or 11,000 people.

So if we can continue to put a focus on the rural areas, too, during this discussion, I would sincerely appreciate it.

And I do not have any time left, Mr. Chairman. So I cannot yield back.

Thank you.

Ms. Titus.

Ms. TITUS. Thank you, Mr. Chairman.

I am proud to say that while some of my colleagues are amazed at this new technology and titillated by its possibilities, the State of Nevada is on top of this. We were the first State—often we are the first—to actually adopt a law to regulate these kinds of vehicles, the use of autonomous on our roads. We did that back in 2011.

And then in the past legislative session, we passed Senate Bill 313 that looked at some aspects of this technology like minimum insurance coverage and other key factors for those who want to permit a vehicle for testing. So we are already moving down this road, and I am glad to see that the Federal Government is taking an interest in it.

In the past, we know that the Federal Government has regulated different safety aspects of both vehicle construction and vehicle use, whether it is seat belts or speed limits or DUI limitations, things that have saved lots of lives and lots of money.

So I would ask you: what can we do at the Federal level to help States begin to plan for this technology because it moves very quickly?

And also, as we move into looking at the next transportation authorization, are there any things we need to build into that in advance so that we are not playing catchup and trying to fix things after the fact as this technology moves ahead?

And I would just ask any of you to address that. Yes, sir.

Mr. STEUDLE. Congresswoman, I would be happy to address that. I think as you look forward to reauthorization of MAP–21 next year, one of the most important things is, as many of my colleagues have said, we need to continue the research piece. We are close in some aspects, but we still have a long way to go. There is a lot more evolution needed for this whole initiative.

Therefore I think that within MAP–21 we need a strong statement of continued research in this area.

As far as actions that I think the Federal Government could take from a regulatory perspective, the model legislation that NHTSA has prepared is a great start. I would agree with my friend from General Motors that we can do this 50 States one at a time. We need to undertake this as one country. We need to say these are the requirements that we need as a country for autonomous vehicles, whether in the testing phase or in the operations phase so that everybody knows that when you are driving a vehicle from Michigan to Ohio and all the way to Nevada that you have the same requirements. That is going to be very, very important and, frankly, that could be part of the reauthorization component as well.

I do think that reauthorization of MAP–21 needs to address the technology components, where we are going, and reserve funding for future research.

Ms. TITUS. Mr. Strickland?

Mr. STRICKLAND. Actually, Congresswoman, I was the only one to actually thank your colleagues and the leadership in the State of Nevada because actually as they were preparing their work in 2011, they asked NHTSA for technical advice, and we actually were able to provide a good amount of assistance for them in their process and path going forward. So we really do appreciate, you know, including the Federal-State relationship and be able to developing that.

I think Kirk noted a couple of things that we are still in a research mode, and I think for all of us, in order to make sure that we have all of the components right, electronic reliability right, performance right, ultimately consumer acceptance, the foundation of research has to be solid because at the end of the day with a new piece of technology, the whiz-bang notion is the first line of headlines, and the second headline is unfortunately that one of these systems does not perform as expected and is part of a crash or is responsible for a crash.

So for us, we need to make sure that the State as test-beds, you know, and the leadership of your State and the great State of Michigan, California and others in terms of creating the right test-beds and the right environment is an important aspect of it, but clearly being able to evolve and develop the policy underpinnings is important as well, as Kirk noted.

Ms. TITUS. Anybody else?

[No response.]

Ms. TITUS. Well, thank you.

Mr. Strickland, while I have you, I wrote a letter to you about the Focus Cities Program, since we are talking about safety and that is about safety and pedestrian safety. Could we get together afterwards or something so I can get a response back from you about my question?

Mr. STRICKLAND. My pleasure, absolutely.

Ms. TITUS. I will not take up time with this hearing, but since I have you here.

Mr. STRICKLAND. Absolutely.

Ms. TITUS. Thank you.

Mr. STRICKLAND. Thank you, ma'am.

Ms. TITUS. All right. Thank you, Mr. Chairman.

Mr. PETRI. Mr. Williams.

Mr. WILLIAMS. Yes, thank you, Mr. Chairman. And I want to thank all of you for being here today.

And full disclosure, number one, I am from Texas. Number two is I am a car dealer. My family has been in the automobile business 39 and I have been in it for 43 years, GM, Chrysler, some other I do not would not tell you about, but so far back. Listening to this testimony, the first Biscayne I sold when I was a kid, the power steering was an option. So was a radio, and now here we are talking about this.

But my first question would be to you, Mr. Strickland, just real quickly. You touched on Tesla. You know, Tesla has a checkered history in Texas, and one of the things I did not hear you say when we were talking about it, was this investigation that you are conducting, was it requested by Tesla?

Mr. STRICKLAND. No, sir. Our investigatory process is independent. It is confidential as well. We go through a review of the data, and then we make a determination whether a formal investigation is needed.

After we have made that formal determination, we then reach out to the manufacturer usually 48 to 72 hours before we post something on the public Web site to inform them that we are opening an investigation, and of course, we ask and hope that they would collaborate and they will work with us through the investigatory process so we can come to a determination which is right for the safety of the driving public and clearly fair to the automaker.

Mr. WILLIAMS. And it is important that everybody is on a level playing field.

Mr. STRICKLAND. Absolutely.

Mr. WILLIAMS. I wanted to bring that up.

The other thing is, Mr. Robinson, I appreciate your comments. Being in the business, when you talk about let the market work, make what the customers and the dealers want to sell, and frivolous regulations, litigations are killing the industry in many cases. I appreciate your comments to continually remind the Government that those are big options to the free market.

And I also would remind you and humbly ask you to make sure your captive finance company is willing to finance these vehicle. That is important.

The other thing, too, I would ask you, Mr. Christensen, is we talk about insurance. What does the insurance company say about this? How are you going to get insurance? How are you going to rate an insurance with no driver? How are these cars going to be insured?

Mr. CHRISTENSEN. That is a key issue moving forward, Congressman. I do not know that any of us really have the answer to that question at this point, but moving forward we want to work together and continue that dialogue and understand what this means for our customers, what the technology is able to do and what it means for the insurance companies so we can work together and answer that question.

Mr. WILLIAMS. Yes, that is a an important issue.

Mr. CHRISTENSEN. Absolutely.

Mr. WILLIAMS. And then, Dr. Schank, thank for you testimony. I would just say this to you. A hundred thousand dollars is a lot of money for one car. The car business is a volume business.

But I will also go back and we have seen cars from the early 1970s, $3,000 up to $60,000, higher now, but that is a scary number. So you are going to have to work on that.

The other things is, too, where I come from in Texas, and we touched a little bit about this, in all seriousness, something like this is going to have to be able to pull a horse trailer, and it just cannot be moving around finding people parking spots. If it is going to work and the customer wants it, it is going to have to be able to serve and it is going to have to be able to have some towing capabilities, if you know what I mean.

And the other thing is I was not happy with your testimony when you talked about it might put fewer vehicles on the road. That is not what Mr. Robinson and I want to hear I do not think when you are in the business. But I do think technology is growing and probably we are heading in this direction, but cost is going to be important, how we are going to insure it, and I do think we talked about earlier in the year there was concern for jobs, and I am all about jobs, but I believe that as we move forward this will actually add jobs because we have seen in the last 40 years more technology brings in a much newer level of technician. No longer are these people wrenches, as we used to call them. They are high-skilled technology people, and I think it will actually add jobs.

But from a person who is going to sell and get it right and make sure I can get them financed, would you do that, Mr. Robinson?

But I appreciate your testimony and thank you for being here, and I yield back.

Mr. PETRI. Thank you.

One of the disadvantages of being chairman sometimes is that you have to stay at a whole hearing. One of the advantages is that you get to ask a few more questions at the end if you would like, and on this particular occasion I do.

One observation first. You mentioned how this technology is gradually being layered in, and in fact, has been for a number of years, and I think evidence of that is that the number of deaths on the Nation's highways has been dropping very significantly over the last 10 or 15 years. It used to be in the neighborhood of 40,000 or 50,000 a year, and now it is in the neighborhood of 30,000 to 40,000. So that is a long way to go to zero, but it is a huge improvement, as our population has been growing and all the rest of it.

Secondly, we never really discussed the implications of this, and this may not be the place to ask about it, but for the commercial trucking industry, clearly this is technology that will make it easier for drivers. It will also help people driving commercial vehicles if it is deployed on them.

We have been tightening up as a Federal Government on hours of service regulations. There used to be a little bit of an informal fudge factor with those because people kept log books and so on, but now with technology it enforce it and people like Snyder trucking in my area and others that are major logistics companies say that it may have some benefit in terms of fatigue and safety, but on the other hand it is costing our economy as their figures are coming in in this new thing billions of dollars in lost efficiency because of how it works.

And so I am curious. If the concern is safety and fatigue, and if technology reduces the stress on a driver and have, in effect, less than full time, well, he is driving long distances and so on; if they have some of the new technology on board, would that provide an opportunity for us to modify some of these one size fits all hours of service rules to be related more to the capabilities of the vehicle?

Is there some way we can have our cake and eat it, too, have greater safety and maintain efficiency?

I mean we could have zero fatalities by just banning cars and trucks, but that is not the way to do it. The way to do it is to make it safer and more efficient, and the hours of service make it less efficient as it turns out, and considerably less. I mean, it is going to lower people's standards of living in the United States because that cost ends up being translated into higher prices for people who are already struggling.

So it is not as though there is a free lunch in this world. I do not know if Mr. Strickland or anyone else would care to comment on that.

Mr. STRICKLAND. Certainly I will be happy to comment in part, Mr. Chairman. Clearly, in terms of the policy, the department and the specifics, it is better handled by the Federal Motor Carrier Safety Administration, Administrator Ferro. She is a person who knows this issue song, chapter and verse and would be better suited to speak to the policy specifics.

I can be happy to speak to the technological specifics, which is that there is always an interplay and an interflow of technology between the light-duty fleet and the heavy-duty fleet. So things such as crash and braking system, forward collision warning systems, lane keeping systems, and you know, electronic stability control for heavy-duty vehicles which we are working on as part of a rulemaking right now are all things that we see in the light-duty fleet which could flow to the trucking fleet, which would improve the margin of safety.

You know, we do believe that a number of the issues that beset the everyday driver of a vehicle would also be able to improve the abilities and, frankly, the success and safety of a commercial driver as well. It is something that NHTSA is working on specifically, but how that may sort of have an opportunity to modify current policies to make sure in terms of driver's time of service and hours of service, that is a longer and larger policy question, and I would clearly have to defer to the agency of expertise.

Mr. PETRI. Yes, sir.

Dr. RAJKUMAR. I would make three more points, Mr. Chairman. First, my understanding is that fuel is the biggest cost factor for the trucking industry. With automation and connected vehicle technologies, trucks could be driving closer to each other on the highways at a uniform speed that would save significant amounts of fuel.

Secondly, those technologies will also allow trucks to drive safely, because they are taking driver distraction out of the equation.

And thirdly, many insurance claims in the trucking industry are the result of accidents that happen in the loading dock. When somebody is trying to pull into the loading dock, they hit something. We can reduce those accidents as well with automation.

Mr. PETRI. Thank you.

One other thing struck me, and I do not know if Mr. Robinson would care to comment on it. Maybe other vehicle manufacturers provide this as well, but the technology is also helping to prevent theft and lower insurance costs in some regard, I guess. Onstar and others, you can call and they can turn your car off, and the police if they get your license number or whatever can call ahead and stop the car on the highway practically, as I understand it today, and that has to mean fewer auto thefts over time.

Mr. ROBINSON. Yes, that is true, Mr. Chairman. We have that capability with Onstar. You know, the lesson in all of this as we are talking about these technologies is the interface between the technologies that have been developed separately, but they have a relationship to one another, and as we get to the V2V types of connectivity that Mr. Strickland and Mr. Steudle are talking about, I think it is just going to enhance all the more these systems that have been developed separately that enhance safety, but collectively are going to do an even greater job.

Mr. PETRI. Thank you.

One final thing for me, and that is that Mr. Christensen and earlier Mr. Robinson and I were talking a little bit about how this is going, and, Mr. Christensen, you seemed to indicate a little more I do not know if you would say optimism or pace by saying you have a target of 2020 for autonomous vehicles. Is that as opposed to a building block approach or is that at a certain benchmark in a building block approach, or what does an autonomous vehicle in 2020 type goal mean?

We do not want to oversell that in 5 years or 10 years there is going to be this car that you tell it's Garmin where you want to go, and then you hop in the backseat and go to sleep and it drives you off to Chicago or something.

Mr. CHRISTENSEN. Yes, thank you, Chairman.

So as I mentioned, our CEO set a very aggressive goal for 2020 for this autonomous vehicle. Primarily by setting these ambitious goals, he feels that that is the best way to drive innovation.

What exactly the vehicle potential is in 2020, honestly it has yet to be determined in terms of the exact capabilities and what will be available. We do completely agree that it is going to be a step-by-step approach. There will be features added to the vehicle, driver assistance features. The vehicle in a way you could say is partnering with the driver moving forward, but we feel that by 2020 we will have a vehicle that has some level of clear autonomous capability that is recognized by the driver.

But, again, there is going to be this balance between what the technology is capable of and what the customer is willing to accept at that point. So our direction is to strive for the best that we can do, the greatest technology, the greatest performance, and balance that with the customer acceptance.

Mr. PETRI. Thank you.

Ms. Norton.

Ms. NORTON. My regrets that I have missed most of the testimony, but I will be interested in being briefed and reading the record.

I met with some of you from GE. I understand that the auto manufacturers, of course, would be most logically developing or interested in developing this technology. Is this really practical?

I asked if anyone had asked about the cost, and I understood that they had. Is this a practical way to approach the car of the future, or do you think that like—I do not know—electric cars or not electric cars, but hybrid cars, that the prices ultimately have come so that they are no longer out of reach?

Mr. CHRISTENSEN. Thank you, Ranking Member Norton.

I can respond to that a little bit. As we move forward, would you let me know your question?

Ms. NORTON. Yes. I want to know if these cars and I understand that someone did ask about the price of the cars, and it was like $100,000.

Mr. CHRISTENSEN. Absolutely.

Ms. NORTON. So I am trying to find out with every kind of technology it costs a great deal in the beginning, and of course with more users the price goes down, and I am wondering how practical it is to even think about driverless cars given what the public expects to pay for a car.

Mr. CHRISTENSEN. So looking forward to 2020, we think that working with our suppliers, we found I will call it a glide path down to an affordable type technology for the certain types of scanners that we are looking at. This has been talked about for many years. Autonomous vehicles have been talked about, and there has been different methods or ways to achieve this in terms of implanting magnets in the road and having the vehicle follow that and what have you, but we are finally to the point that the sensor technology has the capability to provide that recognition that is necessary, and we see that it finally has that glide path down toward an affordable cost, that we should be able to achieve that by 2020. We can see the light at the end of the tunnel basically, that the cost will be affordable within the next 5 to 10 years.

Mr. ROBINSON. The way I would answer your question, Congresswoman, is that we will get there in bites, and we will get there because we are providing value to the customer that they are willing to pay for as these steps are taken.

An example would be that some of the sophisticated active safety systems we are talking about, whether it is adaptive cruise control or automatic braking, initially they would be on premium products. We are introducing those same features on a Chevrolet. The Chevrolet Impala has those features.

Now, we probably could not have visualized that 5 years ago. So my expectation is that we will get there in steps. The technology will be introduced in steps when we get the cost at a level where the customer is prepared to pay for that value and sees that value for the money.

Ms. NORTON. Would it be easier to do this on electric cars than on cars that use every kind of fuel?

Mr. ROBINSON. I do not think the propulsion system has as much to do with it as the technology reliability and durability itself, regardless of whether it is an electric car or a diesel driven car.

Mr. CHRISTENSEN. Yes, there are some advantages from a development standpoint, and we have used our Leaf as a development platform for autonomous vehicles because everything is already——

Ms. NORTON. Say that again. I am sorry. I did not hear you.

Mr. CHRISTENSEN. Our current Nissan Leaf, the electric vehicle, we have used that as our development platform. Being that it is an electric vehicle, everything on the vehicle in terms of the braking and acceleration is already electric. So it is an easy vehicle to adopt.

But we see that the capability of autonomous vehicles can, as Mr. Robinson said, apply to any type of powertrain.

Ms. NORTON. Did you want to? Yes, sir.

Dr. RAJKUMAR. Yes. The autonomous car at Carnegie Mellon is an internal combustion engine vehicle, so you can add the technology to that platform or to an electric vehicle. You need electric power to power the sensors, the computers, and the actuators. It is easier to do that with an electric vehicle, but it can be done on any platform.

Ms. NORTON. I see. Now, do I understand Google was also developing one of these autonomous vehicles? And what does that say about who is likely to be the leader in developing them?

I mean, do you have to know something about cars in order to really do it?

Mr. STRICKLAND. Ranking Member, yes, Google is one of the nontraditional companies that is entering into the automotive space, specifically with the software package to enable a self-driving vehicle in certain modes.

And I think what you will likely see, frankly, in a number of spaces, and clearly the manufacturers can speak for themselves, auto manufacturers are sort of less being seen as auto manufacturers and seen more as just broad technology companies. So you will be seeing the manufacturers, frankly, entering into other spaces regarding to telematics and electronics and these other issues, just like Google is putting their systems onto, I think they are using a Toyota platform.

So you may see, frankly, other nontraditional companies in the manufacturing space in the future years to come as well, but clearly, that also speaks to the fact of what NHTSA's responsibility is as an agency for us to create a regulatory playing field that makes sure that any company that is entering the space is actually producing systems that are safe and reliable, both from electronics and from a performance standpoint.

Ms. NORTON. Is there any place in the world that is ready to actually use autonomous vehicles on the road?

Mr. STRICKLAND. From our work and analysis right now, there is no fully autonomous vehicle that is ready for mass commercialization. As Mr. Robinson and Mr. Christensen noted, each of the manufacturers actually are working on the building blocks now and active safety systems, and I think what you will see is an evolution of these technologies over the years as crashing and braking systems get better, as other sensors, lane keeping gets better and other, frankly, technological innovations, but you will see something approaching a car that is self-driving in certain modes of operation possibly in the future all the way to an automated vehicle.

But at this point NHTSA is not aware of any, you know, vehicle that is fully ready for a commercialized use in a full autonomous mode.

Ms. NORTON. Now, the American manufacturers, and I should ask our American manufacturers, fell behind when hybrid cars came on the road. Where are our car manufacturers relative to the other manufacturers who sell very well in the United States on autonomous vehicles or is this an American thing?

Mr. ROBINSON. Actually, Congresswoman, I think across the board, regardless of where their home base is, whether it is German companies, Japanese companies or U.S.-based companies, everybody is looking at these issues that I know of and have their own test programs.

One of the things that we all have talked about is the need for flexibility because we think the marketplace will help determine the best technologies for the money. Customers have a great way of telling us what they want.

Ms. NORTON. What do you mean by "flexibility"? I am sorry.

Mr. ROBINSON. Not to prescribe a specific approach to solving an issue, for instance, whether it is a crash mitigation system or automated braking system or anything else that we have talked about.

I think it is a great thing to have standard expectations in terms of performance, but let the market decide who has created the best mousetrap, if you will, to solve that problem at the best cost, and so we are all about the marketplace, winning in the marketplace, letting customers decide.

I think the way NHTSA has laid out its framework or its outline for the future, I think, it provides for adaptability. It provides for flexibility in achieving these goals, and I think that is wise.

Ms. NORTON. Mr. Strickland, do you agree with that approach? I mean, is that how you are approaching?

Mr. STRICKLAND. Absolutely, Congresswoman. NHTSA has to basically do its work on performance standards because we cannot anticipate the next great innovation. If you pick a design standard, which is "you have to build this particular car or this particular engine this particular way," you are, frankly, stifling the ability for some future improvement that you cannot anticipate.

As I said, in an earlier question about this, the one evolution in the work in automated driving is performance standards work well in terms of how well a car avoids a crash, how much fuel a car should use, but when you are talking about electronics, where you are basically dealing with hundreds of thousands, millions of lines of code, being able to take in thousands of variables a second for the car that is essentially making a decision, we are likely going to have to move to something like a process standard. What is the way the manufacturers tested and developed their system to be able to take into account all of these things that we expect for proper roadway safety?

And that is going to be a slight difference from what the agency has done in the past, but we think it is, again, what Mr. Robinson alluded to, an even-handed, balanced way to not stifle innovation, but have certain guarantees that there is going to be safe performance of all these systems.

Ms. NORTON. Yes. Build the car, and then we will learn what we have to do to regulate it.

Mr. STRICKLAND. Exactly right.

Ms. NORTON. Thank you very much, Mr. Chairman.

Mr. PETRI. Thank you, and thank you all for your testimony and those who worked to prepare it.

I would ask unanimous consent that the record of today's hearing remain open until such time as our witnesses have provided answers to any questions that may be submitted to them in writing, and unanimous consent that the record will remain open for 15 days for additional comments and information submitted by Members or witnesses to be included in the record of today's hearing.

If no one has any further comments or questions, this hearing is adjourned.

[Whereupon, at 11:50 a.m., the subcommittee was adjourned.]

Congressman Steve Cohen
Prepared Remarks: The Subcommittee on Highways and Transit
How Autonomous Vehicles Will Shape the Future of Surface Transportation
November 19, 2013

- I would like to thank the Chairman and Ranking Member for organizing this hearing on the important and interesting topic of the future of autonomous vehicles.

- My interest in this topic is not only based on whether or not autonomous cars can make our highways safer, but also on how much they can cut down on fuel consumption here in the United States.

- I have concerns about the safety of these vehicles, especially if the future of the freight industry may come to rely upon them.

- I have read many articles about state and local governments across the country—from Florida to Ann Arbor—that are looking to implement autonomous vehicles to save their governments money and expand transportation access for their citizens.

- I am glad to welcome such a diverse panel of witnesses here today to discuss this topic and I look forward to hearing from each of them on how their respective industries are preparing for the future of the driverless car in the United States.

Testimony of
The Honorable David L. Strickland
Administrator
National Highway Traffic Safety Administration

House Committee on Transportation and Infrastructure
Subcommittee on Highways and Transit

Hearing on

How Autonomous Vehicles Will Shape the Future of Surface Transportation

November 19, 2013

Chairman Petri, Ranking Member Holmes Norton, and members of the Committee, I appreciate this opportunity to testify before you on automated vehicles and the implications for the future of surface transportation.

The future of the automobile is extremely bright. Increasingly, a car's capabilities are determined more by its electronics than by its mechanics. This is bringing countless innovations that improve driver comfort, provide useful information and entertainment, and, most importantly, advance safety.

As I have stated in prior testimony before Congress, safety is the National Highway Traffic Safety Administration's (NHTSA) top priority. Our programs are all designed to reduce crashes resulting in deaths and injuries. According to estimates, there were 33,561 fatalities on America's roadways in 2012. This represents an increase of about 3.3 percent as compared to the 32,367 fatalities that occurred in 2011. If these projections are realized, 2012 will be the first year with a year-to-year increase in fatalities since 2005. In addition to the devastation that these crashes cause to families, the economic costs to society reach into the hundreds of billions of dollars. Automated vehicles can potentially help reduce these numbers significantly.

Before getting into automated vehicles, I would like to highlight some of the work the agency has done to improve vehicle occupant survivability, primarily by advancing the vehicle's crashworthiness. Through technologies such as seat belts and air bags, occupants are more likely to survive a crash than they were 20 or 30 years ago. The agency will continue working on improvements to crashworthiness exemplified by recent final rules on roof strength and preventing occupants from being ejected in crashes. Our current research efforts are aimed at developing improvements to our child safety standards; a new frontal crash test for adults, the elderly, and pedestrians; advancing batteries and other alternative fuel research; and improving our understanding of crash injury and impact mechanisms through advanced biomechanics to develop future crash test dummies and models.

Advanced Braking Technologies. At the same time, there are exciting prospects for improving roadway safety through new crash avoidance technologies. Recognizing the promise these technologies hold, the agency has been aggressively pursuing many of the emerging technologies that are now deployed on new vehicles. We believe advanced technologies, such as electronic stability control, can mitigate a crash or even prevent it from occurring in the first place.

To that end, I am pleased to highlight the "Significant and Seamless" initiative that we recently announced. Significant and Seamless aims to address the areas in highway safety where the industry can fast-track existing technology. One major component of the initiative is Forward Collision Avoidance and Mitigation, which is a sensor-based vehicle technology that could detect an imminent forward crash with another vehicle or pedestrian. In 2012, one-third of all police reported crashes involved a rear-end collision with another vehicle as the first harmful event in the crash. The system would alert the driver to take corrective action or automatically apply the brakes to assist in preventing or reducing the severity of the crash.

I believe that the agency's work on crash avoidance research is the foundation for automated vehicles. We are actively evaluating the newest technologies that incorporate active braking in addition to warning drivers to avoid crashes. In particular, NHTSA is focusing its efforts on dynamic braking and crash-imminent braking systems. Such technologies employ radar, camera, lidar or the fusion of these technologies to detect and track vehicles or objects in the forward path and activate the brakes if the driver fails to do so or supplement the driver's braking to avoid or mitigate collisions. We are also evaluating whether enhancements to these systems could be robust enough to detect and avoid pedestrian impacts. The agency estimates that these technologies could impact approximately 900,000 rear-end (vehicle to vehicle) and 29,000 pedestrian crashes each year and thus offer the potential for substantially reducing property damage, injuries, and fatalities associated with motor vehicle crashes. NHTSA is currently evaluating system performance in a variety of crash scenarios and under controlled test conditions to develop new ways in estimating the real world benefits these advanced systems could provide. We sought public comments on our initial findings in 2011 and have now conducted additional analyses and research in response to those comments. Based on its research, the agency has enough data to make an agency decision this year as to pathways to advance market penetration into the rest of the fleet.

Vehicle-to-Vehicle Communications. NHTSA, along with the Research and Innovative Technology Administration (RITA), and the Federal Highway Administration, have greatly accelerated our efforts to initiate and complete research on vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) platforms designed to increase driver situational awareness and reduce and mitigate crashes. We believe V2V technology will complement and ultimately merge with the advanced braking systems and other crash avoidance technologies that we are currently evaluating to shape the future of motor vehicle safety. V2V will give drivers information needed to make safe decisions on the road that cameras and radars just cannot provide. This added capability not only offers the potential to enhance effectiveness of current production crash avoidance systems, but also enables more complex crash scenarios, such as those occurring at intersections, to be addressed. We currently estimate V2V could potentially address about 80 percent of crashes involving non-impaired drivers once the entire vehicle fleet is equipped with V2V technology. This leading-edge technology also holds the potential for improving mobility and benefitting the environment by connecting vehicles not just with each other, but also with road infrastructure.

The V2V program has been developed around Digital Short-Range Communications (DSRC) technology that operates on Federal Communications Commission licensed spectrum. Located in the 5.9 GHz band, the physical characteristics of this spectrum is able to support data from a number of safety applications that require nearly instantaneous information relay. Since this spectrum was first allocated, the Department has conducted significant research developing the concept, supporting consensus standards both in the U.S. and with other Nations, and working with the auto manufacturers on coordinated V2V technology development. The Federal Communications Commission is considering making portions of the 5GHz spectrum, including the 5.9GHz spectrum that DSRC relies on, available to accommodate growing data transmissions from unlicensed devices, such as Wi-Fi. I recognize the FCC will look at "harmful interference" as part of its consideration and would like to note that, in order to provide a reliable and trusted public safety service, current DSRC enabled safety devices require instant availability to the medium to meet safety requirements. In other words, a DSRC transmitter needs to be able to transmit whenever it senses the requirement to transmit, so that the basic safety message is immediately shared with recipients in real time to be useful. Thus, DOT would initially define "harmful interference" with safety as anything that prevents or delays access to the desired channel, or otherwise pre-empts the applications from providing its life safety capability.

For passenger vehicles, we have established a collaborative research effort with a consortium of automobile manufacturers to facilitate the development and are exploring possible deployment of models for V2V communication safety systems. The project is completing the development and testing of several safety applications, addressing interoperability issues, and evaluating safety benefits for a limited set of applications. We started by holding driver acceptance clinics across the country between August 2011 and January 2012. The evaluation included more than 700 drivers who experienced crash warnings while driving vehicles. The feedback from drivers was overwhelmingly positive, with over 90 percent expressing a desire for such a system in their personal vehicles.

This past August, the Department completed the Connected Vehicle Safety Pilot Model Deployment in Ann Arbor, MI. The Model Deployment encompassed various types of vehicles that included a mix of integrated, retrofitted, and aftermarket vehicle safety systems. This program demonstrated V2V and V2I safety applications, interoperability, and scalability in a data rich environment and provided real-world field data that we are using to develop a better understanding of the operational policy issues associated with V2V and V2I deployment. The safety pilot program enlisted approximately 3,000 specially equipped vehicles to operate in day-to-day driving and provided an opportunity to collect the first-of-its-kind real world data that cannot be duplicated in a laboratory setting. It represents the largest test ever of connected vehicles in a real-world environment. Given the potential of this transformative technology, we have accelerated our efforts. NHTSA is using the results from the Safety Pilot and other studies to decide this year whether to further advance the technology through regulatory action, additional research, or a combination of both. We expect to issue decisions on light duty vehicles this year, followed by a decision on heavy-duty vehicles in 2014.

The Federal Highway Administration (FHWA) has actively conducted research in support of developing a cooperative vehicle-highway system that enables vehicle automation. This work includes studying the impacts of platooning commercial vehicles through Cooperative Adaptive Cruise Control, or CACC. CACC will allow significant reductions in the headway between connected-automated vehicles with improved safety at highway speeds, greater use of existing lane capacity, and improvements in fuel economy (up to 20 percent savings). FHWA's other efforts include working with public agencies and vehicle manufacturers to better understand how a connected infrastructure system, including roads, sensors, and traffic control devices, can interact with and support automated or partially automated vehicles. And the FHWA provides the conduit by which the opportunities and challenges of vehicle-highway automation will be coordinated with State Departments of Transportation and local and Tribal agencies.

Automated Vehicles. Recently, traditional and non-traditional auto companies have unveiled research projects to develop what some call "autonomous" (self-driving) vehicles that can perform certain driving functions automatically. These companies identify safety as one of the compelling factors favoring automation. To accomplish the most sophisticated self-driving applications, they envision a system of cameras, radar, lidar, vehicle-to-vehicle communications and other sensors integrated with sophisticated algorithms that can monitor the road in an increasingly wide variety of roadway, weather, and traffic scenarios. Such systems have greater awareness and can more rapidly and reliably make decisions than the average driver. Not surprisingly, this vision has captured the Nation's attention. What was once previously thought of as science fiction and decades away from reality may now appear to be just around the corner, particularly as some of these companies are touting that they will have a commercially available vehicle in the next five years.

Vehicle manufacturers have already begun to offer, and in some cases, such as Electronic Stability Control, NHTSA has already regulated what we call single function automated systems. Manufacturers continue to develop these systems and are now combining functionalities to achieve higher levels of automation. Some vehicle manufacturers indicate that consumers will see some of these more advanced combined systems in the U.S. in the next few years but full self-driving is several years away. NHTSA has been actively involved in researching the near term technologies because we already believe many of them hold great safety promise. For example, NHTSA is engaged in research to evaluate the effectiveness of currently available automated braking systems in avoiding or mitigating crashes. As part of this research, the agency is partnering with a broad set of stakeholders to develop test procedures and to evaluate the technologies and methods to assess their potential safety benefits, as previously mentioned.

NHTSA conceives of these many and varied innovations as three distinct streams of technological change and development that are occurring simultaneously — (1) in-vehicle crash avoidance systems that provide warnings and/or limited automated control of safety functions; (2) crash avoidance systems enhanced by V2V communications; and (3) self-driving vehicles.

The confluence of these three streams of innovation has created a fair amount of confusion in making distinctions between different concepts and in finding commonly understood category descriptions. NHTSA finds that it is helpful to think of these emerging technologies as part of a continuum of vehicle control automation. The continuum, discussed below, runs from vehicles with no active control systems all the way to full automation and self-driving. While NHTSA is conducting research along the entire automation continuum, our emphasis initially is on determining whether those crash avoidance and mitigation technologies that are currently available (or soon to be available) are not only safe, but may also be effective in reducing crashes. Because these same technologies are the building blocks that may one day lead to a driverless vehicle, we have also begun research focused on safety principles that may apply to even higher levels of automation, such as driver behavior in the context of highly automated vehicle safety systems.

NHTSA has proposed definitions for five levels of automation to allow for clarity in discussing this topic with manufacturers, policymakers, and other stakeholders. The definitions cover the complete range of vehicle automation, ranging from vehicles that do not have any of their control systems automated (level 0) through fully automated vehicles (level 4).

Level 0—No Automation. At the initial Level 0, the driver is in complete control of the primary vehicle controls (steering, brake, and throttle) at all times, and is solely responsible for monitoring the roadway and for safe operation of all vehicle controls. Vehicles that have certain driver support or convenience systems, but do not have control authority over steering, braking, or throttle, would still be considered Level 0 vehicles. Examples include systems that provide only warnings (e.g., forward collision warning, lane departure warning, blind spot monitoring) as well as systems providing automated secondary controls such as wipers, headlights, turn signals, hazard lights, etc. Although a vehicle with V2V warning technology alone would be considered Level 0, that technology could significantly augment, and could be necessary to fully implement, many of the technologies described below. Furthermore, it would be capable of providing warnings in several scenarios where sensors and cameras cannot (e.g., vehicles approaching each other at intersections).

Level 1—Function Specific Automation. Level 1 automation involves one specific control function that is automated (note: a Level 1 vehicle may feature multiple automated functions, but they operate independently from each other). The driver still maintains overall control, and is solely responsible for safe operation, but can choose to cede limited authority over a primary control. Examples of Level 1 automation include:

- adaptive cruise control, where the driver sets a specific speed and does not have to continue pressing the accelerator;
- electronic stability control, where the vehicle automatically reduces power to the wheels and/or applies brakes when cornering too aggressively; or
- dynamic brake assist, where the vehicle automatically provides additional braking power if it senses that the driver's braking input is insufficient to avoid a collision.

The vehicle may have multiple capabilities combining individual driver support and crash avoidance technologies, but it does not replace driver vigilance and does not assume driving responsibility from the driver. The vehicle's automated system may assist or augment the driver in operating one of the primary controls—either steering or braking/throttle controls (but not both). As a result, there is no combination of vehicle control systems working in unison that enables the driver to be disengaged from physically operating the vehicle by taking hands off the steering wheel *and* feet off the pedals at the same time.

Level 2—Combined Function Automation. Level 2 automation involves at least two primary control functions designed to work together to relieve the driver of control of those functions. Level 2 automated vehicles share authority allowing the driver to cede active primary control in certain limited driving situations. Combining adaptive cruise control with lane keeping assistance would be an example of Level 2 automation.[1] The driver is still responsible for monitoring the roadway and is expected to be available for control at all times and on short notice. The system can relinquish control with no advance warning and the driver must be ready to take control of the vehicle safely. The major distinction between Level 1 and Level 2 is that, at level 2, in the specific operating conditions for which the system is designed, the driver can disengage from physically operating the vehicle by taking hands off the steering wheel *and* feet off the pedals at the same time.

[1] Adaptive cruise control utilizes sensors (often radar) to automatically adjust speed to maintain a safe distance from vehicles ahead. Lane keeping systems will automatically take steps (through steering adjustments) to keep the vehicle in its lane if sensors detect that the vehicle will depart from the lane.

Level 3—Limited Self-Driving Automation. Level 3 automation enables the driver to cede full control of all steering, brake, and throttle functions to the vehicle. The driver is expected to be available for occasional control, but with a comfortable transition time that will enable the driver to regain situational awareness. The vehicle is designed to ensure safe operation during the automated driving mode, observing all rules of the road. An example would be an automated or self-driving car that can determine when the system is no longer able to support automation, such as entering a construction area. At this point, the vehicle signals the driver to reengage the driving task. The major distinction between Level 2 and Level 3 is that, at Level 3, the vehicle is designed so that the driver is not expected to constantly monitor the roadway while driving and provides sufficient time for the driver to reengage in driving.

Level 4—Full Self-Driving Automation. The vehicle is designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. Such a design anticipates that the driver will provide destination or navigation input, but is not expected to be available for control at any point during the drive. This includes both occupied and unoccupied vehicles. By design, safe operation rests solely on the automated vehicle system.

By ensuring that our research plan includes the entire automation continuum, the agency strives to remain knowledgeable about the full range of potential benefits and risks of increasing vehicle automation. The agency's work on automated vehicles is designed to—

- address safety questions about driver engagement and re-engagement across levels of automation;
- evaluate concepts of operation and development of system requirements; and
- provide guidelines for automated sensing and control.

As we continue our work on Level 1 automation and our efforts to calculate the safety benefits that those single-function systems may offer in the near term, we have begun new research on Levels 2-4. NHTSA is working cooperatively with other DOT agencies on this research, given its relevance to the intermodal Intelligent Transportation Systems program. We are also engaged in a broader policy development process across the Executive Branch. For our part, we have identified three key areas for preliminary research—(1) human factors and the human-vehicle interface; (2) initial system performance requirements; and (3) electronic control system safety. NHTSA's research will inform policy decisions, assist in developing an overall set of requirements and standards for automated vehicles, identify any additional areas that require examination, and build a comprehensive knowledge base for the agency as automated system technologies progress.

Recommendations for State Actions Concerning Self-driving Vehicles. Several states have enacted legislation expressly authorizing operation of "autonomous" vehicles within their borders under certain conditions. Generally, these laws seem to contemplate Levels 3 and 4. We offer these recommendations to state drafters of legislation and regulations governing the licensing, testing, and operation of self-driving vehicles on public roads in order to encourage the safe development and implementation of automated vehicle technology, which holds the potential for significant long-term safety benefits. In general, we believe that states are well suited to address issues such as licensing, driver training, and conditions for operation related to specific types of vehicles. However, in light of NHTSA's relative expertise and national regulatory authority over vehicle safety, and given the quickly changing technologies involved, we are concerned about whether state regulation of the automated vehicle technologies (as opposed to their operators or operations) is feasible or advisable. Such regulation at this time may stifle innovation needed to improve safety and reliability. Should states adopt standards for the regulation of automated vehicle technologies, NHTSA will need to evaluate their relationship to Federal Motor Vehicle Safety Standards. Moreover, we do not recommend at this time that states permit operation of self-driving vehicles for purposes other than testing.

While the agency does not believe that self-driving vehicles are currently ready to be driven on public roads for purposes other than testing, I would like to emphasize that we are encouraged by innovations in automated driving and their potential to transform our roadways. For states interested in enacting legislation to support self-driving vehicles, NHTSA recommends that states—

(1) Ensure that the driver understands how to operate a self-driving vehicle safely through a driver-licensing program.
(2) Ensure that on-road testing of self-driving vehicles minimizes risks to other road users. This includes certifying that the vehicle has already operated for a certain number of miles in self-driving mode without incident prior to testing the vehicle on public roads.
(3) Limit testing operations to roadway, traffic, and environmental conditions suitable for the capabilities of the test self-driving vehicles. We encourage states to consider appropriate limitations on the conditions in which a vehicle may be operated in self-driving mode.
(4) Establish reporting requirements to monitor the performance of self-driving technology during testing.
(5) Ensure that the process for transitioning from self-driving mode to driver control is safe, simple, and timely.
(6) Ensure that test vehicles have the capability to detect, record, and inform the driver that the automated systems have malfunctioned.
(7) Ensure that installation and operation of any self-driving vehicle technology does not disable any Federally required safety features or systems. Federal law prohibits making inoperative any Federally required safety system and the installation of self-driving technologies should not degrade the performance of any of those Federally required systems or the overall safety of the vehicle.
(8) Ensure that self-driving vehicles record information about the status of the automated control technologies in the event of a crash or loss of vehicle control.

NHTSA does not recommend that states authorize the operation of self-driving vehicles (Levels 3 - 4) for purposes other than testing at this time. We believe that there are technological and human factor issues that must be addressed before self-driving vehicles can be made widely available. Self-driving vehicle technology is not yet at the stage of sophistication or demonstrated safety capability that it should be authorized for general driving purposes. As innovation in this area continues and the maturity of self-driving technology increases, we will reconsider our present position on this issue.

Driver Vehicle Interfaces for Warning Systems and Automated Vehicles. Recognizing the risks of driver distraction, vehicle warning systems introduce a new set of challenges to the driver. Many current crash avoidance systems provide a warning to the driver, expecting the driver to take appropriate action (engage the brake or steer) to avoid a crash. In order to determine if regulations or standardization is needed, there are several issues we need to understand better, such as: will the driver understand the warning systems when they activate given the variety in the vehicle fleet, will the driver become startled if the vehicle intervenes to avoid a crash, or is there a better way to warn the driver?

We are conducting extensive human factors research with the goal of developing requirements for the driver-vehicle interface for automated vehicles. The objective is to ensure that drivers can safely and seamlessly transition between automated and non-automated vehicle operation, and that any additional information relevant to safe operation is effectively communicated. The research will primarily focus on Level 2 and 3 systems. As new automated driving concepts emerge, we will evaluate the need for driver training in automated systems. Additionally, NHTSA will be developing test and evaluation tools (simulators, test vehicles, etc.) to evaluate driver and system performance for various automated vehicle concepts.

As a first step toward completing research on these issues, the agency is evaluating emerging Level 2 and Level 3 system concepts to answer fundamental human factors questions. The evaluation will examine how drivers react and perform in these types of automated vehicles. In addition, we will consider driver vehicle interface concepts that may be needed to ensure that drivers safely transition between automated driving and manual operation of the vehicle. Ultimately, we want to improve motor vehicle safety by defining the requirements for automation in normal driving that are (1) operationally intuitive for drivers under diverse driving conditions; (2) compatible with driver abilities and expectations; (3) supportive of improving safety by reducing driver error; (4) operational only to the extent granted by the driver and always deferent to the driver; and (5) secure from malicious external control and tampering. Through this research, we hope to develop recommendations for specific requirements needed for the driver-vehicle interface to allow safe operation and transition between automated and non-automated vehicle operation.

As you can see, the promise of advanced vehicles that can avoid crashes is extremely bright. While there are certainly risks with any emerging technology, I firmly believe that, when this risk is properly identified, understood, and mitigated, we can minimize it and fully reap the potential benefits. There are a lot of exciting innovations coming, and NHTSA is working hard, as it has done in the past and will continue to do in the future, to ensure that all vehicles on the Nation's roadways are safe and reliable. I thank you again for this opportunity to testify, and I am happy to take questions.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

AASHTO

THE VOICE OF TRANSPORTATION

TESTIMONY OF

THE HONORABLE KIRK STEUDLE

DIRECTOR,
MICHIGAN DEPARTMENT OF TRANSPORTATION

ON BEHALF OF

THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

REGARDING

How Autonomous Vehicles Will Shape the Future of Surface Transportation

BEFORE THE

SUBCOMMITTEE ON HIGHWAYS AND TRANSIT
COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE
UNITED STATES HOUSE OF REPRESENTATIVES

NOVEMBER 19, 2013

100 YEARS AASHTO THE VOICE OF TRANSPORTATION 1914–2014

American Association of State Highway and Transportation Officials♦444 North Capitol Street, N.W., Suite 249, Washington, D.C. 20001♦202-624-5800

Introduction

Chairman Petri, Ranking Member Norton, and Members of the Subcommittee, thank you for the opportunity to share the American Association of State Highway and Transportation Officials' (AASHTO) views on autonomous vehicles and how they will affect the future of transportation. My name is Kirk Steudle and I am the Director of the Michigan Department of Transportation. I am also a current member of the AASHTO Board of Directors and past President of AASHTO. Today I am proud to testify on behalf of AASHTO, a non-partisan, non-profit association that represents the State departments of transportation (DOTs) of all 50 states, Washington, D.C. and Puerto Rico, which will be commemorating its 100^{th} anniversary in 2014.

First of all, I would like to thank you, Mr. Chairman, and this subcommittee for your role in the development of national surface transportation policy, which contributes greatly to the improvement of highway and transit facilities across the country, the implementation of critical transportation safety and research programs, and the regulation of commercial motor vehicle operations. It is therefore very logical that this committee would bring forth a topic that speaks directly to the future of our transportation system – and the not-too-distant future, at that – autonomous vehicles.

Numerous research consortia, academic institutions, government agencies, and private sector industries are working on various aspects of bringing to life a viable driverless vehicle. No longer the work of science fiction, a fleet of autonomous vehicles will, in all likelihood, be driving our roads and highways in our lifetime. The benefits will be numerous: a significant reduction in crashes and the associated deaths and injuries; greater efficiencies in the use of our limited infrastructure; and increased mobility options for underserved communities such as the elderly and disabled, not to mention many benefits we presently cannot begin to predict.

The Big Picture

I believe it is best to start my testimony today with a view of the big picture of autonomous vehicles and how they will change our lives and affect the way we travel. In reality, autonomous vehicles are a means to achieving the larger goal of a modern society which maintains and operates the safest and most efficient transportation system possible. It is clear that autonomous vehicles have the potential to help us reach this bigger goal. We in the transportation industry can now envision a future with accident-free vehicles; vehicles that can at times drive by themselves; and vehicles, drivers, and transportation infrastructure that are connected safely and securely for reliable information sharing.

To reach this ultimate goal, many years of research, testing, and evolution of vehicles, technology, and infrastructure will have to take place. And this evolution will include a wide range of enabling technologies and opportunities, from sensor-based information to wireless communications between vehicles and vehicles with the infrastructure, and other technologies we haven't even thought of yet. We do not want to limit our options or reduce the possibilities of what research and technology could produce in the next 5, 10, or 20 years – We must look at all options and combinations of options for achieving this tremendous vision of safety and mobility in the future. It will undoubtedly take time to achieve the vision we set out today as technology becomes refined and accepted by consumers. New vehicles typically represent approximately 6-7% of the total automotive fleet; consequently, a typical market penetration curve would reach 50% of the vehicle fleet in 7 to 8 years, assuming all vehicles are to be fully equipped and no unforeseen events disrupt market adoption. Therefore, decisions that we make must consider the evolutionary process that will take us from the grand visions of today to the realities of tomorrow.

The Benefits

It is exciting, however, to think about the possibilities that connected and driverless vehicles present, none of which is more important for human society than potential safety benefits. 5.3 million police-reported vehicle crashes occurred in the United States in 2011, resulting in about 32,000 fatalities and more than 2.2 million injuries. According to a 2008 National Motor Vehicle Crash Causation Survey conducted by NHTSA, around 90% of all crashes have some human contribution attached. Currently, crashes can only be avoided by what the driver can see. Humans are unable to see around the corner of a building, over the crest of a hill, or past a large obstacle such as a freight truck, among others. If we take the driver out of the equation and replace him with sensory and communications equipment capable of "seeing" and "talking to" other vehicles and the infrastructure – especially those that cannot be seen by the naked eye – we have the potential to reduce vehicle crashes significantly. Examples of some of the safety technologies include:

- Warnings of potential crashes before they happen (either through sensor technology for vehicles within sight or short-range communications for hazards that are not visible to the driver)
- Avoidance technology to steer away from or around an obstacle
- Automatic braking to react more quickly than humanly possible
- Extended green or yellow time on traffic signals if approaching too quickly to stop
- Traffic signal override to give emergency vehicles the green (currently possible for ambulances, police, fire)

Data in a 2012 NHTSA Fatal Crash Analysis survey shows that more than 40% of fatal crashes involve alcohol, distraction, drug involvement, and/or fatigue. At the very least, fully autonomous vehicles, if realized, can make up for human failings of this nature. Connected-vehicle technology, itself, (which involves communication between vehicles and with the infrastructure), has the potential to mitigate up to around 80% of unimpaired crashes, according to a study by KPMG and the Center for Automotive Research.

At some point in our lives, a majority of us will be disabled in one way or another, whether it is temporary due to injury (such as a broken arm or leg) or more permanent, such as from a disease (Parkinson's, epilepsy, etc.). Many of us have already experienced being driven to and from school or work, doctor's appointments, or running errands. An autonomous vehicle, even with just a few technologies, could significantly improve mobility for those who are temporarily or permanently disabled by reducing or eliminating their reliance on outside assistance for transportation. This, in turn, could reduce the need for "demand-response transit" and other services that are currently provided by governments across the country. It should be noted, however, that current technology has its limits and states that have already enacted laws related to driverless vehicles (including California, Nevada, and Florida) have mandated that drivers be able to take over control of the vehicle should it be required.

In addition, if we are fortunate enough to live past retirement age, we will be senior citizens with vehicle needs that go beyond the typical driver. Transportation professionals and the automobile industry are already accounting for the "baby boom" generation's aging (including such things as reduced reaction times and physical mobility) by increasing the size and legibility of road signs and providing in-vehicle assistance such as back-up cameras and brake assistance. Autonomous vehicles will provide increasing mobility options to our aging population.

It is not just vehicle operators who will see benefits of safety improvements. Pedestrians, cyclists, and motorcyclists could enjoy safety benefits assuming the technology can one day be equipped to detect sizes and shapes of different "obstacles." Finally, American society stands to save not just lives, but dollars as well. A study by a UT-Austin researcher projects a $17.7 billion, $158.8 billion, and $355.4 billion dollar comprehensive cost savings from a reduction in crashes in scenarios with 10%, 50%, and 90% market penetration rate, respectively.

We stand to see benefits from increased mobility and efficiency as well. The reaction time of a human driver is significantly slower than that of a computer – 2.5 seconds for perception and then reaction to an event is typical – so both safety and mobility can be improved with the addition of computerized systems in vehicles to assist in the driving task. Because cars will be able to react to each other more quickly, they will be able to drive closer together, allowing the transportation systems to operate more efficiently with fewer slow-downs caused by crashes and sudden movements, all while increasing the number of vehicles per lane-mile. To put this in numbers, the Urban Mobility Report prepared by the Texas A&M Transportation Institute indicated that congestion in 498 urban areas during 2011 accounted for 5.5 billion hours of extra time and 2.9 billion gallons of wasted fuel at a cost of $121 billion annually. The cost to the average commuter was $818 in 2011. To slash these numbers would add significant economic activity into the American economy and make both passenger- and freight-travel more efficient.

The System of the Future

Let us now get back to grand picture. As we look to the future, we see a more automated and seamless transportation system interacting daily with a drastically different society. In 20 years, the influx of advancements in sensor technologies and the beginning of interconnected communications between cars, infrastructure, and the surrounding environment will start to make a sizable dent in the number of crashes, injuries, and fatalities occurring on our highways. It will also reduce congestion by allowing cars to travel closer together, and improve the mobility of citizens who depend on transportation to get them from point A to point B. Fifty years from now, an interconnected fleet of vehicles, interacting with each other as well as with the infrastructure, and connected seamlessly to other modes of travel including high-speed rail, aviation, and transit, could take you – on verbal command – from your origin to your destination without incident and without a driver. The vehicle you use might be subscription-based, and you would have access to whatever style of vehicle you need for the trip you are making – whether single-occupant commuting to work, vacation with the family, or trip to Home Depot.

It is also entirely possible that the way we design and build transportation infrastructure could change dramatically. With potentially "crash-less" cars, the need for extra-wide lanes, guardrails, rumble strips, wide shoulders, even stop signs could decrease exponentially. The footprint transportation would leave on the environment would be reduced and decreases to costs would be very noticeable. Even conservative estimates of a 10 percent reduction in infrastructure investment would result in billions of dollars in savings to users and taxpayers. A recent research study showed that based on a 10% discount rate, annual comprehensive costs savings are estimated to be $37.6 billion, $206.8 billion, and $434.7 billion for a 10%, 50%, and 90% market penetration, respectively, while comprehensive cost savings per autonomous vehicle would be $3,120, $4,580, and $6,680 for the same penetration rates. When looking at the net present value of automated vehicle benefits, minus the purchase price, one sees comprehensive cost savings of $13,730, $29,840, and $47,810, based on those same penetration rates. If these figures are even close to accurate in the future, it will represent a fundamental change in the economic footprint left by the transportation sector and will make our society more modern, more interconnected, and safer than ever before seen on wheels.

Challenges

The technology of both autonomous vehicles and connected vehicles/infrastructure are not without its challenges, unknowns and implications. First, with more people being able to drive, potentially significant increases in wear and tear on infrastructure could occur, albeit possibly tempered by lighter vehicles, which could counter the decreases in infrastructure expansion that I mentioned previously. In any case imaginable, especially given our current aging infrastructure, infrastructure investment will need the full-attention of policymakers in the coming years. This is not even mentioning the investment needed to equip vehicles and to retrofit pieces of roadway infrastructure with technologies or higher grade materials to accommodate autonomous vehicles, regardless of the technologies used. For example, sensor-based systems will need assurances of well-maintained or even more reflective pavement markings and traffic signs that are readable by computers, while communications systems will need periodic signal repeaters along the roadway corridors. We need a fuller picture of these potential scenarios and related costs to come up with a precise analysis of the benefits and costs so, at the very least, those who work on our transportation network can more accurately plan for the future.

Another pressing challenge will be on the legal front when discussing liability, licensing, and regulatory issues. If autonomous vehicles and connected technology become more prevalent, states will be pressed to develop regulations and policies to accommodate the changing landscape. How quickly the technology develops will determine how quickly states may need to pass the legal and regulatory framework necessary. Some issues will include liability for potential accidents, insurance regulations on autonomous vehicles, and overarching federal mandates on future technologies.

Security and privacy will also become larger issues, as well, relative to the development of this technology. We as Americans have already started conversations on the privacy and security of this type of data. However, when the data are coming from something as personal as an automobile, privacy and security issues become paramount. Data sharing could prove problematic for those who do not wish to have their private lives out in the open. Questions have already been posed by researchers and will need to be answered in the coming years regarding what data will be shared, with whom it will be shared, in what way will it be made available, and for what ends will it be used. Also, could cars be hacked? Disruption via viruses could cause nationwide disruption to the transportation system, which would devastate the economy and all segments of society. Risks of such an attack would have to be mitigated so as to protect the well-being of those in the transportation network and the infrastructure investment.

A challenge that is specific to the connected vehicle program and the safety applications that are being planned to prevent crashes is the need for fast and secure communications—faster than currently available with traditional cellular communications. Dedicated short-range communication (DSRC) is uniquely suited to this type of safety application because it provides fast network acquisition, low latency, high reliability, priority for safety applications, interoperability, security, and privacy. AASHTO, U.S. DOT, and numerous automobile manufacturers have been specifically researching this complex matter. To test this technology, US DOT is sponsoring a pilot test called the Safety Pilot Model Deployment (Safety Pilot), which is being conducted by the University of Michigan Transportation Research Institute and is taking place in Ann Arbor, Michigan, from August 2012 to February 2014. The primary goals of this pilot are to test the effectiveness of vehicle-to-vehicle technologies in real-world situations and to measure their potential benefits. Tests involve:

- hardware to send and receive data among vehicles,
- software applications to analyze data and identify potential collisions,
- vehicle features that issue warnings to drivers of these potential collisions, and
- a security system to ensure trust in the data that are being communicated among vehicles.

In total, about 2,700 passenger vehicles are equipped with these technologies in order to participate in the Safety Pilot. Due to the potential to positively transform highway safety, NHTSA is considering requiring DSRC communication technology on new cars in the future, and a decision is expected in the next month or so.

There are deployment issues to confront as well. The potential benefits of vehicle-to-vehicle technologies, vehicle-to-infrastructure technologies, and autonomous vehicles are dependent upon a number of factors including: their deployment levels; how drivers respond to warning messages; and the deployment of other safety technologies that can provide similar benefits. According to USDOT, the safety benefits of vehicle-to-vehicle technologies will be maximized with near full deployment across the U.S. vehicle fleet, but that does not mean that benefits will not be realized in the interim. Even if NHTSA pursues a rulemaking requiring installation of these technologies in new vehicles, it could take a number of years until benefits are fully realized due to the rate of turnover of the fleet. According to one automobile manufacturer interviewed by GAO, given the rate of new vehicle sales, it could take up to 20 years for the entire U.S. vehicle fleet to turn over.

There are also a number of issues that State DOTs will have to confront over the coming years as connected vehicle technology and automated vehicles become more commonplace. We as an industry will have to determine the necessary performance expectations of roadway infrastructure to adequately support the technical needs of driverless vehicles and how these increased performance requirements will be funded. It is also prudent and necessary to think about the interim timeframe when both potentially autonomous and non-autonomous vehicles will be on the roadway. Higher retro-reflectivity of signs and pavement markings and added transition zones for engagement and disengagement of autonomous features will be needed in a mixed scenario before the fleet and the infrastructure is fully switched over. In addition, recovery zones may be needed should a vehicle cease to function properly or a driver fails to re-assume positive control of an autonomous vehicle. These are just a few examples of the potential infrastructure upgrades that will need to be studied in fuller detail.

Michigan Experience

The Safety Pilot Model Deployment, as well as other connected vehicle test bed activities undertaken in Michigan, has provided insight into what we can be prepared for as new technologies are adopted into our transportation system.

One of the critical areas for success of the deployment of these advanced systems is the interoperability of the technology between different makers of field and automobile systems. The success of the Safety Pilot in Ann Arbor has shown that this level of interoperability is most definitely achievable; this level of focus will have to be maintained in order to ensure functional, safe systems regardless of who makes these systems, and regardless of where in the country they are used.

We talked about the challenges of data privacy before. One thing we have found is that these systems are generating massive amounts of data – as a matter of fact, more data than we expected when we first began deployment efforts. With this influx of "Big" data, the need for ensuring the privacy of the data and the data generators, and the ability to process it into useable information, becomes focused much more into the center stage.

These new technologies and amount of data also present an additional challenge for most transportation agencies across the country. This technology requires a set of skills to develop, operate and maintain that traditionally haven't been associated with public transportation agencies. Agencies will need to be flexible in developing and recruiting a workforce with the advanced technological skills needed to develop, operate, and maintain these sophisticated hardware and software networks.

Recommendations

So, how do we go forward from here? There are several recommendations I would offer to this committee and the Congress on how to most effectively prepare for this sea-change in the way surface transportation functions.

The first will be to encourage NHTSA to make a decision on vehicle requirements later this year. NHTSA is planning to announce further actions it will take regarding connected vehicle technologies for passenger vehicles, including potentially announcing intent to pursue future regulatory action such as a proposed rulemaking to mandate the installation of vehicle-to-vehicle technologies in newly manufactured passenger vehicles. The 2013 NHTSA decision will determine the future of connected vehicle technology for safety. If NHTSA pursues a rulemaking on safety applications, vehicles equipped with dedicated short-range communications (DSRC) may begin rolling off the production line in late 2019. These vehicles would broadcast information such as their location, speeds, and direction of travel through the high-speed communication of DSRC. How quickly this technology moves forward will depend greatly on this very important decision. Having resolution here is critically important.

It is also necessary to protect the DSRC's 5.9 GHz spectrum for the connected vehicle program and ensure that the possible sharing with other wireless users of the radio-frequency spectrum used by vehicle-to-vehicle communications will not adversely affect the technology's performance. This spectrum provides us the most promising attributes necessary for connected vehicle/infrastructure technology. The President and Congress have responded to growing demand for wireless broadband services by making changes in the law to promote efficient use of spectrum, including the band previously set aside for use by DSRC-based technologies. We would urge that the Congress be prudent about this specific spectrum since it may be critical to the success of the connected vehicle and infrastructure technology.

Finally, there are several measures that can be taken during the next round of Surface Transportation reauthorization. The Congress has the potential to make significant strides with this new technology depending on measures placed in the reauthorization of MAP-21. Additional funding for research is necessary to more fully understand the breadth of possible operating scenarios and implications that autonomous vehicle technology and connected vehicle/infrastructure technology will have on society. These include studies on market penetration evaluations, transition issues with mixed fleets of autonomous and non-autonomous vehicles, performance and system reliability issues, changes to travel demand patterns, alterations to vehicle-miles traveled and vehicle emissions, integrated automated vehicle and intelligent transportation systems (ITS) infrastructure investigations, and potentially necessary federal mandates to operate a seamless automated system in the future.

Your support is also sought in continuing the collaboration that has been underway for several years between the USDOT, State DOTs, and global automakers. The cooperation between these three entities might very well determine the success of these technologies and their potential integration into the transportation system. One such example could be support for the Center for Operations Excellence, which is being jointly developed by AASHTO, the Institute of Transportation Engineers (ITE), ITS America and FHWA. The Center will be able to help address implementation issues with the conversion of connected vehicle/infrastructure and autonomous vehicle technologies. This venture, which is being established now, will be funded and jointly operated by AASHTO, ITE, ITS America, and FHWA and could serve as an important tool for governments in their transition to more autonomous transportation systems.

Chairman Petri, I once again thank you and your committee for allowing me to speak on this very exciting and important development in the transportation industry. Surface transportation has been drastically changed with the advent of computer technology, and automated and connected vehicles stand as the next stepping stone toward our goal of delivering a safer, more efficient transportation system for our country. I will be happy to answer any questions the committee might have.

Committee on Transportation and Infrastructure
Subcommittee on Highways and Transit
Hearing on "How Autonomous Vehicles Will Shape the Future of Surface Transportation"
November 19, 2013
Questions for the Record

Questions from Rep. Don Young

1. ***When you refer to an "autonomous vehicle," what role, if any, do you see the driver having?***

   For the foreseeable future all the "autonomous vehicles" will require a licensed driver to be present in the vehicle, and operating the vehicle. There are currently no commercially available vehicles that can function without a driver. Ultimately, though, this is left up to the discretion of each state through their version of the state Vehicle Code. Off of public roadways (such as at a research institution, or at a private manufacturing or testing site), it is entirely possible, though, that automated vehicles are being "driven" autonomously, without a human operator or driver present.

   Automated vehicle technology is being developed by most if not all of the global vehicle manufacturers and their suppliers, and some are saying that within five years they may have production vehicles that can automate a lot of the driver functions. This added functionality, though, is not expected to completely replace the driver, and a driver/operator is expected to still be required in these vehicles.

   One of the key focus points of automated vehicle technology development is the transfer of control between the automated vehicle system and the driver, including the parameters for when and how this transfer occurs.

2. ***Does a driver need to be available to assume control?***

   Yes, the current near term expectations is for the driver to be always available for either direct control of most vehicle functions, or be available to take back control from the automated vehicle systems at critical times. There are many issues left to resolve, including the public's acceptance and ultimate demand for this technology. In the meantime over the next few years we should expect to see much developmental work underway from both the government and industry sides, and an incremental market introduction of driver assist components that may be part of a future true automated vehicle/autonomous vehicle system. This is a topic we should both support and challenge as the development unfolds.

Testimony of
Michael J. Robinson
Vice President, Sustainability and Global Regulatory Affairs
Before the House Transportation and Infrastructure Subcommittee
On Highways and Transit
("How Autonomous Vehicles Will Shape the Future of Surface Transportation")

Good morning, and thank you for the opportunity to participate in this very important hearing. The role that technology is already playing – and will increasingly play in the future -- to assist the drivers of our vehicles in managing the various conditions and circumstances that they encounter on the highways is fascinating to plan for and be a part of.

Technology advances have been a part of our business and our products since the early days of the automobile. GM is proud to have invented many things that we take for granted these days, like the electric starter; the first all-steel body; the first production vehicle with air bags; the first catalytic converter; safety glass in all locations and OnStar. These "firsts" – among many others -- have helped advance vehicle technology and safety over the decades. Combined with more sophisticated crash test dummies, increasingly rigorous crash test scenarios, and emerging test protocols to evaluate active safety technologies, the advancements to auto performance and safety have been remarkable.

So it is not surprising that GM is investing in technologies that provide increasing levels of driver assistance and vehicle management. And even better, we are working on systems that do not require dramatic upgrades or modifications to the national highway infrastructure network.

To the greatest degree possible, the goal is to keep the systems contained within the vehicles and between vehicles -- with one of the key highway needs being to provide -- at a minimum -- clearly marked lanes and shoulders. This will enhance the capabilities of the technologies we are already using to "sense" the road, such as radar, ultrasonic sensors and cameras, along with GPS location capabilities, to assist the driver.

Our work has taken us a long way. We're making important steps in implementing active safety technology -- but there is still much work to be done before a fully autonomous vehicle can be commercialized.

Over the past two years the media has devoted much attention to the idea of a "self-driving" car. Everyone from traditional automotive companies and technology companies to universities have had something to say and in some cases a technology to demonstrate. These demonstrations are both interesting and exciting, as they stretch our imagination to think about what the future may be like.

For the most part, as the name implies, people assume that an autonomous vehicle will take you to your destination without your involvement -- after simply issuing a command -- without any oversight by the driver.

Let me say for the record, that these types of systems are a significant distance into the future. Realistically, we expect that for the foreseeable future, while systems will add automation to support the driving task, the driver will still need to be engaged and in control. This is because driving is a very complicated task, and it will take some time for computer-driven systems to be capable of managing and reacting to all of the situations that drivers encounter. In addition, the existing U.S. car parc numbers hundreds of millions of vehicles. So even as we promote more and more technology to enhance this capability, we should expect it to take a generation (or more) for this technology to be commonplace and reach the level of "driver freedom" that some envision.

For GM, the underpinnings of this debate started in 1948, when Ralph Teetor invented what eventually became the modern Cruise Control. Noteworthy is that it was not until 1958 that the system was integrated into a production automobile. Even then, the systems were not standard -- and they were very pricey. Most consumers during that time felt that their money had better uses – and they could just depress the accelerator pedal themselves.

Still, the advent of Cruise Control was the first time that some aspect of vehicle control was allowed to be removed from the driver. It was not designed for safety – but more of a customer convenience feature.

Today, GM offers "Adaptive Cruise Control" (ACC) on several vehicles, which is an example of the "building blocks" we are developing toward more automated systems of the future. ACC is an intelligent form of cruise control that slows down and speeds up the vehicle automatically with the traffic ahead. Like normal cruise control, the driver sets the speed – but there is also a gap setting. ACC is typically paired with a collision warning system that alerts the driver of a potential collision ahead -- and may also be equipped with a system that begins braking before the driver might have time to react. Such systems provide great driving assistance, but they do not replace the oversight that the driver must provide.

GM has talked publically about taking this type of system to the next level – for example, adding the ability of the vehicle to maintain lane control. We call this more advanced system "Super Cruise" – and expect that it will provide even greater assistance to drivers, including hands-free capability on certain freeway drives. This system, too, though, will require a driver's supervision. We believe that this type of technology is realistic in the amount of automation that can be brought to market yet this decade. In fact, *Popular Mechanics* named GM's Super Cruise semi-automated driving technology a winner of its ninth annual Breakthrough Awards that recognize innovators and products that advance the fields of technology, medicine, space exploration, and automotive design.

Currently, the definition of autonomous/automated technology is being discussed and frequently is interpreted in different ways. NHTSA's recent document entitled "Preliminary Statement of Policy Concerning Automated Vehicles" really starts to frame that discussion, and will provide the basis for the collaborative work that will need to be done among the various involved players down the road. NHTSA has indicated that it intends to regularly review and update this document based on the development of technology and new opportunities. The Society of Automotive Engineers (SAE), and organizations like the German automobile association (VDA) in Europe, are also working on similar documents.

At the same time, we are also seeing that a number of states are – or plan to become -- involved in defining, guiding or regulating autonomous technology implementation. We have already seen states introduce and consider legislation, and in a few cases pass legislation regulating autonomous vehicles. GM understands the intentions behind these regulations, but for now, we believe they are premature. In some cases, states could unintentionally or needlessly restrict vehicles already on the road – or technology development and implementation that is underway. We hope NHTSA will lead the way here – so we are working with one federal approach to addressing automated technology – and not a patchwork of various state attempts to become involved.

One of the benefits of greater automated control of the vehicle is the additional highway safety it can provide. Technologies that provide incremental assistance to the driver to better manage the task of keeping the vehicle under control are good for safety and can minimize the potential for or likelihood of crashes. In the coming years, automated driving systems paired with advanced safety systems, could help reduce the severity of a crash, or in some cases eliminate many crashes by interceding on behalf of drivers before they're even aware of a hazardous situation.

In addition to the obvious highway safety benefits, wide implementation of these systems could offer potentially significant benefits for improved fuel economy and CO_2 reduction. Also, eliminating -- or virtually eliminating -- crashes could have profound impact on how we engineer vehicles for occupant safety and crash worthiness. It will give us an opportunity to take a fresh look at how we design body structures to manage crash energy. Consequently, there may be opportunities to reduce vehicle mass and engineer vehicles differently. Finally, the ability to sense other cars, traffic congestion and even pedestrians would allow for smoother traffic flows, reduced noise, less pollution and overall enhanced safety.

So, you may ask "how can we get this technology on the road faster -- what can we do to support it and move it along?" Let me mention three areas that will be important to us as we pursue these technologies:

1. Let the market work -- let manufacturers like GM do what we do best and compete for customers with features that add real value to their drive today and in next generation models;
2. Support a federal approach to addressing any relevant operating requirements, guidelines and standards -- so that automated technologies and connected vehicle communications are consistent, validated and secure. Also, a reasonable phase in period for any requirements is critical; and finally
3. Provide an environment that promotes the development and implementation of these technologies in the U.S. -- rather than in other countries. For example, protecting

automakers from frivolous litigation for systems that meet performance requirements and relevant government operating standards.

In conclusion, moving towards significant levels of autonomy in vehicle control are worth our best efforts. For now, they will come forth incrementally -- as technologies are proven to be durable, reliable and cost effective for our customers. They may not result in "driver-less" vehicles for many years to come – but the benefits of even the steady incremental changes we are making are worth the investment and continued exploration.

Thank you again for this opportunity to testify.

QFRs for Mike Robinson of General Motors

Rep. Don Young:

Q: When you refer to an "autonomous vehicle", what role, if any do you see the driver having?

A: For the near–term, vehicles with automated technologies will support/assist the driving task, but the driver will still need to be engaged and in control.

When people talk about fully autonomous vehicles, they are likely imagining a vehicle that will take them to their destination without any involvement -- after simply issuing a command/location -- without any involvement by the driver. These types of systems are a significant distance into the future.

Q: Does the driver need to be available in the vehicle to assume control?

A: Yes, for the foreseeable future, automated technologies will require that the driver still be engaged and in control. As noted above, fully autonomous vehicles, where the vehicle would be in control, are a significant distance into the future.

Rep. Howard Coble:

Q: Have the OEMs designing new autonomous vehicles with advanced electronic parts given any thought to the reutilization of these parts at the vehicle's end of life? Because as you know, there had long been a vibrant recycled OEM parts market for and many in the automotive parts supply chain rely on the ability to reuse OEM parts from vehicles that are no longer operable due to total loss determinations or end of life designations. Given that over 80 percent of today's cars are recycled, have you planned for how the parts harvested from these autonomous vehicles might be reused? Will the data be available to ensure that recyclers can determine which parts fit specific make, model, and year cars?

A: As you note, the automobile is currently one of the most recycled products in the market. According to the Alliance of Automobile Manufacturers, Automotive Recyclers Association (ARA), and the Institute of Scrap Recycling Industries (ISRI), more than 95% of all U.S. vehicles are recycled and approximately 86% of each of those vehicles is reused, recycled, or burned for energy recovery. U.S. automobile dismantling and recycling is a well-established and highly innovative $22 billion industry. Automobile recycling has developed to the current degree and adapted to many changes in vehicle design over the years because of the active involvement of the OEMs and the recycling community. I know that these past efforts will indeed continue to be pursued with these new technologies. As before, the auto industry will continue to work with dismantlers and recyclers to ensure the recycle rate stays high.

Testimony of Andy Christensen
Senior Manager, Technology Planning
Nissan
Before the U.S. House Transportation and Infrastructure Committee's
Subcommittee on Highways and Transit
November 19, 2013

Thank you, Chairman Petri, Ranking Member Norton, and members of the committee. I am the Senior Manager for Technology Planning at Nissan's Technical Center located in Farmington Hills, Michigan. Nissan has established ambitious goals for the development of autonomous vehicles, so I am particularly honored to testify about how autonomous vehicles will shape the future of transportation.

Carlos Ghosn, the CEO of the Renault-Nissan Alliance, recently announced a goal for Nissan to have an affordable autonomous drive vehicle ready by 2020. This time frame is challenging, but we believe achievable.

Autonomous driving technologies can be classified by the level of automation, ranging from emerging active safety technologies such as Forward Emergency Braking, to more autonomous vehicles, and ultimately driverless cars. While many advantages are often cited for each level of autonomous technology, the most important reason to pursue its development is the potential to achieve safety benefits. It is estimated that over 90% of the more than 6 million accidents occurring annually in the United States involve human error, and the typical crash involves some level of driver inattention. We believe that autonomous driving technology has the potential to successfully address the types of situations resulting in these accidents.

Nissan's work on autonomous drive is a continuation of over 10 years of crash avoidance technology development, inspired by our Safety Shield Concept. This proactive development philosophy has enabled Nissan to introduce technologies designed to help drivers avoid a variety of risks from the front, side and rear of the vehicle, including the world's first Backup Collision Intervention and Predictive Forward Collision Warning systems. It is these active safety systems that will form the foundation of our autonomous drive technologies.

Nissan's efforts are focused on preparing technology that operates within the available roadway infrastructure. In the future, additional benefits could be achieved if autonomous technology is fully integrated with the transportation infrastructure, including traffic control and road systems.

While some of the technologies that will act as the foundation for autonomous driving are already being introduced, and we believe in their potential, the development of autonomous technology remains a challenging task which will require careful planning and resource allocation.

From an engineering standpoint, Nissan is already investing in the future of autonomous driving. In the United States, Nissan has teams working at our technical center in Michigan and we've also opened a research facility in Silicon Valley to integrate the rich IT knowledge available there. We are also creating a dedicated autonomous vehicle proving ground in Japan. Although Nissan is developing most of this technology in-house, we will also partner with others as needed; for example, we will collaborate with top level universities such as Oxford, Stanford, MIT and CMU.

However, a successful introduction of autonomous driving will require more than careful engineering development. Autonomous driving may significantly alter the way society views driving, so social acceptability will be an important component and should be carefully managed in parallel with the technical development. An ongoing and open dialogue among stakeholders is critical to help address the social framework needed to support autonomous technology deployment.

The necessary technical achievements and the maturing of social acceptance will be fostered gradually, step by step. Nissan conducted an autonomous driving demonstration at an event in California this summer, and we are ready to conduct field operation tests in the United States and other countries. Nissan also received the first official license plate for an autonomous vehicle in Japan, authorizing us to operate test vehicles on public roads. We have already begun conducting testing on roads in Japan, including a recent drive with Prime Minister Shinzo Abe. These demonstration events and field tests are important not only from a technology development perspective, but also to educate the public and to help us understand social opinion.

With the potential societal benefit that can come with autonomous driving, Nissan believes that the United States can take a leading role to help promote safe and dynamic development of the technology. Such leadership may include the consideration of appropriate legislative action, funding for research and development, and studying the need for investment in wireless communication infrastructure to support future advancements.

We hope that road traffic safety in the United States will be dramatically improved with the advent of autonomous driving, and we believe Nissan's commitment will contribute significantly to this progress. We look forward to working with members of Congress as we move toward this challenging goal. Mr. Chairman and the committee, I thank you for your time and your interest in this important issue.

Follow-up questions from the Nov 19th Subcommittee hearing on Autonomous Vehicles – Due Dec 20th

Questions from Rep. Don Young

1) **When you refer to an autonomous vehicle, what role, if any, do you see the driver having?**

   Nissan Answer: The definition of a vehicle with autonomous capability ranges across a spectrum from where the driver is still supervising the driving task and monitoring the environment to complete disengagement of the driver when the system can perform driving tasks and monitor the environment.

2) **Does a driver need to be available in the vehicle to assume control?**

   Nissan Answer: For most levels of autonomous capability, yes; the driver will need to be available to assume control. Only in the most advanced form of the technology will a driver not be needed.

3) **In your statement you recently announced a goal of having an affordable, autonomous drive vehicle ready by 2020. Do you envision a driver in the car or the vehicle operating without a driver present?**

   Nissan Answer: In 2020, a driver will need to be present in the vehicle.

   What role, if any, would you see in having a driver present in the vehicle?

   Nissan Answer: The driver will be necessary to monitor the autonomous system and the environment and will be able to take control of the vehicle at any time.

4) **NHTSA currently has very clear districted [distracted] driving guidelines to ensure drivers are focused on safety issues and the environment around them. How do you perceive those regulations changing as vehicle technologies advance, become more autonomous?**

   Nissan Answer: We would anticipate that the NHTSA distracted driving guidelines will continue to evolve in conjunction with the vehicle's capability. As autonomous drive technology advances, the current guidelines should be reviewed to determine if they are appropriate for models equipped with more developed systems.

5) **Do you see a full range of regulations for different types of vehicles?**

   Nissan Answer: Nissan has not analyzed what regulatory structure may pertain to vehicles as different levels of autonomous drive capability become available. We are focused on developing the technology and working to ensure an effective and appropriate driver vehicle interaction.

6) **At what point in time do you envision video streaming and expanded entertainment options to be available to the driver?**

   Nissan Answer: We imagine that when autonomous systems have the capability to completely manage the driving task and monitor the environment the driver may have the opportunity to engage in other activities.

7) **You've set an ambitious goal for electric vehicles and now you've set an ambitious goal for autonomous vehicles. Do you envision a large number of autonomous vehicles on the road?**

Nissan Answer: Nissan believes there is a significant customer benefit provided by autonomous drive technologies and the market will drive expansion of the technology over time. At this time, Nissan has not yet announced any projections on the potential size of the market.

Questions from Rep. John Duncan

1) **How will motorcycles be integrated into a transportation system that includes a high percentage of autonomous vehicles?**

   Nissan Answer: Nissan's autonomous drive technology is being designed to work within the existing infrastructure including all vehicle types. Nissan is not seeking to apply our technology to motorcycles, but they will be recognized by our systems, as will all other motor vehicle types.

2) **Obviously motorcycles and scooters have a smaller profile than other vehicles. Is anyone taking these 2-wheeled vehicles into consideration as we move along a path towards autonomous vehicles, and does, or will, the technology exist to make sure all vehicles, no matter how small, can safely communicate with each other?**

   Nissan Answer: Yes, Nissan is taking account of all vehicle types irrespective of their profile. The range of objects autonomous drive systems will have to deal with include those smaller than scooters and motorcycles.

TESTIMONY

Dr. Raj Rajkumar, Carnegie Mellon University

Before the

House Committee on Transportation and Infrastructure

Subcommittee on Highways and Transit

November 19, 2013

Autonomous Driving Technologies: On the Road to Reality

Thank you Chairman Petri and Ranking Member Holmes Norton for convening this important hearing and for your pioneering leadership in supporting innovations that have the potential to bring cost-effective improvements to highway safety and efficiency. I am honored to share my views as a researcher working with my colleagues at Carnegie Mellon University and the University of Pennsylvania who are part of our joint U.S. DOT National University Transportation Center (UTC) for Safety, which is dedicated to the invention and adoption of technologies that aim at the ultimate goal of zero traffic fatalities. Our work is also supported by the Hillman Foundation based in Pittsburgh.

Our center, Technologies for Safe and Efficient Transportation, or T-SET, focuses on not only developing technologies to improve safety, but also deploying them. We are proud to have over 40 partners in an active consortium, whose goal is to accelerate the transfer of technologies from our research lab to commercial use in the transportation sector. Our work is also supported by the National Science Foundation through the Cyber-Physical Systems (CPS) program. "Cyber-physical systems" utilize the cyber capabilities of computing and communications to monitor and control aspects of the physical world. Autonomous vehicles represent a classical example of cyber-physical systems, where sensors obtain information about the rapid changes in the immediate environment, computers communicate among themselves to process the information in real-time, and send commands to actuators that steer, brake and apply the throttle. All these operations have to be carried out safely, reliably, securely and cost-effectively. The fundamental scientific building blocks of cyber-physical systems have broad applicability to many other domains including smart grids, aerospace, manufacturing, process control, healthcare, medical devices, agriculture, and all modes of transportation including transit.

This hearing is very timely because there is tremendous excitement building around autonomous vehicle capability not only in industry and academia, but in the minds of the traffic-weary traveling public. Rapid advances in technologies are bringing the promise of autonomous driving within sight. Such a fundamental and historic transformation in transportation would arguably be rivaled only by the introduction of the automobile at the turn of the last century.

Today, we can undoubtedly envision a future of driving that is dramatically safer, more energy-efficient, more sustainable, more productive and, of particular interest in our major cities like Washington D.C., less congested.

Autonomous driving technologies can also contribute to completely new transportation paradigms that can generate significant cost savings for American taxpayers. Vehicles can travel closer to each other, utilizing available roads better and traveling at uniform, and therefore faster, speeds. Finally, these technologies are also contributing to a new wave of innovation led by our automotive industry, which can contribute to growth across the entire U.S. economy and create new jobs. This in turn will keep the nation as the global leader in intelligent transportation systems.

It is essential that we move forward with a clear vision of the future we seek to invent and build. While autonomous technologies are a catalyst to fundamentally transforming transportation, the well-being of our fellow citizens should always be at the center of this vision. This underlying principle, I believe, should guide both technology and policy development.

My testimony will focus mainly on the technologies and their promise. I wish to emphasize the critical importance of fostering a comprehensive approach to technology development. Specifically, my testimony will highlight the importance of continued investment in basic research to address significant technical challenges that remain in the way of achieving fully autonomous vehicle travel. It will also touch upon the need to integrate technology and policy development in order to accelerate innovation and adoption.

Mr. Chairman, the grim statistics that call out for the pursuit of technologies to make our vehicles and roads safer are well known to the members of this Committee, but they are worth re-capping to underscore the urgency of this need and the fundamental reason we are here today.

More than 1.2 million people die globally each year as a result of traffic accidents. These accidents are the number one cause of death of individuals between 10 and 24 years of age. The economic cost of these accidents is estimated to be about 518 billion dollars per year. However, the staggering loss due to the suffering of those left behind as well as the lost contribution to society of those whose lives ended prematurely is incalculable.

The average American spends one work-week per year stuck in traffic delays. The European Union estimates that traffic delays cost the continent 80 billion euros per year in lost productivity. The loss of independence faced by aging and disabled people who can no longer drive, as well as the burden placed on their families, is also significant and merits special mention.

Autonomous driving is a realistic and near-term prospective solution to these challenges. Indeed, as Chairman Shuster recently showed through his willingness to experience CMU's driverless vehicle first-hand on a 33-mile ride on September 4 in Pittsburgh, autonomous vehicles have already arrived in the sense that they have been shown to be feasible and practical in real-world, unconstrained street and highway traffic conditions. We are very grateful for his leadership as well as that of the Members here today in recognizing the importance of this emerging technology.

An autonomous vehicle is really the convergence of a host of technologies. It is a system built on breakthroughs in sensing and actuator technologies, and continuing improvements in computing and communications. Put another way, autonomous driving is an emerging and welcome result of the rich foundation of federal investments in basic research in engineering, computer science and robotics. However, it is also built upon steady and continuous innovations incrementally deployed by the automotive industry to harness advanced driver assist systems for safety and driver comfort. For example, adaptive cruise control systems and lane departure warning systems leverage advances in sensing, computer vision and distributed real-time processing. These cutting-edge technologies exist in some commercially available cars today.

The seminal turning point in the pursuit of the grand vision of autonomous driving was the Urban Grand Challenge sponsored by the Defense Advanced Research Projects Agency within DoD. The DARPA Urban Challenge, won by a team from Carnegie Mellon University in 2007, demonstrated the potential of autonomous driving in an urban setting. However, that Challenge, featuring heavily-instrumented experimental prototype vehicles, featured no pedestrians, only limited traffic, constant and uninterrupted access to GPS services, and only daytime driving in clear weather conditions.

Bringing autonomous driving into reality requires continued fundamental research to address the challenges presented by poor weather, non-ideal road surfaces, different lighting conditions, fixed and moving obstacles--- from fallen trees to darting children, and the need for redundancy to ensure safe recovery from any failure of sensors, actuators, computers or communications networks. Fundamental advances must also be made in the capability to verify and validate the correct and secure operations of autonomous driving systems. While extensive testing will always be needed, a countless number of possibilities can be encountered on the roads. Technologies to model and verify operations under all possible conditions will allow the public to gain confidence in the reliability of autonomous driving systems. Research into prognostics to locate problems before they lead to vehicle failures would significantly enhance the reliable day-to-day operations of large fleets of autonomous vehicles. Since intruders and other malicious attackers can potentially cause major damage, core research challenges in enforcing the security and privacy of these cyber-physical autonomous systems must also be addressed.

These are just some of the technical challenges I referred to earlier.

Besides addressing these fundamental scientific challenges and technology gaps with active support from General Motors, the National Science Foundation and the US Department of Transportation, we at Carnegie Mellon University have been working to improve the aesthetics of the autonomous vehicle in order to create a product that consumers will actually want to purchase. We envision a future where autonomous driving capabilities dramatically reduce accidents, improve productivity, enhance the quality of life for the elderly and the physically disadvantaged, reduce pollution, improve gas mileage and decrease material costs—all without abrogating the role of the automobile in American life.

One pivotal research thrust that will accelerate the safety and reliability of autonomous driving capabilities involves connected vehicle (V2V) technologies. The US Department of Transportation has rightly placed heavy emphasis on connected vehicles, which enable automobiles to communicate with one another and with the infrastructure. The accurate and reliable operation of autonomous vehicles will be significantly improved by the seamless integration of automation and connected vehicles. Vehicle-to-infrastructure (referred to as V2I) integrates sensing and robotic systems to enable communications between the vehicle and the fixed infrastructure through which it must navigate. V2I and V2V together will lead to dramatic improvements in safety and noticeable reductions in congestion.

Carnegie Mellon has developed a 1.8 mile test-bed with 11 instrumented traffic lights along a highway in the township of Cranberry, 20 miles north of Pittsburgh. In the next year, a larger test-bed will be developed near the Carnegie Mellon campus to further extend these capabilities.

V2I and V2V systems can provide benefits that extend beyond accident avoidance. These systems can remarkably enhance real-time signalization—reducing travel time, fuel consumption and pollution. And we have only just begun to imagine the future possibilities. For example, researchers at Carnegie Mellon are exploring opportunities for V2V systems to be used by bicyclists and pedestrians. Similarly, the Big Data opportunities created by vehicles which can talk to each other and the infrastructure will yield innovations in mobility analytics to identify and resolve traffic bottlenecks, to help emergency responders and to better integrate different modes of transportation including transit. Finally, research at Carnegie Mellon University is also exploring advances in sensing and computations to create more accurate and detailed bridge and highway monitoring capabilities at a small fraction of the cost of current systems.

While all of this technology holds great promise for dramatically improving roadway safety and efficiency, the following are some considerations for policymakers.

First, we should exercise caution in rushing to deploy technologies before ensuring that they can be fully trusted. For the foreseeable future, a human must continue to sit in the driver's seat even if the vehicle is driving itself. The role of the human would be to act as a monitor who takes over control when appropriate. To re-state, we should not expect that, in the next few years, automobiles will drive themselves without a human in the loop. Rather, these technologies will continue to advance in discrete steps with a licensed driver in the driver's seat. Only sometime during the 2020s will a fully autonomous system that does not require a human to be in the driver's seat become feasible.

Secondly, we must recognize that the pace of advances and adoption will be predicated strongly on the level of support for continued research. There is enormous global economic opportunity in the future of autonomy in the transportation sector. Ensuring that the US remains at the leading edge of this massive economic opportunity will require serious R&D investments in both basic research and applied test-beds linking industry, universities, companies and communities. This model of collaboration has been at the heart of our work with the University of Pennsylvania, the Pennsylvania Department of Transportation and our community partners in Pittsburgh and Philadelphia. These models are also at the heart of the vision that the Department of Transportation, the Research and Innovative Technology

Administration (RITA) and the National Science Foundation have been aggressively encouraging and pursuing.

Thirdly, we must ensure that policy and regulatory innovations evolve along with the technology. V2I and V2V communications may also require new models of multi-governmental coordination on signaling and infrastructure investments. Wireless spectrum allocated to vehicular communications will save lives and property, and any spectrum sharing that is envisioned must not take away from the safety benefits of these communications. In other cases, the policy agenda may require bringing together regulatory and policy communities that have traditionally acted separately. For example, if vehicles do not crash, they can be lighter and offer better mileage. If vehicle traffic flows better, emissions and fuel consumption drop. We should also engage the auto safety and environmental policy communities, because the implications for new pathways to realizing national goals via non-regulatory means are profound.

Fourthly, we must ensure that adequate privacy and cyber-physical security safeguards are developed and integrated.

Finally, I would add that these challenges should not deter policymakers from pursuing the goal of autonomous vehicles because this technology holds tremendous promise to reduce highway spending. I anticipate that we will see major positive impact on highway spending in the 2030-40 timeframe with investments we make in developing autonomous vehicle technology today.

In closing, I would like to thank the Members of this Committee for the opportunity to speak to you today on an area of research that for me has developed into a consuming passion. It is my hope that, over the next couple of decades, our nation will be able to look back at this moment with pride as one in which our policy leaders joined together to work toward a vision that profoundly transformed our economy and our lives.

Carnegie Mellon
GOVERNMENT RELATIONS

Friday, December 13, 2013

Dr. Raj Rajkumar, Carnegie Mellon University
Answers to Questions For the Record from The Honorable Don Young
Transportation and Infrastructure Subcommittee on Highways and Transit
November 19, 2013 Hearing, "How Autonomous Vehicles Will Shape the Future of Surface Transportation"

Q. When you refer to an "autonomous vehicle," what role, if any, do you see the driver having?

A. For the next ten to fifteen years, I believe an "autonomous vehicle" will require a licensed driver behind the wheel to override the autonomous features when prudent.

Q. Does a driver need to be available in the vehicle to assume control?

A. Yes, for the foreseeable future. As autonomous technologies are incrementally adopted in commercial vehicles, the role of the driver will become more passive over time, so that increasingly the driver becomes a "monitor" of the vehicle's performance and actions. For example, currently a driver can use cruise control for highway driving and brake only when it becomes necessary due to slowing or exiting traffic.

Contact:

Debbie Tekavec
Director of Federal Relations
Carnegie Mellon University
100 Maryland Ave. NE
Suite 512
Washington DC 20002
202 547 8515
dtekavec@cmu.edu

Written Testimony of Joshua Schank, President and CEO of the Eno Center for Transportation

Presented to the House of Representatives Transportation and Infrastructure Subcommittee on Highways and Transit

Hearing on "How Autonomous Vehicles Will Shape the Future of Surface Transportation"

Tuesday, November 19, 2013

Chairman Petri, Ranking Member Holmes Norton, and the distinguished members of this subcommittee, thank you for inviting me here today to testify before you. My name is Joshua Schank and I am the President and CEO of the Eno Center for Transportation. Eno is a 92-year-old national transportation policy think tank. The founder, William P. Eno, got into a traffic jam as a child while riding in a horse and buggy, and from then on was devoted to improving traffic and highway safety; he left the Eno Center for Transportation as his legacy. Eno is a neutral, non-partisan organization that aims to promote policy innovation within transportation and provide leadership development for transportation professionals. It is through the lens of innovation that we approach the policy issues surrounding the introduction of autonomous vehicles.

Last month Eno released a paper titled *Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers, and Policy Recommendations,* authored by Eno Fellow Daniel Fagnant and his advisor at the University of Texas, Kara Kockelman. Substantial time and research has been devoted to the development of autonomous vehicles, how they function, how they can be improved, and what possibilities they hold. However, much less information is available exploring how these vehicles will relate and interact with the driving infrastructure and system we currently have in place. Creating fully functional vehicles that can operate themselves is only half of the battle, figuring out how these vehicles will integrate onto our highways and roads is a much more challenging task. Working with Daniel over the past year, we sought to define the barriers that exist to integration and determine how federal policy can play a role in facilitating a relatively smooth transition.

Our report analyzed existing research that has quantified the potential benefits of autonomous vehicles. These potential benefits include increased safety, reduced traffic congestion, fuel savings, and greater mobility for those who cannot drive. If autonomous vehicles are able to reach a significant market penetration, it is likely that these benefits will be quite substantial. AVs could improve safety by eliminating human errors and impaired or distracted driving. Over 40 percent of fatal automotive crashes involve alcohol, distraction, drug involvement and/or fatigue. Self-driven vehicles will not have human failings, and we estimate that a 50 percent market penetration alone could save almost 10,000 lives per year. Congestion will be diminished because with a 50 percent market penetration, cooperative adapted cruise control is projected to increase highway lane capacity by 21 percent, and cut fuel consumption by 224 million gallons per year, for a savings of approximately $37.4 billion annually. In terms of behavior, autonomous vehicles offer independent mobility to populations that previously did not have that luxury, including children and the elderly. At a 50 percent market penetration, it is estimated that in comprehensive costs, including safety, congestion benefits, and other impacts, AVs will save the economy $3,320 annually per vehicle.

However, vehicle costs, licensing, liability, and security and privacy concerns create considerable impediments to the proliferation of autonomous vehicles. It is estimated that autonomous vehicles will initially cost more than $100,000, a price tag that is simply unaffordable for most Americans. Licensing and liability become problematic, as there are no standards in place and it is unclear who the responsible party would be in an incident involving an AV operation. Finally, security and privacy concerns are always present when new technologies and data accumulation are factors. AV technology is likely to advance with or without legislative and agency actions at the federal level. However, the manner in which AV technologies progress and will eventually be implemented depends on overcoming these barriers.

The Eno Center for Transportation recommends a number of policy advances including the expansion of autonomous vehicle research, the development of federal guidelines for autonomous vehicle licensing, and defining appropriate standards for liability, security, and data privacy.

1. **Expand Autonomous Vehicle Research:** There has been substantial investment in research and development of AV technologies, but there is relatively little understanding of how AVs will affect the transportation system. Federal, state, and local agencies, as well as stakeholders should facilitate and fund research to enable us to better anticipate and more effectively plan for AV opportunities and impacts.

2. **Develop Federal Guidelines for Autonomous Vehicle Licensing:** To facilitate regulatory consistency, the U.S. DOT should develop a framework and set of national guidelines for AV licensing at the state level. Though NHTSA has developed broad principles for AV testing, licensing AVs for use by the general public is mostly a state-by-state endeavor at this point. With a more uniform set of standards in place, states can pool efforts in developing safety, operations, and other requirements. Policy makers should also consider potential regulatory downsides and the effects of excessive caution, which may be harmful to technological advancement and delay or reduce economic benefits.

3. **Determine Appropriate Standards for Liability, Security, and Data Privacy:** Liability, security, and privacy concerns represent a substantial barrier to widespread implementation of AV technologies. Federal and state governments need to address these issues to give manufacturers and investors more certainty in development. Any AV-enabling legislation should also consider privacy issues to balance concerns against potential data-use benefits.

Technological advances in autonomous vehicles are progressing and it is possible that these vehicles will be commercially available within the decade. The introduction of vehicles that drive themselves will present a challenge in terms of culture, legalities, liability, security, and privacy. While the process of integration of autonomous vehicles into our system is likely to be rocky, there are steps that we can take in order to provide the clearest opportunity and space for these vehicles. Through expanding our research and creating legal standards and regulations for autonomous vehicles, we have the opportunity to provide an example for other nations in their own transitions. If we are able to facilitate the introduction of autonomous vehicles into our system, comprehensive benefits will include crash cost savings, congestion benefits, and behavioral changes.

Again, Chairman Petri, Ranking Member Holmes Norton, and the distinguished members of this subcommittee, thank you for inviting me here to testify before you today, and I look forward to participating in continuing conversations on this emerging issue.

Eno Center for Transportation
1710 Rhode Island Ave, Suite 500
Washington, DC 20036

December 11, 2013

Committee on Transportation and Infrastructure
Subcommittee on Highways and Transit
Hearing on "How Autonomous Vehicles Will Shape the Future of Surface Transportation"
November 19,2013
Re: Question for the Record

Dear Honorable Congressman Thomas Petri,

Thank you for your questions seeking clarity regarding Dr. Schank's testimony before the Subcommittee on Highways and Transit on November 19th, 2013, concerning "How Autonomous Vehicles Will Shape the Future of Surface Transportation". Our responses to questions from Rep. Don Young are as follows:

1. When you refer to an "autonomous vehicle," what role, if any, do you see the driver having?

In our estimation, we believe that drivers will have the ability to gain full control of their vehicle at any moment, possessing the ability to switch autonomous mode on and off. This will be particularly necessary for early models, where the driver is available to act as an added failsafe, as well as in instances where he or she chooses to drive for reasons of personal preference. Of course, vehicle automation technology may also take control from the human driver in order to avoid a crash, as is already occurring with features such as automatic forward collision braking.

2. Does a driver need to be available in the vehicle to assume control?

In early implementations, we believe that it is necessary for a driver to be available in the vehicle to assume control in the case of an emergency. However, as time and technology advances, we believe that vehicles will become fully autonomous, and have no need for any driver. Indeed, human drivers may eventually be removed entirely from some vehicles, particularly for commercial, shared autonomous vehicles (i.e., driverless taxis), and transit fleets.

Additionally, the National Highway Traffic Safety Administration (NHTSA) notes four levels of automation as follows:

- Function-specific automation (Level 1)

- Combined function automation (Level 2)
- Limited self-driving automation (Level 3)
- Full self-driving automation (Level 4)

With Level 4 automation, no driver is required in the vehicle.

With Level 3 automation, a driver is required in certain circumstances and environments, but not all. Volvo's "auto-valet" concept is one example, where their cars can self-park in defined parking garages and lots and would not need a driver to be present. Another Level 3 example is automated driving on freeways, where road conditions are relatively uniform and driving operation is straightforward. In this instance, a driver would likely need to be present in the vehicle not for freeway driving, but rather in order to resume control just before or after leaving the freeway.

Once again, thank you for your questions and please do not hesitate to ask if you have any further questions.

Sincerely,

Daniel J. Fagnant, University of Texas at Austin
Dr. Kara Kockelman, University of Texas at Austin
Dr. Joshua Schank, Eno Center for Transportation
Paul Lewis, Eno Center for Transportation

Before the
Subcommittee on Highways and Transit
Committee on Transportation & Infrastructure
U.S. House of Representatives

Hearing on "How Autonomous Vehicles Will Shape the Future of Surface Transportation"

Statement of the
Consumer Electronics Association (CEA)

November 19, 2013

Subcommittee Chairman Petri, Ranking Member Norton and Members of the committee, on behalf of the Consumer Electronics Association (CEA), thank you for the opportunity to submit written testimony for today's hearing on autonomous vehicles.

CEA is the preeminent trade association representing the consumer technology industry. CEA's over 2,000 American corporate members include consumer electronics companies, internet providers and retailers as well as car makers, first tier suppliers and auto aftermarket device developers and manufacturers. We own and produce the world's most important technology event, the International CES.

The next time you get behind the wheel and before you start the ignition, take a moment to appreciate how much technology is in your car. You may have adaptive cruise control or Bluetooth connecting your mobile devices to your car stereo. Maybe you have front and rear park assist cameras, blind spot indicators or collision avoidance systems. You may drive one of the six million American cars with GM's OnStar system, which immediately reports collisions and air bag deployments. Almost every recent model car offers more technology to make a run to the grocery store than the Apollo astronauts had to land on the moon in 1969.

As technology continues to advance, our cars will take on more responsibility for mundane driving tasks. One day soon, your car will literally drive itself. When the first driverless car rolls off the assembly line, it will embody years of research and development by engineers, computer scientists, behaviorists and safety experts in the automotive, consumer electronics (CE) and IT industries.

The automotive sector is one of the most vibrant spaces for innovation in the CE industry today. The evidence of this growth is apparent in the historic attendance by automotive companies at the 2013 International CES®, and again in 2014, where this year nine of the top ten car makers will be exhibiting their cars as rolling miracles in technology, and many will showcase advancements in driverless car technology.

Consumer interest in driverless cars continues to improve as well. A recent Consumer Electronics Association (CEA)® survey found that 79 percent of consumers would be willing to be a passenger in a driverless car. So, it should come as no surprise that CEA named driverless cars as one of the top five technologies to watch in 2014. Someday soon, driverless car technologies will be common, and the elderly, the disabled and society as a whole will benefit from a safer, more empowering driving experience.

The certain progress to driverless car technology results from private sector innovation that not only enhances the driving experience but also makes it safer. CEA members agree that safety is the top priority in the developing and producing car technology, and several companies have developed breakthrough technologies to ensure drivers focus on the road, stay in their lanes and avoid collisions. Indeed, first-generation driverless cars are now on the road that not only provide cautionary warnings against a car stopping in front of you, but also track the car in front of the car in front of you, and if necessary, will take over control of the car to ensure a collision is avoided.

Technology holds the key to driver safety, and we are increasingly educating consumers on the options available to them and the safe use of technology in cars. CEA supports bans on texting while driving and recently launched the Driver Device Interface Working Group to develop standards and recommendations for safer user experiences in line with NHTSA Phase I guidelines. Through our new Innovating Safety public education campaign, the industry is alerting the driving public about the innovative products that keep drivers safer while allowing them to stay connected.

Drivers have amazing access to technologies that limit distraction, improve awareness and help them navigate the road, and soon our cars will drive themselves. As the industry continues to research and develop the technologies that will usher in the age of the driverless car, innovators will offer more products and devices to make the driving experience safer. As this evolution continues, Congress must be mindful to keep the door to innovation open to encourage a future full of new discoveries.