

**TRANSPORTATION OF TOMORROW: EMERGING  
TECHNOLOGIES THAT WILL MOVE AMERICA**

---

---

**HEARING**

BEFORE THE

**COMMITTEE ON COMMERCE,  
SCIENCE, AND TRANSPORTATION  
UNITED STATES SENATE**

**ONE HUNDRED FIFTEENTH CONGRESS**

**SECOND SESSION**

—————  
**SEPTEMBER 13, 2018**  
—————

Printed for the use of the Committee on Commerce, Science, and Transportation



Available online: <http://www.govinfo.gov>

—————  
U.S. GOVERNMENT PUBLISHING OFFICE

55-086 PDF

WASHINGTON : 2024

SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

JOHN THUNE, South Dakota, *Chairman*

ROGER WICKER, Mississippi  
ROY BLUNT, Missouri  
TED CRUZ, Texas  
DEB FISCHER, Nebraska  
JERRY MORAN, Kansas  
DAN SULLIVAN, Alaska  
DEAN HELLER, Nevada  
JAMES INHOFE, Oklahoma  
MIKE LEE, Utah  
RON JOHNSON, Wisconsin  
SHELLEY MOORE CAPITO, West Virginia  
CORY GARDNER, Colorado  
TODD YOUNG, Indiana

BILL NELSON, Florida, *Ranking*  
MARIA CANTWELL, Washington  
AMY KLOBUCHAR, Minnesota  
RICHARD BLUMENTHAL, Connecticut  
BRIAN SCHATZ, Hawaii  
EDWARD MARKEY, Massachusetts  
TOM UDALL, New Mexico  
GARY PETERS, Michigan  
TAMMY BALDWIN, Wisconsin  
TAMMY DUCKWORTH, Illinois  
MAGGIE HASSAN, New Hampshire  
CATHERINE CORTEZ MASTO, Nevada  
JON TESTER, Montana

NICK ROSSI, *Staff Director*

ADRIAN ARNAKIS, *Deputy Staff Director*

JASON VAN BEEK, *General Counsel*

KIM LIPSKY, *Democratic Staff Director*

CHRIS DAY, *Democratic Deputy Staff Director*

RENAE BLACK, *Senior Counsel*

# CONTENTS

---

	Page
Hearing held on September 13, 2018 .....	1
Statement of Senator Thune .....	1
Statement of Senator Cortez Masto .....	3
Statement of Senator Peters .....	29
Statement of Senator Hassan .....	31
Statement of Senator Tester .....	33
Statement of Senator Markey .....	36
Statement of Senator Cantwell .....	38
Statement of Senator Klobuchar .....	39
Statement of Senator Gardner .....	41
Statement of Senator Blumenthal .....	44
Prepared statement from Catherine Chase, President, Advocates for Highway and Auto Safety .....	46
WITNESSES	
Tina Quigley, General Manager, Regional Transportation Commission of Southern Nevada .....	4
Prepared statement .....	5
Davis S. Sanford, Naval Unmanned and Future Technologies, Rolls-Royce Marine North America, Inc. ....	9
Prepared statement .....	11
Laurie Tolson, Chief Digital Officer, GE Transportation .....	16
Prepared statement .....	18
Josh Raycroft, Director, Business Strategy, Virgin Hyperloop One .....	21
Prepared statement .....	23



**TRANSPORTATION OF TOMORROW:  
EMERGING TECHNOLOGIES THAT WILL  
MOVE AMERICA**

—————  
**THURSDAY, SEPTEMBER 13, 2018**

U.S. SENATE,  
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,  
*Washington, DC.*

The Committee met, pursuant to notice, at 10 a.m. in room SR-253, Russell Senate Office Building, Hon. John Thune, Chairman of the Committee, presiding.

Present: Senators Thune [presiding], Cortez Masto, Peters, Hassan, Tester, Markey, Cantwell, Klobuchar, Gardner, and Blumenthal.

**OPENING STATEMENT OF HON. JOHN THUNE,  
U.S. SENATOR FROM SOUTH DAKOTA**

The CHAIRMAN. Good morning. This nation built the Erie Canal, the Transcontinental Railroad, the Wright 1903 Flyer, and the Interstate Highway System.

These advancements made America's transportation system the envy of the world and unlocked enormous opportunities for Americans. They created jobs and new sources of wealth, opened markets, connected rural areas to urban areas, and the coast to the heartland, improved the efficiency and safety of the movement of people and goods, and gave American businesses a significant advantage over economic competitors.

More recently, however, our transportation system has struggled to keep pace with the growing demands of a dynamic economy. Freight movement is expected to double over the next few decades. The growth of e-commerce continues to present new opportunities and challenges and competition from foreign countries is strong.

Meanwhile, our roadways are increasingly congested as Americans spend too many hours stuck in traffic at a cost of over a \$160 billion per year in wasted time, fuel, and vehicle wear and tear, and transportation connections in many areas, including rural areas, are hindered by deteriorating infrastructure conditions.

While there is a real need for robust investment, the transportation sector also needs innovative solutions to enhance the safety and efficiency of our system. It is essential that the private and public sectors work together to prepare for the future and to promote technologies that will improve the ways in which people and goods get to and from their destinations, including urban and rural areas.

Technology has the potential to make it easier to get to work, get our groceries, plan our businesses or pick up our kids or grandkids. Technological changes and innovation may transform all aspects of our transportation network from vehicles and equipment to the underlying infrastructure to the logistics software that helps connect us.

Our Committee has been active in this Congress in automated vehicles, next generation telecom, unmanned aircraft systems or drones, and other emerging technology issues.

Senator Peters and I have been advancing our AV START Act to facilitate the safe development of automated vehicles which will help save lives, improve mobility for all Americans, including those with disabilities, and create new jobs while maintaining U.S. leadership in this important technology.

With the passage of MOBILE NOW, my work with Senator Schatz, and the STREAMLINE Small Cell Deployment Act and the Committee's related work on 5G Spectrum, we are also working to maintain American leadership in next generation communications technology, a position that China and others seek for themselves.

In addition, this Committee has included several provisions in the Senate FAA bill that will help promote drone technologies while addressing safety and privacy issues and improving enforcement and Federal oversight of drone operations.

Of course, there are many other forms of technology within the Committee's jurisdiction that will transform how we do business. An important role of this committee is to hold these types of hearings to better inform Congress and the public on emerging technologies in areas under our purview.

While we do not always know which technologies will succeed or what the technological maturation process will look like or mean for our every-day lives, it is critical that Congress engage with innovators and ensure Federal policy supports and does not hold back American ingenuity.

I expect this hearing will examine how emerging transportation technologies will fit within Federal regulatory financing and permitting policies. It will help answer an ongoing question and that is how should the Federal Government best engage in the transportation of tomorrow?

Answering these questions can help ensure our transportation system keeps pace with the dynamic economy and is the envy of the world.

This morning, we'll be hearing from a distinguished panel of witnesses on new and exciting areas of transportation that will transform the way that people and goods move in the 21st Century.

I look forward to hearing from all of you and for all your testimony this morning and look forward to having an opportunity to interact with you with some questions when we conclude our statements.

I will now recognize our Ranking Member, Senator Cortez Masto, for an opening statement.

**STATEMENT OF HON. CATHERINE CORTEZ MASTO,  
U.S. SENATOR FROM NEVADA**

Senator CORTEZ MASTO. Thank you. Thank you, Mr. Chair, for holding this hearing, and I want to thank Ranking Member Nelson, as well. I'm very excited about today's panel, very excited about the subject matter.

This is something that I have been talking about and promoting around the halls here in Congress because Nevada is an innovation state, very, very excited to have this conversation today.

You know, I have been talking about the fact that Nevada is an innovative state where the State Department of Transportation has worked to license the Nation's first autonomous semi-truck, where the City of Reno is a designee in the FAA's new UAS Integration Pilot Program, having just announced their recent first multi-drone delivery of automated external defibrillators in the presence of the FAA, and its other innovations in transit, like our Washoe County Regional Transportation Commission, which is pursuing a full range of electric buses.

So I am glad that Virgin Hyperloop One is here as they have a fascinating test track and manufacturing outfit in North Las Vegas. All of this plays into what I have been advocating here in the Senate for most of my tenure, including my bipartisan Moving FIRST Act with Senators Burr and Nelson, incentivizing the use of emerging technologies to develop smart communities and intelligent transportation systems which can improve safety and efficiency, reduce costs, cut down on pollution, help us reach disadvantaged populations, and much more.

This is something that is happening around the country and the world and I believe we should think of it as a global race.

Here in the U.S., places like Farmington Hills, Michigan, have used smart street lights to help manage traffic flows. Norwalk, Connecticut, used a smart parking app to allow residents to see available parking in real time, and in Milwaukee, police are using sensors to pinpoint gunfire, cutting down response times and improving safety, and globally, places like Grenoble in France have tested three-wheeled electric vehicles for customers to drive on the last leg of their journey into and out of the city, and in Masdar, Abu Dhabi, a similar project system works with autonomous cars, and in Nevada, we are helping to lead the way in all of these technologies.

So I look forward to this distinguished panel and the conversations today, and thank you again, Mr. Chairman, for your willingness to hold the hearing today.

The CHAIRMAN. Thank you, Senator Cortez Masto, and we'll proceed now with our panel and start on my left and your right.

With us, we have Ms. Tina Quigley, who's General Manager, Regional Transportation Commission of Southern Nevada, and Las Vegas, Nevada; and next to her we have Mr. Davis Sanford, Campaigns Lead, Naval Ship Intelligence & Technologies with Rolls-Royce Marine in North America; Ms. Laurie Tolson, who is the Chief Digital Officer for GE Transportation; and Mr. Josh Raycroft, who's Director of Business Strategy at Virgin Hyperloop One.

So thank you all for being here. We look forward to hearing from you and would ask, if you can, to confine your oral remarks as close

to five minutes as possible. We'll make sure that the entirety of your remarks are included as a part of the permanent record of the hearing.

So, Ms. Quigley, welcome. Please proceed.

**STATEMENT OF TINA QUIGLEY, GENERAL MANAGER,  
REGIONAL TRANSPORTATION COMMISSION  
OF SOUTHERN NEVADA**

Ms. QUIGLEY. Thank you. Good morning. Again, my name is Tina Quigley. I'm General Manager of the Regional Transportation Commission of Southern Nevada.

I'd like to sincerely thank Chairman Thune, Ranking Member Nelson, Senator Cortez Masto, and Senator Heller, who's not able to be here today, for inviting me here.

The RTC is a bit of an unusual agency in that we are the single agency overseeing several transportation functions in the Las Vegas region. We're the public transit agency, we're the roadway planning and funding agency, we're the region's MPO or metropolitan planning organization, and, in addition, we are a centralized traffic management agency, which allows us to easily collect, manage, and analyze region-wide data.

With the help of private sector partners, we can leverage our infrastructure and data to test and implement smart solutions to our safety, capacity, and congestion challenges.

Our region is growing at one of the fastest rates in the Nation and our tourist numbers, which are currently over 43 million visitors a year, we basically have a super bowl every weekend, are estimated to grow by 25 percent over the next 15 years.

We like to say "technology is the new asphalt," given that new technologies, when integrated into infrastructure, can deliver greater capacity enhancements and greater return on investments compared to paving just additional vehicle lane miles.

It's clear we must lean in and not only embrace innovation, but also facilitate and drive it. At an agency level, this requires us to overcome our natural inclination to be apprehensive of unconventional partnerships and a bit distrusting of private sector's financial motives. No offense.

To help address this in Southern Nevada, all five of our cities, the county, Nevada Department of Transportation, and the RTC universally adopted a common Southern Nevada Smart Community Vision that guides technology solutions, regardless of jurisdictional boundaries.

This vision document provides a blueprint for continued coordination among the partners as they work with various private sector industry companies. An example of a few of the projects and initiatives that we have underway at the RTC include a partnership with Waycare. This groundbreaking technology compiles and analyzes data to report in real time the location of accidents and predict where dangerous driving conditions may occur and so far since we employed this, we are identifying accidents 12 minutes faster on average which means we can clear them faster, allowing traffic to flow again, and reducing the chance of secondary accidents.

We recently collaborated with Lyft to launch an on-demand pilot program to provide non-ADA para-transit service. We worked with

Aptiv to launch a fleet of 30 autonomous vehicles in Las Vegas on the Lyft Network.

Nexar introduced a vehicle-to-vehicle network via a smart phone video app that will provide drivers real-time alerts to prevent vehicle, cyclists, and pedestrian collisions.

Across the country, whether urban or rural, our communities are at a crossroads when it comes to mobility and transportation investments. We know we can no longer deliver policies and infrastructure that rely on yesterday's solutions.

Consumer preference and expectations are rapidly changing and a failure to keep pace can result in public investments that are ineffective, inefficient, and may be inappropriate.

There's a constant stream of new mobility options. However, our ability to access and integrate them is limited because they do not necessarily fit into a traditional transportation mold.

Congress now has a significant opportunity with the upcoming reauthorization of the FAST Act to help states and local communities partner with the Federal Government and private industry to advance new and efficient mobility technologies.

Federal funding for private and public partnerships is essential. We need to identify and support flexible policies that provide additional opportunities for pilots and testing new approaches.

The creation of the ATCMTD Program in the FAST Act was a good start for providing competitive grants for advanced transportation technologies. However, the authorized funding is not sufficient.

Additional opportunities are in Senator Cortez Masto's Moving FIRST Act, which will enable more communities and states to compete for resources to fund efficient and innovative transportation projects, and in Senator Heller's Amendment to the THUD Appropriations Minibus would require DOT to assist local communities and transportation agencies on advancing smart cities solutions.

In conclusion, the opportunity is real and the timing could not be better to embrace it. As communities like ours face the risk and uncertainty of being amongst the first to embrace a new brand of mobility, the decisive factor is simple: collaboration.

Absent congressional support, there's no realistic pathway to think differently, much less do differently, relative to transportation.

Together, however, the opportunities to improve lives and accelerate the economy through advanced mobility are boundless.

Thank you.

[The prepared statement of Ms. Quigley follows:]

PREPARED STATEMENT OF TINA QUIGLEY, GENERAL MANAGER, REGIONAL  
TRANSPORTATION COMMISSION OF SOUTHERN NEVADA

Good morning, I am Tina Quigley, and I serve as the General Manager of the Regional Transportation Commission of Southern Nevada. I would like to thank Chairman Thune, Ranking Member Nelson, Senator Cortez-Masto, and Senator Heller for inviting me to be here today. I appreciate the opportunity to speak about one of the most exciting and critical issues affecting the transportation industry today.

**About the RTC**

The RTC oversees the Las Vegas region's public transit, traffic management, transportation planning, and roadway funding. We also are the metropolitan plan-

ning organization (MPO) and administer Southern Nevada Strong, our regional planning effort to build complete communities throughout Southern Nevada.

In addition, our integrated Intelligent Transportation System (ITS), housed at our traffic management center, spans all local jurisdictions in the Southern Nevada region. This centralized traffic management operation makes it easier for transportation and technology companies to access data and demonstrate products.

In 2017, Nevada passed Assembly Bill 69, which provides a regulatory structure that welcomes advance mobility. Given our regional transportation authority combined with an innovation-friendly regulatory structure, we have the ability to forge public-private, multi-jurisdictional, and intergovernmental partnerships that leverage technology as a solution to our region's current and future mobility challenges.

#### **Uncertainty of Innovation Against the Yoke of Convention**

Our community, like many communities across the county, is at a crossroads when it comes to urban mobility and transportation investments. We can no longer afford to develop, implement, and invest in policies and infrastructure that rely on yesterday's transportation and mobility solutions.

This is especially critical at a time when today's cities and citizens require more of our infrastructure investment. We are, and have always been consumer focused. However, consumer preference and expectations are rapidly changing, and a failure to keep pace could have far-reaching effects on urban mobility.

Over the last several decades, while we were investing in traditional solutions, private sector innovation shifted the terrain of urban mobility, making it more personalized, nimble, accessible, and convenient throughout the country. This entrepreneurial spirit created companies like Uber, Lyft, Aptiv, BCyle, and Lime focused on ride sharing, autonomous vehicles, bike share, and electric scooters. These companies and their innovative ideas are transforming the way people choose to move in and around our communities.

As the market continues to evolve, we have seen a seven percent decline in transit ridership across the country. Today, we are forced to weigh the uncertainty of innovation against the yoke of convention. As our communities continue to grow and technology evolves, there is a constant stream of new mobility options; however, our ability to access and integrate them is limited because they do not fit into a traditional transportation mold.

Ultimately, we need to work better with private industry and the Federal government to develop and invest in communities that create and encourage an ecosystem of mobility solutions foundational to a "smart community," creating workable pathways that promote mobility, safety, and economic development while ensuring that we have transportation options that are affordable, equitable, and accessible.

#### **Revolutionizing Our Transportation Network in the Digital Age**

We believe that "technology is the new asphalt" given that new technologies, when integrated into existing and new transportation infrastructure, can deliver significantly higher returns on investment compared to the traditional approach of simply building another lane. Advanced technology developments such as connected and autonomous vehicles, faster wireless communications, and greater data sharing, offer unprecedented opportunities to create safer, less congested, and more efficient communities.

In this decade alone, private industry is paving the way and transforming our transportation network. From ride share to bike share, connected and autonomous vehicles to Hyperloop and The Boring Company, these developments have and continue to disrupt the movement of people, goods, and services.

Transportation agencies, like the RTC of Southern Nevada, are working tirelessly to learn about and test new technologies because we see firsthand their potential to improve the quality of life of our citizens and to leverage our existing infrastructure. We believe that we must lean in and not only embrace innovation—but also facilitate and drive it. This requires us to overcome our natural inclinations to be apprehensive of unconventional partnerships and to distrust private sector's financial motivations.

To achieve that goal, collaboration between public and private partners and among local jurisdictions and government agencies at all levels are critical. We need to work together to ensure we are developing policies, building infrastructure, and creating vehicles that can accommodate the mobility of the future.

#### **Smart Mobility Technology and Innovative Solutions**

All six jurisdictions in Southern Nevada, the Nevada Department of Transportation, and the RTC recently adopted a unified "Southern Nevada Smart Community Vision." This vision guides the introduction of technological solutions that seamlessly interact and complement each other, regardless of jurisdictional bound-

aries. The “Southern Nevada Smart Community Vision” provides a blueprint for continued coordination and cooperation among government and community stakeholders as they work with various private-industry companies to leverage advanced technology to build a smarter and more connected Southern Nevada. Currently, multiple jurisdictions and agencies are working together with private industry partners to test and deploy technologies that can provide solutions for our mobility challenges.

#### *Innovation in Infrastructure*

A groundbreaking technology currently deployed in Southern Nevada is a partnership with Waycare, whose technology helps improve safety and efficiency on freeways and major arterials. Waycare compiles and analyzes data to report in real-time the location of accidents and predict where dangerous driving conditions or congestion may occur. This technology enables faster validation and response to roadway incidents. It also more efficiently uses resources to proactively deploy traffic patrols and abatement efforts with the goal of preventing incidents. The RTC Traffic Management Center uses Waycare’s real-time analytics to better optimize traffic flows. So far, through Waycare, the RTC’s early incident identification is on average approximately 12 minutes faster than prior modes of incident identification. By identifying incidents sooner, we can clear them faster, restoring normal traffic flow, and reducing the chance of secondary accidents. As a result, this technology is increasing safety and reducing traffic congestion on our roadways.

Our regionally coordinated, traffic management operations also prompted Audi to select Southern Nevada to debut the first of its kind “Time to Green” dashboard feature, which enables the car and driver to receive real time alerts when traffic lights will change. This information not only allows drivers to be more informed, prepared, and alert, but it is also a first step to developing autonomous vehicles and a data exchange that will help better manage congestion on crowded roadways.

As connected and autonomous vehicles continue to evolve, a central challenge to consumer acceptance is the question of how the vehicles will operate safely and obey local rules of the roads. To address this challenge, the RTC most recently partnered with the world leader in connected car services and transportation analytics, INRIX, on a first-of-its-kind platform called AV Road Rules (AVRR) to help ensure the safe and effective operation of highly automated vehicles (HAVs) on public roads. INRIX’s state-of-the-art platform allows cities and transportation authorities to digitize their traffic rules and restrictions, such as speed limits, crosswalks, turn restrictions, and bikes lanes. This platform can be communicated to HAVs, allowing them to operate safely and effectively. The AVRR platform also enables HAVs to report infrastructure needs, such as potholes, inadequate lane striping, and signage issues, to the appropriate transportation authorities. This is a valuable tool for cities to more quickly identify infrastructure needs and leverage HAV operations to improve the safety and comfort of public streets for all users.

#### *Innovation in Public Transportation*

Building on this regional cooperation and data exchange model, the RTC, along with the City of Las Vegas, provide traffic signal data to the Nation’s first self-driving shuttle that operates in mixed traffic. Sponsored by AAA and Keolis, the autonomous bus is fully integrated with “smart city” infrastructure along a half-mile loop in downtown Las Vegas. This pilot project tests autonomous and intelligent infrastructure technology, and it will also help develop standards for how government agencies can share data with vehicles, as Federal standards do not currently exist.

The project enables the RTC, the City of Las Vegas, and project partners to better understand the customer experience and learn more about how autonomous vehicles operate in mixed traffic so autonomous vehicles can be deployed for public use in the future. Over the course of the yearlong pilot, the self-driving shuttle provided a quarter-million residents and visitors to Las Vegas with a first-hand experience of autonomous vehicle technology, exposing most riders to the technology for the first time. People have embraced the shuttle, which averages 150 riders per day and has transported more than 23,000 passengers so far. It is critical that people have the opportunity to experience in-person these advanced technologies so they are comfortable with the changes that will occur in the near future.

We also recently collaborated with Lyft to launch a six-month on-demand pilot program to provide non-ADA paratransit service to approximately 145 existing customers. This pilot was designed to help reduce response time; improve mobility management; create an on-demand, individualized service; and reduce cost. We performed 5,000 trips, saved more than \$100,000, significantly reducing wait times and improving service for our paratransit customers.

In addition, Aptiv, a global technology company that develops safer, greener, and more connected transportation solutions, launched a fleet of 30 autonomous vehicles in Las Vegas on the Lyft network. On an opt-in basis, passengers have the ability to hail a self-driving vehicle equipped with Aptiv technology to and from more than 20 high-demand locations including the Las Vegas Strip. Lyft and Aptiv's self-driving program is the largest commercial program that is available to the public today and represents a major milestone in mobility and the future of transportation. This partnership further exposes our residents and visitors to autonomous vehicle technology and its benefits.

### **Education and Maintaining Our Infrastructure**

According to a RAND Corporation study: "allowing wide use of autonomous vehicles when they are just 10 percent better than current American drivers could prevent thousands of road fatalities over the next 15 years and possibly hundreds of thousands of fatalities over 30 years, compared to waiting until they are 75 percent or 90 percent better."<sup>1</sup>

Yet, the public's perception about whether autonomous vehicles improve safety stands in stark contrast to this data. In 2016, Cox Automotive found that 63 percent of respondents felt roadways would be safer if all cars were autonomous, versus only 45 percent this year.<sup>2</sup> Moreover, in a study conducted by AAA, more than half (54 percent) said they would feel less safe sharing the road with AVs<sup>3</sup>. Clearly, technology may be moving full-steam ahead, but the travelling public may not yet be on board.

We must collaboratively work together to educate the public about emerging transportation technologies such as connected and autonomous vehicles and better explain their benefits and how they will transform transportation. We need to enable our constituents to experience these advanced technologies in-person, so they are comfortable with the changes that are coming.

As driving continues to become less burdensome, motorists may be more inclined to get inside their vehicles and commute, adding miles traveled to the infrastructure requirements. We are already seeing that to a certain extent with the growing use of ride-hailing companies like Uber and Lyft.

If autonomous cars are added to the mix, they become even more attractive transportation options, allowing riders to work and read while on their commute. Thus, vehicle miles traveled (VMT) will likely increase as self-driving cars becoming more prevalent, and increased VMT forces policymakers to strongly consider increased investment and expansion in smart infrastructure.

As the metropolitan planning organization for the Southern Nevada region, we have the responsibility to revitalize our infrastructure and modernize our outmoded transportation system to ensure that we are accommodating the needs of all roadway users. In some cases throughout Las Vegas, we can no longer add capacity by adding more roads—so we must look to technology to help manage congestion and capacity.

### **Ultimately Building the Transportation of Tomorrow**

Over the last decade, we have witnessed technology rapidly transform mobility; and, as it does, policy and cultural questions continue to evolve. I assure you that your constituents' expectations are evolving at a similar, if not faster, clip. It is my sincere hope that we do not fear this change, but embrace it, by establishing new funding opportunities, updating regulations, and rethinking planning practices.

Congress has a significant opportunity, with the upcoming reauthorization of the FAST Act, to help develop, support, and invest in the infrastructure of tomorrow that empowers local communities to partner with the Federal government and private industry to advance mobility, data, and intelligent transportation systems.

Federal funding for private and public partnerships in this realm is essential. We need to identify and support flexible policies that provide additional opportunities to pilot and test new ideas and technologies. We need workable definitions of public transportation including the guidelines for funding eligibility and mechanisms. We need the Federal government to be our invested partners with these new and inno-

<sup>1</sup>RAND Corporation, "Introducing Autonomous Vehicles Sooner Could Save Hundreds of Thousands of Lives Over Time." <https://www.rand.org/news/press/2017/11/07.html> (November 7, 2017).

<sup>2</sup>Cox Enterprises, "2018 Cox Automotive Evolution of Mobility Study," <https://d8imphy647zgz.cloudfront.net/wp-content/uploads/2018/08/2018-Cox-Automotive-Evolution-of-Mobility-Study-Autonomous-Vehicles-Research-FINAL.pdf>, (August 2018).

<sup>3</sup>AAA, "Americans Feel Unsafe Sharing the Road with Fully Self-Driving Cars," <https://newsroom.aaa.com/2017/03/americans-feel-unsafe-sharing-road-fully-self-driving-cars/>, (March 7, 2017).

vative approaches. The creation of the Advanced Transportation and Congestion Management Technologies Deployment Program, in the FAST Act, was a good start by providing competitive grants for advanced transportation technologies to states, local governments, and transportation agencies. The authorized \$60 million a year, however, is not sufficient to meet the nationwide demand for automated vehicle deployment.

Additional opportunities are in Senator Cortez Masto's *Moving and Fostering Innovation to Revolutionize Smarter Transportation (Moving FIRST) Act*, Senator Cantwell's *Smart Cities and Communities Act of 2017*, and Senator Heller's recent Smart Cities amendment to the Transportation-HUD Appropriations minibus legislation. Senator Cortez Masto's legislation will enable more communities, regardless of size, to compete for resources to fund efficient and innovative transportation projects. The legislation will expand the 2015 Strengthening Mobility and Revolutionizing Transportation (SMART) Cities Challenge administered by the U.S. Department of Transportation, and its funding can help meet a community's transportation needs and support the development of groundbreaking partnerships. Senator Cantwell's legislation will direct the Departments of Commerce, Energy, HUD and Transportation, and the National Science Foundation to establish the Interagency Council on Smart Cities to promote coordination among the Federal agencies on smart cities. The legislation also requires the council to develop a multiyear strategy for the coordination of smart cities, the development of partnerships with the private sector, and the promotion of international cooperation. In addition, Senator Heller's amendment would require the U.S. Department of Transportation to engage with and assist local communities, metropolitan planning organizations, and regional transportation commissions on advancing Smart City solutions.

In conclusion, the opportunity is real, and the timing could not be better to embrace it. As communities like ours face the risk and uncertainty of being among the first to embrace a new brand of urban mobility, the decisive factor is simple: *collaboration*. Absent Congressional support, there is no realistic pathway to think differently—much less do differently—relative to transportation. Together, however, the opportunities to improve lives and accelerate the economy through advanced mobility are boundless.

The CHAIRMAN. Thank you, Ms. Quigley.  
Mr. Sanford.

**STATEMENT OF DAVIS S. SANFORD, CAMPAIGNS LEAD,  
NAVAL UNMANNED AND FUTURE TECHNOLOGIES,  
ROLLS-ROYCE MARINE NORTH AMERICA, INC.**

Mr. SANFORD. Chairman Thune, Ranking Member Cortez Masto, and Members of the Committee, if the Committee will allow, I would like to share a short video of our vision for autonomous ships to set the stage for my testimony.

[Video shown.]

Mr. SANFORD. Thank you for allowing me today to come before you to discuss innovative technologies in the commercial naval unmanned surface vessel market and potential opportunities and obstacles in this sector.

By introduction, Rolls-Royce is one of the world's leading industrial technology companies. Rolls-Royce has more than 6,300 U.S. employees in 27 states supporting civil aerospace power systems and defense.

Rolls-Royce hardware can be found in more than 90 percent of the U.S. Navy's surface fleet, on 70 international maritime forces, and on over 30,000 commercial vessels.

As we look to the next hundred years, we strive to continuously innovate to provide the best solutions in the markets we serve. This requires us to anticipate the opportunities and challenges that our customers will face in the coming years. We believe that electrification and digitalization will define the world's future power needs.

Current initiatives, like enhanced engine analytics and civil aero, will enable greater asset utilization for our customers, hybrid electric solutions to realize eVTOL in urban air mobility setting, and advances in digitalization, which is cultivating the next generation of advanced sensors, communications, data processing, machine learning, artificial intelligence, robotics, and additive layer manufacturing.

At Rolls-Royce, we believe these innovations are coming to reality, culminating in the development of remote and autonomous shipping that will be safer, more efficient, and less expensive to build and operate, and our unrivaled expertise and equipment knowledge will help transfer today's vessels to tomorrow's needs.

The emerging unmanned maritime market is in the medium-to-large unmanned surface vessels typically over 90 feet in length. These vessels are considerably more complicated than our current unmanned surface vessels on the market and, when manned, would have licensed mariners operating the bridge and in a separate set of places mariners and marine engineers operating critical ship systems, such as engines, generators, electrical distribution and auxiliary systems.

When discussing the technologies currently developed, find it useful to think of them in two categories that relate to how a manned vessel operates: bridge autonomy and ship system autonomy. Broadly speaking, bridge autonomy technology are those that reduce or replace activities typically performed by a vessel's deck officers. These activities include voyage planning, autonomous navigation, real-time situational awareness, and autonomous communications to name a few.

Ship system autonomous technology seeks to reduce or replace activities typically completed by a vessel's marine engineers. An autonomous machinery controller system will make decisions that a typical marine engineer onboard a vessel would make.

Shore-side remote operating centers will oversee the vessels while at sea and will remotely operate the vessels when near port or under other circumstances. Such centers are expected to be manned by professional mariners as ships are operated today but they'll return home after each shift rather than after months at sea.

Maritime academies will need to adapt their curriculums to meet the demand for the new class of sailor.

We at Rolls-Royce believe that these and other emerging technologies hold great promise for a positive impact throughout the marine industry.

In terms of safety, more than 70 percent of all marine accidents are the result of human error or interference. Having autonomous vessels that do not fatigue or lose concentration, we expect ship accidents to be reduced but not eliminated.

Cost savings will be another driver for the commercial industry to invest in autonomous vessels. Through improved vessel efficiency, reliability, and availability, total transportation costs could decrease by 20 percent.

Emerging and existing risks will continue to be an issue in the maritime industry, such as cyber attacks and boarding by unknown entities at sea.

Looking to application of these emerging technologies, Rolls-Royce is collaborating with Switzer, a Danish global towage operator, in demonstrating the world's first remotely operated commercial vessel, a 91-foot tug located in Copenhagen.

The U.S. Navy, through its unmanned vessel Seahunter, the upcoming Overlord Program, and other autonomous vessel programs, is researching the potential of medium and large unmanned surface vessels and how they'll be utilized for future naval operations.

However, we as an industry face challenges in the development of future unmanned surface vessels, including maritime regulation, export controls, insurance, and communication band width, to name a few.

These are the challenges we face. These are the opportunities we see.

Once again, I thank the Committee for allowing me to brief its members on the promise of unmanned commercial and naval vessels. It's critical for the U.S. Government, including our representatives in Congress, and the domestic shipping industry, to begin to develop a roadmap that logically addresses both the opportunities for and the barriers to the development of medium and large unmanned surface vessels.

We would respectfully suggest that collaboration is a keystone when it comes to modifying existing rules and regulations and developing new policies into the exciting future in the marine sector.

I stand by ready to take any questions you may have.

[The prepared statement of Mr. Sanford follows:]

PREPARED STATEMENT OF DAVIS S. SANFORD, CAMPAIGNS LEAD, NAVAL UNMANNED AND FUTURE TECHNOLOGIES, ROLLS-ROYCE MARINE NORTH AMERICA, INC.

Chairman Thune, Ranking Member Nelson and Members of the Committee, thank you for allowing me to come before you today to discuss innovative technologies in commercial and naval unmanned and autonomous surface vessels; and to offer a perspective on the current opportunities and obstacles that industry anticipates as these next generation ships and systems move closer to becoming a widespread reality.

Rolls-Royce is one of the world's leading industrial technology companies pioneering cutting-edge technologies that deliver the cleanest, safest and most competitive solutions to our planet's vital power needs across land, sea, and air.

With operations in the United States for over 100 years, Rolls-Royce has more than 6,300 employees across 27 states; producing state-of-the-art engines and propulsion systems. In addition to powering some of the world's foremost civilian aircraft, we provide U.S. engineered power systems and equipment for a number of Department of Defense aviation platforms, including the C-130 transport; the V-22 Osprey tilt rotor; the unmanned Global Hawk and Triton; and the short take off and vertical landing (STOVL) variant of the F-35 Lightning II.

In addition to powering 70 international maritime forces, and on over 30,000 commercial vessels, Rolls-Royce is a proud provider of power products to the United State Navy and Coast Guard. Our hardware can be found on the Nation's most capable ships, including the *Nimitz* and *Ford* class aircraft carriers; *Arleigh Burke* and *Zumwalt* Class destroyers; both variants of the Navy's Littoral Combat Ships; and the Coast Guard's National Security, Offshore Patrol, and Fast Response cutters. In fact, more than ninety percent of the Navy's battle force ships are driven by propellers crafted in the Rolls-Royce propeller foundry in Pascagoula, Mississippi.

Rolls-Royce is at the forefront of innovation and experience in the maritime sector. Today, the Rolls-Royce Ship Intelligence group already delivers multifaceted enhancements in vessel performance, operation and safety, and it will continue to play a role in redefining the industry as we move toward a more remote and autonomous world. Rolls-Royce believes remote and autonomous ships will be safer, more efficient and cheaper to build and operate. Our unrivalled expertise and equipment knowledge will help transform today's vessels for tomorrow's needs.

### Current Developing Technologies

Worldwide, there are over 100 companies working on small unmanned surface vessels, ranging in size from a few feet up to 50 feet in length. Each ship has demonstrated differing abilities to operate without human input in applications ranging from recreation and commercial, to defense and security operations. Looking to the emerging unmanned surface market, these vessels are in the medium to large size, typically over 90 feet in length. These vessels are considerably more complicated, and, when manned, have licensed mariners operating the bridge, and a separate set of licensed marine engineers operating critical ship systems, including engines, electrical plant, cargo handling, and ballasting operations.

When discussing the technologies under development, it is useful to think of them in two categories that relate to how a manned vessel operates: bridge autonomy and ship system autonomy.

#### Bridge Autonomy

Bridge autonomy technologies will reduce or replace activities typically performed by a vessel's deck officers. These activities include; mission planning, autonomous navigation, situational awareness, and communications. Mission planning defines where the vessel is going and how it will get there. Autonomous navigation is the system programmed to execute the mission plan, including adherence to the International Regulations for Preventing Collisions at Sea (COLREGS), cognizance of navigational aids, and obstacle avoidance.



Reduced Visibility Environment

Situational awareness tools include radar, LiDAR (light detection and ranging), video, thermal imaging, and Automatic Identification System (AIS), allowing the vessel to identify and avoid other vessels and obstacles.



Intelligent Awareness

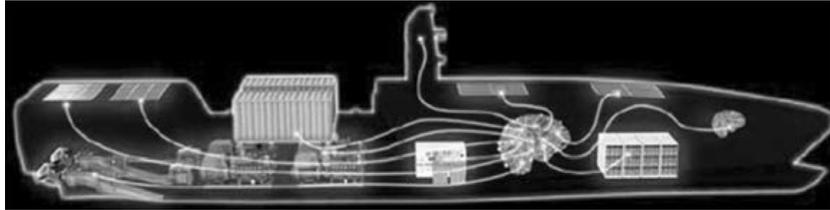
The situational awareness data feeds into the autonomous navigation system, enabling it to safely execute the mission. Despite the vastness of the open ocean, the sea is a constantly moving body, with vessels operating at different speeds and traveling in all directions. This greatly increases the complexity built into an unmanned vessel so that it may operate autonomously.

Autonomous Ship Communications includes transmissions with other vessels, both manned and unmanned, via VHF, and communications to shore facilities through VHF, cellular networks, and/or satellite communications. It is critical for cyber security be built into all autonomy systems at the beginning to ensure that the vessels cannot be hacked or taken over by third parties.

#### Ship System Autonomy

Ship system autonomous technology applications reduce or replace activities typically completed by the vessel's marine engineers. The primary system performing this function is an autonomous machinery control system, designed to execute the

decisions that a typical on board marine engineer would make based on standard bridge operations. These include but are not limited to, speed and direction, maintenance of ship system requirements, equipment availability, and system troubleshooting, among many others. The machinery control system uses energy management, equipment health monitoring, propulsion control, and integrated platform management systems and other enabling technologies to monitor, control and direct the on board ship systems (ie power generation, propulsion, electrical distribution, ballast, lighting, lubrication, fuel, cooling, steering, and water).



Ship System Autonomy Network

Energy management technology monitors and compares the current operational profile of a vessel and assesses how it might more efficiently operate. An example of this would be an adjustment of vessel speed to enable the propulsion plant to run at peak performance. Similar to equipment deployed in the Rolls-Royce powered civil aviation fleet, equipment health monitoring surveys the ship's systems to ensure that they are operating properly, and to identify potential issues that may forecast a system shutdown. A propulsion system equipment health monitoring system could identify a fault in an engine lubricating oil system, shutting the unit down to prevent an engine failure. Additionally, if an engine shut down could potentially result in the vessel's grounding, or result in a similarly dangerous situation, the autonomous machinery controller, through communication with the autonomous navigation system, could independently make the decision to operate the engine until the risk has passed.

The continued development and operation of ships with electric propulsion systems will lead to improved reliability, reduced maintenance, and improved energy efficiency throughout the ship. These technologies complement those being developed for the autonomous operation of unmanned surface vessels.

#### Shore Side Operations

Currently under development, shore side remote operating centers may have the capability of performing many of the operations and system maintenance functions for certain cargo ships and other vessels. These centers will be manned by professional mariners and engineers, on-hand to support unmanned fleet operations.



Roll-Royce Remote Operating Center Concept

As envisioned, mariners could monitor vessel operations from a supervisory position and take over remote operation of the vessel when near port, or if other circumstances require. It is also conceivable that harbor pilots will be able to take command of arriving vessels sailing into port, thus removing the risk associated with a pilot transferring to a ship at sea, and potentially improving the efficiency of bringing a ship into port. System monitoring, data analysis, and failure diagnosis of equipment operating on vessels at sea, performed by maritime professionals, may also be performed at these facilities.

#### **Impact of Emerging Technologies**

These technologies are expected to positively improve safety and increase efficiencies benefiting the marine industry. In terms of safety, it is notable that more than 70 percent<sup>1</sup> of all marine accidents are the result of human error or interference. By reducing or eliminating the number of people operating a vessel, it's expected there will be fewer accidents. However, autonomous ship systems are not failsafe and autonomous systems will not reduce the accident rate to zero as the acceptance and use of autonomous ships may also result in new types of accidents.



Rolls-Royce Autonomous Container Ship Concept

Cost savings will be another driver for the commercial industry to invest in autonomous vessels. Through improved vessel efficiency, reliability, and availability, it is estimated that transportation costs could decrease by 20 percent. Cost savings can be found through lower power usage and demand, fewer operating and hotel load systems, elimination of the deck house, and a consequent reduction in the number of systems requiring maintenance at sea.

Despite these advances, there are and will continue to be shipping activities that require a full crew, maintaining humans in the loop, particularly for shipborne activities that might be considered higher risk or labor intensive. Examples would include passenger vessels, oilfield service and crew boats, and ships carrying hazardous materials. In some of these applications, however, automating systems like navigation may still be possible.

In evaluating the impact of emerging technology, the improved quality of life for the mariner is a very important factor to consider. Instead of spending several months at sea and away from home, mariners will have the option to pursue a career allowing them to work shore side, returning home after a scheduled work shift. As autonomous ship systems make the inevitable transition from commercial to military applications, specialty vessels may be fielded and autonomously missionized or remotely operated for dangerous or repetitive operations. Examples include ISR operations in hostile waters, border security, search and rescue, and drug smuggling detection and interdiction.

#### **Risks to Maritime Industry**

The acceptance and adoption of commercial autonomous ships and ship intelligence systems carries both risks and opportunities for the maritime industry. The greatest risk may be that of a cyber-attack, whereby a foreign or independent actor takes control of an unmanned vessel for ransom, theft, or terrorist purposes. In addition to hardening shore side and shipboard control systems, vessels must also be designed to thwart or prevent ship boardings at sea.

<sup>1</sup>European Maritime Safety Agency Annual Report 2015

There is also a potential impact to the number of licensed U.S. mariners that may be at sea at any one time. With an increased use of automation and autonomous technologies for shipping and ship operations, licensed and trained mariners may spend less time at sea as opportunities are created for them to move off the vessel and into remote operating centers or other ship support activities. To fill the need for mariners in the autonomous ship space, maritime academies must adapt their curricula to meet demand for a new class of sailor.

### Applications

Rolls-Royce is a technology leader in the field of autonomous shipping and ship intelligence systems, and is actively testing and refining its systems and capabilities. Rolls-Royce is collaborating with Svitzer, a global towage operator, in demonstrating the world's first remotely operated commercial vessel, the 91 foot *Svitzer Hermod* tugboat. The tug, located in Copenhagen Harbor, demonstrates the ability of a land based captain to remotely control a working boat and executing representative tugboat operations from a remote operating center at the company's headquarters.



Remote Control Svitzer Hermod Bridge—Rolls-Royce/Svitzer Remote Operating Center, Copenhagen

Rolls-Royce has also engineered and installed automatic water crossing systems into vessels operated by Fjord1, a Norwegian passenger ferry company. These ferries, first delivered in 2017, provide autonomous, point to point, ferry service for passenger and vehicular traffic, and rely on a totally electric propulsion system. For these and other commercial vessels, Rolls-Royce developed and implemented complementary energy management and equipment health management systems.

In the not too distant future, the commercial industry is expected to adopt unmanned surface vessels for container ships, bulk carriers, and tugs. In the naval and defense market, unmanned surface vessels are already being studied for broader defensive and offensive operations, special operations, and fleet auxiliary ships. There are a number of companies developing technologies and systems for the next generation of commercial shipping. In fact the Norwegian company Yara is building the world's first autonomous and fully electric container vessel. It is expected to begin autonomous operations in 2020.

In the United States, DARPA and the U.S. Navy are leading the effort to develop and deploy unmanned surface, and subsurface, vessels for a variety of defensive operations, including anti-submarine, mine countermeasure, force protection and survey operations. The U.S. Navy through its ACTUV, Overlord, and other autonomous vessel programs is researching the limitations and capabilities of medium and large unmanned surface vessels, and how they will be utilized in future naval operations.

### Barriers to Development

As companies move forward with the development of unmanned surface vessels, and shipping companies consider integrating autonomous ships and ship systems into their fleets, it's important to note that there are maritime regulations, or the lack thereof, that may hinder further development, and consequent adoption, of these technologies. For example, the U.S. COLREGS do not allow for the unmanned operation of a vessel. The Navy, however, has more flexibility in the deployment of autonomous boats or other vessels. The International Maritime Organization (IMO) has similar regulations prohibiting unmanned ship operations. Looking to the future, however, IMO is examining the issues surrounding autonomous vessel operations and is reviewing the universe of maritime regulations and how they might be adapted or amended to satisfy current limitations within ship operations and the International Convention for the Safety of Life at Sea (SOLAS) requirements.

With the exception of the Navy's national defense autonomous vessels work, much of the medium and large unmanned surface vessel development and testing is taking place outside of the U.S. Export control and other perceived restrictions on foreign technologies being imported into the U.S. have inhibited the transfer of autonomous ship technologies to the United States. Quite frankly, companies are concerned that technology brought into the U.S. will be unduly regulated and restricted from selling that commercial technology abroad. Obviously there is a need to control certain autonomous ship technologies that have military and national security applications. However, concern remains that commercial and defense autonomous ship technology will be looped into a generic category making export difficult hence disincentivising companies from investing in the U.S. As companies begin investing in autonomous ships and related technologies, including larger unmanned surface vessels, the insurance industry must also plan for and create products that will provide insurance for these vessels, during both development stages and eventual operation. Lloyd's Register is monitoring the performance of the Rolls-Royce and the Svitzer remotely operated tug to understand and evaluate this emerging technology. Within the U.S., insurance companies and regulators will soon need to take an active role in designing and implementing policies and regulation for next generation of passenger and cargo vessels.

As unmanned surface vessels move offshore, the availability of communication and data transfer bandwidths will be a major limiting factor for remote, shore side, autonomous ship operation centers, and their ability to monitor and visualize what is taking place on the ship. While satellite communications have improved greatly over the last decade, the bandwidth needed to exchange real-time information as is currently done with the Svitzer tug, could quickly escalate to a point countering any efficiency gains.

#### **Closing Thoughts**

It is critical for the United States and the domestic shipping industry to begin developing a roadmap to logically address both the opportunities for and the barriers to the development of medium and large unmanned and autonomous surface vessels.

Similar to unmanned aerial systems test ranges, to the extent possible, certain areas of our national waters might be delineated for unmanned and autonomous vessels testing. Isolated from recreational boating and cargo sea lanes, industry, with government support, could define a controlled area for testing with predetermined rules, regulations, and monitoring. This would simplify the process for notification and approval by regulatory bodies, including the Coast Guard and other state and local marine law enforcement agencies.

To support the development of unmanned and autonomous ship technologies in the U.S., the Federal Government and industry must collaborate on the development of new and modified export rules relative to unmanned surface vessel technologies. Doing so will enable easier flow of technology between trusted parties, and encourage further technological innovation and collaboration by the United States and its allies.

Once again, we thank the Committee for allowing us to brief its Members on the promise of unmanned autonomous commercial and naval vessels.

The CHAIRMAN. Thank you, Mr. Sanford.  
Ms. Tolson.

#### **STATEMENT OF LAURIE TOLSON, CHIEF DIGITAL OFFICER, GE TRANSPORTATION**

Ms. TOLSON. Mr. Chairman, Ranking Member Cortez Masto, and Members of the Committee, I'm Laurie Tolson, Chief Digital Officer for GE Transportation.

Thank you for the opportunity to testify before the Committee on Emerging Technologies that Will Move America.

Today, I will talk about one of our most exciting digital success stories, the Port Optimizer. This optimizer applies GE innovation in solving the logistics challenges which face our country's major ports.

First, let me provide some context. In the wake of unprecedented changes in the maritime shipping industry and the West Coast con-

gestion of 2014 and 2015, consistency emerged that more efficiency cargo handling was possible through improved information sharing and collaboration among supply chain actors.

Against this backdrop, GE Transportation partnered with the Port of Los Angeles, the largest container port in the U.S., to take a huge digital leap forward in the movement of goods.

We started with the basic question. What if ports have forward visibility to arriving vessels as far as two weeks ahead of time versus the 2-days we experience now in the current process?

We tested this at the port and we found that this advanced visibility allows for better planning and predictability, making for a more efficient supply chain, and in late 2016, we partnered to develop a common portal that provided secure real-time access to cargo data.

The custom-build application was piloted by the port's largest terminal with two of the largest shipping lines, Maersk and MCO. Participants also included beneficial cargo owners, like Walmart, Target, and Nike, trucking companies, UP and BNSF, chassis providers, and the largest marine terminal port operator in the port, AP Moller.

Based on that pilot, the port estimates that complete implementation of the solution would yield 10 percent improvement in throughput and up to 12 percent increase in productivity as trucks reduce their turn times, railroads plan train schedules better, cargo moves faster, and containers receive fewer touches as they go throughout the process.

From that successful pilot, we entered into a longer-term partnership with the port to develop and deploy what is now the Port Optimizer. By integrating data from an across-the-port ecosystem and combining machine learning and deep domain expertise, the optimizer helps supply chain monitor and respond to dynamic conditions, better align people and resources, and proactively communicate across functions.

Let me highlight a few of the benefits to key stakeholders, benefits to truckers. The port's average turn time for trucks is about 70–80 minutes, which is quite long. This needs to come down to afford drivers the ability to earn sufficient compensation, maintain and reinvest in their equipment, and ensure a sustainable carriage fleet.

Our solution will help by allowing the trucking community to plan ahead with labor and equipment, make operational decisions based on incoming volume, and better planned dispatch. We can do this by, first, providing single source of information for trucking companies who plan container drop-offs and pickups. Today, they have to monitor 13 different websites to get this information.

Second, by enabling truck appointments to be made in one place in a standard way and allowing trucking companies to make same-day changes, the appointments can be better handled. Right now, if there's a missed appointment, it's very costly to rebook, takes time and resources.

Benefits to the environment. The efficiency has a positive environmental impact. Reduced turn times obviously minimize the time trucks idle at the port and associated emissions can be reduced by up to about 40 percent, we're estimating.

Data-sharing allows the container to move through a terminal with fewer touches, reducing utilization and emissions from the cargo-handling equipment at the port.

Benefits to rail. There are approximately a hundred trains about two miles in length that lead the Port of Los Angeles and Long Beach every day. The railways need to know the volume of cargo coming their way by destination so they can best arrange containers on the train, which is called blocking.

The more upfront information we can give the railroads about where the boxes are ultimately heading, the smarter they can order that cargo on the train when they build them and assemble the engine power they need for the length of the train and the weight, the rail cars and the crews. All this means more jobs.

Benefits to the terminal operators. If we can facilitate better sharing between railroads and marine terminal operators, then the operators can better align their resource plans to changing rail schedules. The operators can reduce costs, they can increase their capacity, lower emissions, increase throughput and create more jobs.

And last in the highlights is benefits to labor. The port has engaged the local longshoremen's union in the development and implementation of the pilot from the very beginning. The union has told us this solution will help and do a better job in planning and organizing a terminal yard as they work to discharge a cargo vessel.

Increased efficiency makes us more competitive, drives more volume, and supports the creation of job growth across the supply chain. One in nine jobs in Los Angeles are at the port and it is the biggest employer in California.

Based on these widespread benefits, the Port Optimizer is now being deployed next door at the Port of Long Beach. We're continuing to add participants in Los Angeles. We are also pushing opportunities with other ports in the U.S. and globally.

There's tremendous interest in the port community for these types of cost-effective digital solutions. The innovation GE is driving with the Port Optimizer is unlocking huge operational capacity at our Nation's ports and across the entire supply chain.

It is about enabling a dramatically more efficient use of existing physical infrastructure by harnessing big data analytics that can expand capacities securely at a fraction of the cost, helps the environment, and is much quicker to deploy. This is truly the future happening now.

Thank you for your time and I look forward to your questions.  
[The prepared statement of Ms. Tolson follows:]

PREPARED STATEMENT OF LAURIE TOLSON, CHIEF DIGITAL OFFICER,  
GE TRANSPORTATION

Mr. Chairman, Members of the Committee, I am Laurie Tolson, Chief Digital Officer for GE Transportation. Thank you for the opportunity to testify before the Committee today on Emerging Technologies That Will Move America.

**Background on GE and GE Transportation**

I am thrilled to be here to highlight some of the innovations that are happening in transportation. GE Transportation is a leading global technology supplier of equipment, services and digital solutions to the rail, mining, marine, stationary power and drilling industries. As the company's Chief Digital Officer, I see innova-

tions in our own business as well as across the GE Company. From pioneering traffic management for drones, developing hybrid-electric propulsion to bringing the first Tier 4 locomotive to market, GE is at the forefront of technology. Exciting new manufacturing techniques like 3D printing and advancements in lightweight materials will transform the way we travel, making transportation safer, more efficient and environmentally sensitive than today. When we pair state of the art hardware with cutting-edge software solutions, the possibilities for our customers are endless. Today I will talk about one of our most exciting digital success stories—the Port Optimizer.

As GE has looked to focus its business on Aviation, Power and Renewable Energy, we have been looking for a new home for the GE Transportation business. You may have seen coverage of our intent to merge with Wabtec. Wabtec is a natural partner—great for our customers, great for our employees, and great for the communities in which we operate.

GE Transportation and Wabtec’s businesses are complementary, and the merger allows us to accelerate innovation and reduce costs, providing our customers with better solutions.

GE Transportation provides digital solutions to many different areas across our industry, from train performance to transportation logistics. With applications in asset performance, train handling, network optimization and supply chain visibility, we’ve seen digital solutions deliver results such as 10–25 percent reduction in mainline failures, average 10 percent in fuel savings, 10 percent improvement in network velocity and 40 percent increase in rail volume.

For example, Trip Optimizer, our smart, automated cruise control system for the rail industry, saves ~1 million gallons of fuel per week. With over 10,000 units deployed, Trip Optimizer is the most widely used energy management system within the freight rail industry.

Looking more broadly about how we integrate our portfolio of solutions for impact across the supply chain, we are launching our new RailConnect Visibility and Planning, which provides a consolidated dashboard view of the railcar supply chain, enabling cargo owners and railroads to plan more effectively and facilitate predictability and efficiency in freight rail.

#### **Port Optimizer Solution**

As I mentioned, one of the innovations we are most excited about is the digital transformation we are facilitating at our Nation’s ports. Think about this as I walk through what we are doing in ports: what if ports can have forward visibility to arriving vessels as far as two weeks ahead of arrival, as compared to just two days under the traditional process? We tested this at the Port of Los Angeles and found that this visibility allows for better planning and predictability, making for a more efficient supply chain—one in which our Nation’s shippers can better serve their customers and meet emerging needs.

As a result, the Port of Los Angeles was able to increase throughput by 10 percent and productivity by 8–12 percent for ground transportation. That is the power of digital solutions we are discussing today.

#### *Port Changes*

As you well know, 90 percent of global trade is waterborne. Seaport cargo activity accounts for 26 percent of U.S. GDP and 23 million American jobs. As the Nation’s gateways to the global economy, seaports are key enablers of U.S. job creation, economic prosperity and American competitiveness.

Yet, maritime shipping is undergoing unprecedented change—including the transition to ultra-large container vessels and the formation of cargo alliances. These changes create greater complexity in cargo sorting and handling at major U.S. ports, leading to suboptimal allocation of equipment and labor, increased cost, and frustration for cargo owners.

In the wake of the West Coast congestion experienced in 2014–15, several multi-stakeholder efforts worked to identify solutions, including the Federal Maritime Commission Supply Chain Innovation Teams and the Department of Commerce Advisory Committee on Supply Chain Competitiveness. Consensus emerged that more efficient cargo handling was possible through improved information sharing and collaboration among supply chain actors. By eliminating the silos of data that currently exist along the maritime supply chain and providing timely information in one place, we can increase throughput efficiency at major port complexes and provide greater value (*i.e.*, visibility and predictability) to cargo owners.

Developing digital solutions that drive efficiency by addressing increasing cargo volumes, capacity constraints, and other operational challenges at ports will result

in game changing economic, environmental, and safety benefits for business, local and national economies, investors, and consumers.

Against this backdrop, GE Transportation (GET) saw an opportunity for this industry—to take a huge digital leap forward in the movement of goods. I want to tell you about our deployment of a visionary solution that promises to weave a digital thread across the entire global supply chain.

#### *Port of Los Angeles Pilot*

In late 2016, we partnered with the Port of Los Angeles to develop a common portal—now known as the GE Port Optimizer—that provides secure, real-time access to cargo data. The custom-built application was piloted at POLA's largest terminal, with the 2 largest shipping lines, Maersk and MSC. Pilot participants also included beneficial cargo owners (BCOs), trucking companies, the Class I railroads, chassis providers, and marine terminal operators.

Based on that 2017 pilot, the Port of Los Angeles estimates that port-wide implementation of the portal would yield a 10 percent improvement in throughput and an 8–12 percent increase in productivity as trucks reduce their turn times, railroads plan train schedules more effectively, cargo moves faster, and lower energy cost and air emissions as containers receive fewer “touches” throughout the process.

#### *Port of Los Angeles Adoption*

With the success of the pilot, we entered into a longer-term partnership with the Port of Los Angeles to develop and deploy what is now the Port Optimizer. The Port Optimizer is a cloud-based software solution that enhances supply chain performance and predictability by delivering real-time data-driven insights through a single portal to partners across the supply chain. By integrating data from across the port ecosystem, and combining machine learning and deep domain expertise, the Optimizer helps the supply chain monitor and respond to dynamic conditions, better align people and resources, and proactively communicate across functions. Key capabilities include:

- Greater visibility for improved asset utilization;
- Single portal to collaborate with supply chain partners;
- Reduced supply chain dislocations by anticipating issues; and
- Increased cargo velocity and improve service delivery

Port Optimizer leverages GET's cloud platform with automated data ingestion, modeling, API capabilities for more modern and real time data sharing & visibility, and advanced analytic capabilities. Additional features under development include export optimization, chassis availability and ordering, scheduling and truck reservations systems, empty container optimizations and returns management, container match back capability, rail optimization, and a Blockchain application pilot.

Port Optimizer is now being deployed to the rest of the San Pedro Bay Port Complex. We are not only expanding from our initial pilot at one terminal in Los Angeles to the entire Port, but also launching a pilot with three of the six terminals in the Port of Long Beach. We are continuing to add participants in Los Angeles, with agreement from 95 percent of the major shipping lines and marine terminal operators. And we are pursuing opportunities with other ports in the U.S. and globally. There is a tremendous interest in the port community for these types of cost effective digital solutions.

Our longer-term goal is to have a significant portion of ports around the world using this platform. As with many digital tools, especially those using AI and machine learning, the more participation we have, the richer the data pool and the more value and efficiencies we can deliver to the global supply chain.

#### **Infrastructure Public Policy Considerations**

Ports across the Nation are in need of infrastructure investment. The American Association of Port Authorities (AAPA) estimates \$66 billion in infrastructure needs at the Nation's ports. Digital infrastructure should be part of the broader infrastructure discussions especially because solutions like the GE Port Optimizer enable more efficient use of existing freight infrastructure. They expand capacity at congested trade corridors and gateways at a fraction of the cost of building new “bricks and mortar” projects and deliver tremendous value for supply chain users.

As Congress considers infrastructure policies and funding, we encourage consideration of digital solutions for enhancing the operations of industrial and critical infrastructure. New digital industrial and critical infrastructure should complement a range of infrastructure modernization priorities—including energy infrastructure, as well as surface transportation, aviation, ports, and other intermodal freight facilities and systems.

We further encourage Members of Congress to consider the critical role of communications and wireless connectivity for industrial and critical infrastructure operators. Access to affordable spectrum for industrial site specific, private wireless networks will improve coverage, data capacity, infrastructure reliability and security. We are an active part of the IIoT Coalition (a group whose members collectively account for approximately 40 percent of the U.S. economy and includes entities such as Port of Los Angeles, FedEx, Union Pacific, Southern Linc and the Utilities and Petroleum industries), that is engaged with the FCC on finding meaningful policies for promoting industrial investment in the 3550–3700 MHz Band (or CBRs) for supporting the deployment of 5G services for use in industrial and critical infrastructure operations.

Digital industrial and critical infrastructure, a component of the Internet of Things (IoT), encompasses software solutions that optimize infrastructure and network performance and outcomes and advanced private wireless networks that enable secure data communications and provide infrastructure operators with dedicated bandwidth for their operations. New infrastructure investment priorities should:

- Ensure eligibility of digital industrial infrastructure across all Federal transportation and power funding and credit support programs.
- Encourage consideration of digital industrial applications—including software—as natural complements to further public investments in “traditional” brick, mortar, steel, and hard equipment assets to enhance system performance.
- Promote the importance of affordable access to wireless spectrum licenses for private wireless networks that allow infrastructure operators to deploy and operate dedicated, site-specific 5G networks for use in digital industrial and critical infrastructure operations.
- Support testing, evaluation, and deployment of all technologies that boost infrastructure performance, *including digital*, to maximize the value of public investments.

#### **Conclusion**

The innovation GE is driving with the Port Optimizer is unlocking huge operational capacity at our Nation’s Ports and across the supply chain. It is enables a dramatically more efficient use of existing physical infrastructure by harnessing Big Data analytics that can expand capacity at a relatively low cost and with much quicker deployment. This is truly the future happening now.

Thank you for your time and I look forward to your questions.

The CHAIRMAN. Thank you, Ms. Tolson.  
Mr. Raycroft.

#### **STATEMENT OF JOSH RAYCROFT, DIRECTOR, BUSINESS STRATEGY, VIRGIN HYPERLOOP ONE**

Mr. RAYCROFT. Chairman Thune, Ranking Member Cortez Masto, and Distinguished Members of the Committee, I want to thank you for inviting me to testify today, to share with you the very exciting innovation happening at Virgin Hyperloop One.

My name is Josh Raycroft, and I am the Director of Business Strategy at our Headquarters in Los Angeles.

Prior to joining Virgin Hyperloop One, I worked as an engineer at GE Aviation. So it’s very gratifying to be able to testify here alongside GE Transportation and other great companies and agencies that are at the cutting edge of transportation technology.

We are a U.S. company that has now grown to 250 employees. I had the opportunity to watch the company grow from just about 20 about 3 years ago. We are—by far—the leading company in this space in advancing hyperloop technology, and we have accomplished amazing achievements that I look forward to sharing with you this morning.

I will start with a brief definition of the technology. The term “hyperloop” is shorthand for what may be better described as a low-pressure/high-speed surface transportation system.

Travel occurs within an enclosure that maintains a very low atmospheric pressure while the vehicle is pressurized to normal atmospheric conditions—very similar to what we experience in commercial aircraft today.

The benefit of the low-pressure environment is that it all but eliminates aerodynamic drag on the vehicle. This allows it to reach very high speeds and consume a small amount of energy while it’s traveling along the track.

We use electromagnetic propulsion to move the vehicle and we use magnetic levitation rather than wheels to allow the vehicle to glide along the track.

In November 2016, we began to build our first full-scale and full-system test site. We did that in Nevada, which we’re very happy that the state has been so helpful in that process. Yes, thanks, Tina.

We call that site Devloop. It’s located about 30 miles north of Las Vegas. This test bed is a 500-meter full-scale hyperloop incorporating all of the elements of our proprietary system.

On May 12, 2017, we had our Kitty Hawk moment. We successfully completed the world’s first full system self-powered hyperloop test run. In December 2017, we reached speeds up to 240 miles per hour. This gives us high confidence that we could reach our target speeds up to about 600 miles per hour as we continue to develop the technology.

I would now like to show you a short video demonstrating what we’ve done with these tests.

[Video shown.]

Mr. RAYCROFT. As you can imagine, as an engineer, that makes me extremely excited to see how fast our team has been able to design, build, and test this very exciting new technology.

While we focused on improving the technology in 2017, we are now focused on commercializing the technology. We have started transportation projects with state and local agencies across the U.S., studying the feasibility of the hyperloop system in their states and regions.

In Colorado, we are partnering with the state on a feasibility study. In the Midwest, we are working with Ohio officials on both a feasibility study and a Tier 1 EIS. In Missouri, we are partnering with the global engineering firm Black & Veatch and others to study the feasibility of a hyperloop along I-70 between St. Louis, Columbia, and Kansas City, and in Texas, the Dallas-Fort Worth officials announced that it will conduct a Tier 2 EIS that will consider both hyperloop and high-speed rail for a 30-mile corridor between Dallas and Fort Worth.

In addition, the Regional Transportation Council announced that it will conduct a feasibility study of the longer route connecting Fort Worth down south to Laredo.

On the Federal side, we plan to expand our engagement with the DOT and with the FRA, which has jurisdiction over our system under current law.

Safety has always been our Number 1 priority and it will continue to be the priority of our engineering team throughout our commercialization. We also believe that as a railroad under Federal law, projects utilizing our technology should be eligible for relevant Federal programs designed to support these projects, such as RIF, TIFIA, formula and discretionary grants, as well as other project finance tools.

We believe hyperloop technology would add tremendous value to our existing transportation system. Hyperloop has the potential to change not only the way people live and work but also the movement of cargo and supply chains and distribution chains.

Time savings will expand opportunities for people and businesses, allowing people to live in less-densely populated areas while having access to jobs, services, and entertainment in the metropolitan areas.

A small business owner could locate his or her company in a smaller city or a rural area, while still having the same access to as a company located in the city center.

Hyperloop systems also allow for faster and more reliable movement of goods and parcels, enabling businesses to react to supply chain shocks on a more nimble basis.

Virgin Hyperloop One is well on its way to building the next generation of high-speed ground transport. We have the opportunity to develop and implement this technology right here in the United States and we're looking forward to furthering the dialogue with the Committee as well as with the DOT.

Thank you, Chairman Thune, thank you, Ranking Member Cortez Masto, for inviting us to testify today.

[The prepared statement of Mr. Raycroft follows:]

PREPARED STATEMENT OF JOSH RAYCROFT, DIRECTOR, BUSINESS STRATEGY,  
VIRGIN HYPERLOOP ONE

Chairman Thune, Ranking Member Nelson and distinguished members of the committee, I want to thank you for inviting me to testify today about the exciting innovation happening at Virgin Hyperloop One.

My name is Josh Raycroft, and I am the Director of Business Strategy at Virgin Hyperloop One in Los Angeles. Prior to joining Virgin Hyperloop One, I worked as an engineer at GE Aviation, so it's very gratifying to be able to testify here along with GE Transportation and other great companies and agencies on the cutting edge of transportation technology.

We are a U.S. company that has now grown to nearly 250 employees, and I have had the unique opportunity to watch the company grow from just 20 employees when I joined three years ago. We are—by far—the leading company in the world in advancing hyperloop technology, and in those three years, we have accomplished amazing achievements that I look forward to sharing with you this morning.

I will start with a brief definition of hyperloop technology. The term “hyperloop” is shorthand for what may better be described as a low pressure high speed surface transportation system. Travel occurs within an enclosure that maintains very low atmospheric pressure while the vehicle is pressurized to normal atmospheric conditions—much like a commercial aircraft. The benefit of the low-pressure environment is that it all but eliminates aerodynamic drag on the vehicle, which allows it to reach very high speeds and maintain those speeds with much less energy.

Anecdotally, I would describe the concept as follows: when you are driving a car and you put your foot on the gas pedal, you accelerate. When you take your foot off the gas pedal—you begin to decelerate. You slow down because of the effects of aerodynamic drag. In a hyperloop environment, the low pressure nearly eliminates the aerodynamic drag, and when you take your foot off the gas pedal, you can continue to go fast and maintain your speed for a very long time. Therefore, you can

reach very high speeds on much less power than conventional surface transportation.

After initial experimentation, evaluation and testing, we settled on a design for our system that utilizes electromagnetic propulsion to move the vehicle and magnetic levitation rather than wheels. The electromagnetic propulsion is similar to an electric car's motor, except that instead of moving in a rotary fashion to turn the axle, the motor moves in a linear manner to propel the vehicle forward.

The magnetic levitation system we utilize is dramatically different from the foreign systems developed many decades ago. Those systems, while engineering marvels at the time, use massive amounts of electricity to accomplish their levitation or require extremely precise construction and maintenance techniques that dramatically increase the installation and operating costs of the system. By contrast, our proprietary levitation system operates with larger tolerances on the track, making it easier to construct and maintain. Furthermore, our system uses significantly less energy than other maglev systems, making it less expensive to operate.

In late 2015, we began building the first scaled prototype of our propulsion system. We demonstrated this to the world in May 2016. In November 2016, we began to build our first full-scale and full-system test site, which we call "DevLoop" in the desert 30 miles north of Las Vegas. We built on land controlled by the Bureau of Land Management (BLM), and I want to compliment the state of Nevada and the Nevada Senators on this committee for the very efficient and effective way that we were able to move through the permitting process to build and begin operations on this site. I also want to recognize Tina Quigley, who is on this panel, for all of her leadership and work with us in southern Nevada.

We completed the construction of DevLoop within six months and began testing in May 2017. This test bed is a 500-meter full scale hyperloop system incorporating all of the elements of the system: A prototype pod vehicle, a low-pressure enclosure to nearly eliminate aerodynamic drag on the vehicle, an airlock, magnetic levitation, electromagnetic propulsion, power electronics and a control system.

Over 400 tests have been performed at DevLoop on all aspects of the system. On May 12, 2017, we had our "Kitty Hawk" moment, successfully completing the world's first full system, self-powered hyperloop test, marking the inaugural run of this new mode of transportation. In December 2017, on only 300 meters of acceleration, we reached speeds of 240 mph.

I would now like to show you a short video from these historic tests.

As you saw in the video, our vehicle is unique. We call our vehicle a "pod". It's not a train. We will run individual pods carrying 20–25 passengers or cargo traveling direct to their destinations on demand. There are no fixed schedules or stops at intermediate stations. The pods are moved by centralized and onboard control systems to maximize the safety and efficiency of the system.

Based on hundreds of tests at the DevLoop site and thousands at our headquarters in Los Angeles, we have integrated major improvements into our system. As we move rapidly toward commercialization, we have started engagement with various agencies across the U.S. studying the feasibility of a hyperloop system in their state and region. In two cases, these projects are advancing toward environmental permitting and the NEPA process.

In Colorado, the Colorado DOT's RoadX program is partnering with Virgin Hyperloop One to study the feasibility of a statewide hyperloop network. The engineering firm AECOM is servicing the state and Virgin Hyperloop One for the study, which is expected to be completed this Fall.

In the Midwest, we are partnering with the Mid-Ohio Regional Planning Commission (MORPC) on two projects: A feasibility study of hyperloop between Pittsburgh, Columbus and Chicago; and a Tier 1 Environmental Impact Statement on the corridor considering both high speed rail and hyperloop technologies.

In Missouri, Virgin Hyperloop One is partnering with the University of Missouri System, the St. Louis Chamber of Commerce, the Kansas City Tech Council and the Missouri Hyperloop Coalition to study the feasibility of a hyperloop along I-70 in Missouri servicing St. Louis, Columbia and Kansas City. The global engineering firm Black & Veatch, based in Kansas City is running the study, which will be completed this fall.

In Texas, the Dallas-Ft. Worth Regional Transportation Council (RTC) announced that it will conduct a Tier 1 Environmental Impact Study (EIS) that will consider both hyperloop and high speed rail for the 30-mile corridor between Dallas and Ft. Worth. In addition, the RTC announced that it will conduct a Feasibility Study of a longer route from Ft. Worth to Laredo. That study will explore both hyperloop and rail options for the corridor. The sponsors plan to move this project into an EIS following completion of the Feasibility Study.

On the Federal side, we plan to expand our engagement with the U.S. Department of Transportation and the Federal Railroad Administration (FRA), which has jurisdiction over our system under 49 U.S.C. §20102 (2)(A). Safety is our number one priority for this system and is an overwhelming focus of our design engineers. We want to work with the FRA and this committee to develop the appropriate safety regulatory framework for our system that will ensure stringent safety measures.

We also believe that as a “railroad” under Federal law, projects utilizing our technology should be eligible for relevant Federal programs designed to support these projects, such as RRIF, TIFIA, formula and discretionary grants and other project finance tools. Clarity of the Federal regulatory and financing framework for this system should be a high priority for USDOT and FRA because of the transformative potential of this American technology.

We believe hyperloop technology would add tremendous value to our existing transportation system. Today, our road, port, airport and rail systems face congestion and capacity challenges. The addition of hyperloop systems would address these and other issues our transportation system faces.

Hyperloop has the potential to change not only the way people live and work, but also the movement of cargo in supply and distribution chains. Speed and time savings will expand opportunities for people and businesses, allowing people to live in less densely populated communities while having access to jobs, services, and entertainment in central metro areas. Furthermore, a small business owner could locate his or her company in a smaller city or rural area but still have the same access as a company located in a city center. Hyperloop systems also allow for faster and more reliable movement of goods and parcels, enabling businesses to react to supply chain shocks on a more nimble basis. We are working with port operators and rail companies to study and operationalize some of these exciting cargo concepts.

Virgin Hyperloop One is well on its way to building the next generation of high speed ground transport. We have an opportunity to develop and implement this technology here right here in the United States. We look forward to working more with this committee and USDOT as we commercialize our technology.

Thank you Chairman Thune and Ranking Member Nelson for inviting us to testify today.

The CHAIRMAN. Thank you, Mr. Raycroft, and I think we overlooked the Senator from Nevada.

Senator CORTEZ MASTO. No, Mr. Chair, thank you. I so appreciate you giving me the opportunity for an introduction, but I think they’ve taken care of it themselves, as you can see. I’m very excited to have representatives—actually, there’s three on the panel right now that have a footprint in Nevada in some form or fashion. So thank you for the opportunity.

The CHAIRMAN. Thanks. I have a question for following up on your remarks there, Mr. Raycroft.

As innovative transportation technology is being developed by Virgin Hyperloop One begin to move beyond this demonstration phase, one of the key questions which I think you alluded to is how hyperloop fits into the current regulatory framework, and your testimony mentioned that you believe that hyperloop should be considered a railroad under Federal law.

If Hyperloop is considered a railroad, what does that mean from a safety perspective?

Mr. RAYCROFT. As I mentioned under current law, that’s how we read that we would fall within the FRA’s jurisdiction.

We acknowledge that there are many aspects of our technology that might not neatly well within that framework.

That said, we know that the FRA has begun implementing more systems safety approach through programs. We think that that could help bridge the gap and we’re looking forward to engaging with them further in discussion to understand how we take this forward.

The CHAIRMAN. If some of the traditional safety regulations don't neatly apply to hyperloop, in your view, how should the Federal Railroad Administration, as a safety regulator, consider your new technology? You kind of touched on that but maybe if you could drill down a little bit on that.

Mr. RAYCROFT. Yes. Certain aspects fit very nicely within that framework. There are other aspects, think of the vehicle that you saw in the video, that resemble commercial aircraft today and so there's certain elements that engagement with some other agencies within the DOT could make sense and we want to engage in those discussions to ensure that we ensure safety. That has been our Number 1 priority as we design the system, but also allowing innovation to move forward.

The CHAIRMAN. And have you looked at other regulatory frameworks that have been proposed for other new entrants into the transportation field that have dealt with some of these similar classification issues and have you learned any lessons? Are there lessons to be learned for an emerging technology like hyperloop, based on what you've seen?

Mr. RAYCROFT. We do think that we are a bit unique. We do have some challenges in that we are really a new mode of transportation. We can look at unmanned aerial systems and vertical take-off and landing aircraft and, to the best of my knowledge, that falls within the FAA. We can look at autonomous vehicles and they're vehicles for us.

We are taking aspects of different types of technologies. So it is a bit more challenging. That's why we need to engage in discussions. The lesson learned that we've taken away from this is that we need to engage early. The earlier we engage with the regulators, the earlier we can make sure that all aspects of safety are being considered from the get-go and so that's our plan.

The CHAIRMAN. Ms. Tolson, I know that the Port Optimizer's up and running at many of the Port of Los Angeles terminals and more recently with the new pilot at the Port of Long Beach.

Your testimony mentioned, based on preliminary results, that the optimizer could achieve a 10 percent increase in throughput, which would be really remarkable, if achieved.

What are GE's plans to expand the technology to other facilities and ports in the country, and what do you see as the impediments to that sort of expansion?

Ms. TOLSON. There has been a lot of interest and we're talking to several ports across the country of how to apply and implement this technology.

We're concentrating right now focused on making sure that this deploys properly and works really well at Port of Long Beach and the Port of Los Angeles.

As far as impediments, there are always funding challenges. I mean, the ports need funding to help put these into place, but as far as other impediments, we're not really running into a lot. It's really the community acceptance. Sharing of data is somewhat new and to many of them, if the operators work within a port system and breaking down those silos has been probably the biggest challenge we've run into, and this is why it was really important to

spend the time with the key stakeholders, you know, getting their inputs and helping them actually design this solution.

That was a key element in making sure it was useful, it would be more accepted, and that it would be effective once it is rolled out. So it's really promising. We're seeing great results. The Port of Long Beach is well underway as far as a pilot and we expect to see this completed and done by the end of this year and then we'll move on and expand outside of those two ports.

The CHAIRMAN. Could you speak to how you're conducting outreach to shippers to be a part of that tool and particularly small companies that import and export that may not have much visibility into the supply chain?

Ms. TOLSON. You know, this is a good question. We've worked with the biggest shipping lines, you know, Maersk, MCO, and several others, to get access to data and make sure that it's secure. This was a high priority for everybody that we talked to, and in conversations with their stakeholders, how does that benefit them, right? How would they actually participate, and it really comes through to how they interact with scheduling systems that are used throughout the supply chain.

The more we expand this, the product itself is very extensible, it's API-driven, so you can add extensions to other systems, so that everybody can have access to certain types of data in a secure way. So that's how we're helping to address that.

The CHAIRMAN. OK. Thank you.

Senator Cortez Masto.

Senator CORTEZ MASTO. Thank you.

Ms. Quigley, let me start with you. Can you further elaborate or just describe the specific local challenges that you're addressing with your efforts to employ smart transportation?

Ms. QUIGLEY. Sure. Our challenges are probably not much different than any community's, although ours may be exacerbated in some areas, but safety, congestion, and capacity, and limited resources to enhance those are our challenges.

So testing, deploying these new technologies is a way for us to enhance capacity, reduce congestion, and increase safety without having to build additional infrastructure, additional lane miles, or having additional right-of-way takings, etcetera.

Senator CORTEZ MASTO. And then you talked a little bit about the public-private partnerships, which I'm a big proponent of, but each state is unique in how that relationship should look.

Can you talk a little bit about that for the state of Nevada and your involvement in a public-private partnership as you employ the emerging technology?

Ms. QUIGLEY. So as we're emerging these new technologies, most of them are in the pilot program or the demonstration phases, so we can vet them through, and one of the advantages of having a pilot program or a demonstration program is that you can work around your existing sometimes stymieing procurement processes, and it's only after you've vetted and you've tested that then you can move forward with the more formal procurement processes. Does that address the question?

Senator CORTEZ MASTO. Thank you. Thank you.

And then, Mr. Raycroft, you talked about moving forward right now in testing the commercialization in certain states.

Let me ask you this. How close is this technology to being truly available for people, passenger use?

Mr. RAYCROFT. So right now, the company's working towards being operational by the mid 2020s.

Senator CORTEZ MASTO. OK. For passenger use?

Mr. RAYCROFT. For passenger use.

Senator CORTEZ MASTO. And I appreciate the conversation that you had with the Chair because, as we develop this emerging technology and get to that point, we are going to have to be flexible with the different regulatory agencies that are out there and hopefully addressing the new emerging technology but still have a safety component and they have to be flexible with accepting this new emerging technology and thinking about it in little different ways. Is that what you were trying to say earlier?

Mr. RAYCROFT. Of course, yes.

Senator CORTEZ MASTO. OK. Thank you.

The conversation I appreciate, Ms. Tolson, you've talked about this, as well, which is creating jobs. Part of this and the use of all of the new technology is how we not only create jobs but there's always been this discussion about displacement of workers, as well, and how we should be working to give them the tools and the skills they need for the use of the technology because it will create jobs in the future.

Can you talk a little bit about how you've created jobs with the emerging technology that you're utilizing? I'm going to ask you to talk a little bit about that.

Mr. Raycroft, as well, could you talk about manufacturing jobs that could come from the use of your new technology, as well?

So, Ms. Tolson?

Ms. TOLSON. Sure. So what we're seeing is that as you can get more throughput and more efficiency inside the port, there's more work to be done. It doesn't slow the shipments that are coming in. They have more work that gets backed up than they can handle. So this actually allows more people to come in, work in this, so you can get that through. That's how we see it, and this is how the union in the conversations is panning out.

Senator CORTEZ MASTO. And that's why labor supports it?

Ms. TOLSON. Yep. Absolutely.

Senator CORTEZ MASTO. Thank you.

Mr. RAYCROFT. As you know, we have opened not only our test facility in North Las Vegas but also a manufacturing facility where we have—that's where we've manufactured and assembled the majority of our components that we built into the test site that you saw on the screen.

As we look to commercialization, as I'm sure you can see, this is a big system. It's an infrastructure. It involves vehicles that resemble the aerospace supply chains that we have in full force out in L.A., that we have throughout the country, my background at GE, and so we do see that there's a lot of potential for manufacturing jobs and those jobs would exist not only during the construction phase of a project where we need to procure the hardware to build the infrastructure but also the vehicles, but those jobs will remain

for maintenance, for spare parts over time, and then we will also have, as we continue to develop the technology and innovate it to new and enhanced efficiencies and cost points, we will have the continued need for development manufacturing and so that will remain and we anticipate fully leveraging our facility in Nevada.

Senator CORTEZ MASTO. Thank you.

And then, Mr. Sanford, you talked a little bit about challenges and barriers. Can you elaborate on some of them and briefly for the Committee?

Mr. SANFORD. Sure. So one of the—I think the outstanding things that's delaying implementation of autonomous ships is regulations, both with the in-country states and from an international level.

So one of the requirements of international regulations of prevention of collisions at sea is to have a look-out on a ship that requires a manned ship. Right now, there's no rule that allows you to supplement that person with a video camera for remote operation or allowing a computer system, an autonomous system to monitor the ship for safety.

There's also the safety of life at sea requirements, which is if a ship's in distress, the closest ship comes and provides support for that ship. How do you handle that with an unmanned ship that doesn't have a crew onboard to help a distressed ship? So those two regulations will come about. That's both at the U.S. level, regulatory level, through U.S. Coast Guard, and then also at the International Maritime Organization level for international regulations because they control everything for the international shipping.

Senator CORTEZ MASTO. Thank you. Thank you, Mr. Chair.

The CHAIRMAN. Thank you, Senator Cortez Masto.

Senator Peters.

**STATEMENT OF HON. GARY PETERS,  
U.S. SENATOR FROM MICHIGAN**

Senator PETERS. Thank you, Mr. Chairman, and thank you to our panelists here today for your testimony.

As Chairman Thune mentioned in his opening comments, this Committee has done quite a bit of work on automation autonomy in terms of vehicles. So it has been interesting to hear testimony about other forms of transportation, in particular with seagoing vessels.

So, Mr. Sanford, I wanted to ask you to talk a little bit about that work and I'm proud in Michigan, in addition to being a leader when it comes to autonomous vehicles, that we are also a leader in autonomous marine research, as well.

In fact, Michigan Tech University and the Smart Ships Coalition has recently launched a Great Lakes Marine Autonomy Research Site. It's the first freshwater test bed of its kind in the world. It's called MARS and it's designed to study and set ground rules for the use of autonomous marine vehicles in the Great Lakes, allowing private-public collaborators to apply these technologies as well as test beta operations.

But many of the transportation stakeholders feel that the U.S. transportation sector, marine transportation sector's significantly lagging behind both the ground and air sectors in our country in

adopting automation and autonomy, and it seems as if Europe and specifically the Nordic countries have a considerable jumpstart on us.

So my first question is, how many of the 100 or so companies worldwide that are working on autonomous ship research and development are headquartered here in the United States, if you know offhand?

Mr. SANFORD. I can't give you a true number. I can think of probably five or six of them without a doubt based in the U.S. Primarily in the U.S., the autonomous ship area is focused around defense application, not the commercial, with some use in surveying of the ships. They're mainly smaller, 40 to 50 feet, in the U.S., looking for mine countermeasure, anti-submarine warfare-type of work with the U.S. Navy, sponsored under contracts with like O&R, PMS46, and that's where most of the focus in the U.S., I believe, has been.

There has been some surveying work done by NOAA with a few companies, such as ASV Global, which is based over here and in the U.K.

When you look at the large shipping industry, which is what I'm here today to talk about, that's primarily been developed offshore, coming out of the Nordic countries, as you mentioned. Finland, Sweden, and Norway have been investing in heavily as a way to kind of reboot and further support their marine industry that's seen a decline over the last several decades as far as mariners at sea running ships.

So that's an area I believe we need to focus on in the U.S. is to help work with that and there are risks and kind of hold-back from international companies invest in the U.S. has been export rules and the way that the U.S. tends to view autonomous technologies and want to export control them. So that has been an area where I've been as I've tried to import the technology into the U.S. and develop them here.

My foreign colleagues and other portions of the company have had to work with them on that to try to overcome that hesitancy because they're worried that it will be export controls or their technology will be ITAR and they won't be able to sell it globally which is where the real money, if you look at commercial shipping, is right now.

Senator PETERS. So do you believe that is the major reason we only have five or six out of a hundred companies dealing with autonomy and most of those are defense-related, as you mentioned? Is it because of that regulation or are there other regulatory impediments that prevent this from occurring?

Mr. SANFORD. Well, there is the ability to test the ships in an environment out at sea in the U.S. where there's no area that can really allow for commercial ships to do that without people on-board.

Right now, they're doing testing usually locally, talking with Coast Guard to get approval to do that, but they are not necessarily approved to have controlled areas in seagoing areas for large ships, if you're talking 200-foot ships, to go out there and test them at sea. So it's a danger area where you're liable without really being able to get insurance to back you up if something were to happen.

Senator PETERS. I'd like to follow up on a question Senator Cortez Masto asked about automation and the impact on jobs which is something we're always concerned about.

You mentioned in your testimony how we need to train a new type of sailor going forward. Could you talk a little bit about the impact of employment when it comes to operating these ships and what sort of training will be required of folks who may still be on a ship that's autonomy? Talk through a little bit about the impact on employment and how we deal with what will be displacement of current jobs.

Mr. SANFORD. Yes, so when you go to fully autonomy ships, there will be no people onboard. That is the plan. That is how you're going to make your true savings as far as the ship goes.

As you do that, you're going to displace the people, able seamen that typically go and maintain the ship while at sea, handling machine breakdowns. So with the ships, you'll have to build in redundancy but those jobs will still have to be done. The ships will have to be maintained but what will happen is those jobs will be brought shore-side and be maintained at dockside with the ships being able to go ahead and forecast what's going to happen, where the maintenance has to be. So that way it will be more service engineers rather than able seamen at sea handling the ships from a technical side. They'll still have to be technical jobs, understand the marine industry, the engines, and overseeing the ships operating at sea.

I like to think of it kind of when the ships switched from sailing ships to steam ships, the seamen went from being sailors going up the mast to trying to haul in sails in bad weather to working in steam engines. It's going to be a ship like that to probably in the industry as far as seamen and operators of the ships maintaining them, making sure they're running, but the technical jobs will still be there. They're just going to be brought shore-side so people don't have to go to sea for weeks and months at a time to maintain them, keep them running.

Senator PETERS. Thank you.

The CHAIRMAN. Thank you, Senator Peters.

Senator Hassan.

**STATEMENT OF HON. MAGGIE HASSAN,  
U.S. SENATOR FROM NEW HAMPSHIRE**

Senator HASSAN. Well, thank you, Mr. Chair, and Ranking Member, and thank you to all of our witnesses for being here today.

I have a question for the panel. As we discuss the importance of new technologies that will make our transportation systems more efficient and safer and overall more accessible and effective, we also have to work to ensure that new transportation technologies serve everybody, including those who experience disabilities.

For many individuals who experience disabilities, access to transportation can determine whether they can seek employment, get to the doctors, and be more engaged members of their communities.

And, Ms. Quigley, you mentioned the pilot you are working on with Lyft and mentioned that right now it's a non-ADA-compliant pilot.

But I just wanted to touch on what you see and all of the panelists see as the opportunity here. I'd like to hear more about what

your companies are working on to expand access for members of our communities who experience disabilities. What do you think can be done to focus on or enhance transportation services for people who experience disabilities and how can Congress be a partner in that? So why don't we start with you, Ms. Quigley?

Ms. QUIGLEY. OK. Thank you. Within our industry, certainly this is a very big conversation, and our industry group, ATA, the American Transit Association, is working to deal with this, as well.

At a local level, you're right, our partnership with Lyft is for non-ADA para-transit trips. That's because that was the type of business and type of vehicles that they currently operate.

I didn't mention that we're also starting to have conversations with another private sector group that has evolved, emerged specifically to address those who are ADA and mobility challenged.

It's a local firm called Tango Car, and we hope to have the same type of partnership with them as we have with Lyft to provide mobility services on demand, same day, point to point services for those who do rely on mobility devices.

Senator HASSAN. Thank you. That's terrific. Anybody else want to add anything? Mr. Raycroft.

Mr. RAYCROFT. Thank you for the question, Senator. You mentioned access for all.

Senator HASSAN. Right.

Mr. RAYCROFT. That's our goal, and our goal is to not only connect big metropolitan areas but also to connect with some smaller places to give opportunities and specifically for those with a disability.

Think of interacting with our system as being very similar to walking down the jet bridge to get on an aircraft. We will have a very similar type of system, very similar type of setup that makes all of us feel comfortable, including those with disabilities, to board safely, to feel comfortable once they're inside the vehicle during the trip, and then on the back end to get out and be on their way. That is the top priority of ours.

Senator HASSAN. OK. Thank you. Anybody else want to add anything?

[No response.]

Senator HASSAN. OK. Thank you. I'll move to my next question.

I will add that one of the things that I think is a challenge here is the realization that there are people who use mobility devices who really can't be separated from the device itself. So a custom wheelchair that somebody has to be moved out of to sit in a chair, for instance, in an airplane not only can get damaged in transport but there are people who can't sit without their custom equipment. So it is increasingly important that the technology finds ways to accommodate that custom equipment along with the person and not see them as separable, and I think if we can focus on that that would be a big step forward for a lot of people who face the most challenges.

I wanted to move to something that, Mr. Raycroft, you just touched on a little bit. As we develop and deploy new forms of transportation, it's really important to keep the unique needs, too, of rural America in mind, and I think that that's what you were just getting at a little bit.

According to the most recent Census, about one in five Americans live in rural areas, including many of the people I represent in New Hampshire. These are areas where low population density and the often large distances between towns and villages means that transportation is critical to ensure that people who live in largely rural areas have access to goods and services.

So to each of you, can you discuss the ways in which your technologies can help people who live in rural areas by making it easier for them to travel in order to get from point A to point B? Why don't we go in reverse order? Mr. Raycroft, if you want to start.

Mr. RAYCROFT. Sure. We are designing the system to be accessible for all. One way that we accomplish that is that we've designed it to be rather modular, such that we could add in smaller stations as necessary and they would have on ramps to merge into the trunk line, very similar to what you see with highways today. So we've put that as a priority in the design process itself.

Think about a good example is the project that we're focused on in Missouri where we're looking to connect Kansas City to St. Louis in a mere 30 minutes. Imagine being able to cross the entire state with an intermediate boarding platform and station in Columbia and being able to connect to that relatively smaller city and giving people there access to jobs, services, and entertainment in the other two major cities within the state.

Senator HASSAN. OK. Thank you.

Ms. TOLSON. And for us, it's really facilitating the flow of goods and making sure that we can continue to do that and create jobs because I didn't mention in the earlier question, you know, how is it actually growing jobs.

Well, the impact of gaining more throughput through the ports actually downstream adds jobs. There are three million jobs that are affected or grown from that supply chain effect and, you know, giving more efficiency again just helps the flow of goods to get to their destination.

We work closely with railroads. That's one of our biggest segments obviously that we serve within Transportation at GE and finding ways to advance and streamline those types of operations, making those safer, as you all know with the PTC efforts that are underway, and getting more automation within the train itself to make sure that we can continue to deliver the goods and services timely and improve those efficiencies.

Senator HASSAN. Well, thank you, and I see that I'm over, Mr. Chair, and I'll follow up with the other two panelists on this issue in writing. Thanks.

The CHAIRMAN. Thank you, Senator Hassan.

Senator Tester.

**STATEMENT OF HON. JON TESTER,  
U.S. SENATOR FROM MONTANA**

Senator TESTER. Thank you, Mr. Chairman, and since I'm the newest guy on the panel, I kind of like this just shooting right down the line.

But, look, thank you all for being here. I got a bunch of questions and I'm going to start with the first one and try to be as concise as you can.

Each one of you are doing something different in a different realm, all dealing with efficiency in transportation. So could you tell me what infrastructure, what infrastructure that you don't have now that you're going to need in order to make what you're trying to do a reality? We'll start with you, Tina.

Ms. QUIGLEY. I would say one of the things that we don't have that we're going to need is to have clear standards and definitions as to what infrastructure is, clearly defining unambiguously the spaces where different types of activities happen, so where we have pedestrians, where we have bikes, where we have crosswalks, where we have stop signs.

The more that we can create standards and invest in infrastructure that is very clear and unambiguous for the autonomous vehicle to be reading.

Senator TESTER. So let me ask you this. Do you have the infrastructure in place right now for the autonomous vehicles to work?

Ms. QUIGLEY. I would say that there will be certain corridors which will be much more appropriate for autonomous vehicles than other corridors.

Senator TESTER. OK. All right. Continue on.

Mr. SANFORD. Thank you. So infrastructure we're looking at is really the shore-side operating centers, so the areas where the people actually monitor the ships from.

Senator TESTER. OK. From a technology standpoint, you can operate everything you need to do with what's there right now. You just need the physical structure to be able to—

Mr. SANFORD. The biggest infrastructure probably when we're out at sea is determining how to increase band width to get the information between the ships and the location.

Senator TESTER. OK. All right.

Ms. TOLSON. One of the things that we're going to need as you go further into the inland into America is Spectrum issue that's at hand right now and having access to that. So that you have large rail yards, you have different port areas that need to and want to build their own area networks that are secure and serve their needs and without that kind of access, it's going to be very challenging.

Senator TESTER. We may get back to that security issue in a minute. Go ahead.

Ms. TOLSON. Yes, and then the other part for us is, you know, the definition, including digital as part of physical infrastructure definition.

Senator TESTER. Correct. That's correct.

Ms. TOLSON. So you can be digitally ready to improve the infrastructure as it goes forward and that's really important to us.

Senator TESTER. OK.

Mr. RAYCROFT. I mentioned the regulatory frameworks. I think that's crucial. To piggyback on Tina's comment about standards, standards for manufacturing, for example, and working with the relevant bodies within the U.S. to formulate those is important for us.

We will continue this development. We have great facilities in Nevada but we will continue to need more facilities for the development of the technology. We will need to develop a lot of software.

We'll need a facility to do that as well as testing and then as far as the actual projects go and the infrastructure, we want to make sure that we're connecting into existing infrastructure, like transit. We want to be intermodal in that way.

Senator TESTER. Gotcha. I'm going to stick with you, Josh. You've got a 500-meter tube now. Is that what I read in your—OK.

Mr. RAYCROFT. Correct.

Senator TESTER. Do you have any projections on what this will cost moving forward per mile at this moment in time? I'm assuming it will decrease with volume?

Mr. RAYCROFT. It will decrease with volume, decrease with time as we continue to innovate. What we built in Las Vegas won't be the final product. That is a development system and we're continuing to innovate. We will study in detail the construction costs and the operating costs in each of the projects.

Senator TESTER. Is there a price point which makes this work as far as construction costs go and which makes it not work? In other words, is there a price point that says I can't compete with air, I can't compete with buses, I can't compete with rail or passenger cars?

Mr. RAYCROFT. Where now we have validation from third parties on our cost point, we think that this is a very viable solution, and given the fact that our system also brings superior benefits because we can move people even faster.

Senator TESTER. So I don't want to put you on the spot, but have you done that analysis on the metrics of where your price point needs to be?

Mr. RAYCROFT. We've done that for some detailed studies outside of the U.S. and now we're working to refine those estimates. As you know, these vary by project. So we're working right now to do that.

Senator TESTER. I think it's really cool. I mean, I remember back when I was a kid, they put those little tubes full of money and they'd shoot them around the office buildings. I think it's pretty neat.

You all talk about efficiency and efficiency means cost savings and one of the biggest cost savings in this—there has been a couple questions before this. I'm going to word it a little different—is manpower reductions. I'm not talking about manpower repurposing. I'm talking about manpower reductions.

Have you—and this may or may not apply to all of you. It certainly applies to Davis and probably Carrie more than the other two. But have you guys done any projections on the percentage of manpower that won't be necessary?

Now I know there will be different people doing different jobs, but overall if we're going to save money and make it more efficient, manpower is a big part of that efficiency savings.

Have you done any research to determine what kind of cost savings there would be in manpower from a percentage standpoint? In other words, 10 percent less people working, whether it's sailors, mechanics, whatever it might be?

Mr. SANFORD. So I haven't looked at the specific manpower. That 20 percent I called was looking at the ship operating costs itself, looking at house loads, exterior cargo you can put on displaced by

all the areas for people and all the systems that they would take up. That's where we see the savings as far as transportation goes.

Senator TESTER. OK. So would that also flow to the manpower? There'd be 20 percent less manpower?

Mr. SANFORD. I don't believe so. You're still going to have to have ships manned. It'll be a different type of manning.

Senator TESTER. Do you think there will be any savings in manpower?

Mr. SANFORD. I think there will be, but I don't have a quantitative number for that, no.

Senator TESTER. OK.

Mr. SANFORD. Let me look into that and I'll see if I can come up with a number.

Senator TESTER. The Chairman is being very generous.

Carrie, really quick, do you have any projections on manpower?

Ms. TOLSON. I do not. I do not have any projections on that. I can get back to you on that, but we expect there actually would be growth.

Senator TESTER. Oh, really?

Ms. TOLSON. Yes.

Senator TESTER. OK. Cool. Thank you.

The CHAIRMAN. Thank you, Senator Tester.

Senator Markey.

**STATEMENT OF HON. EDWARD MARKEY,  
U.S. SENATOR FROM MASSACHUSETTS**

Senator MARKEY. Thank you, Mr. Chairman, very much.

Just following up on Senator Tester's question, again my father was a truck driver. He was a milkman. Then all the milkmen got laid off, every milkman. No more milk going to homes. So that's a small example of what can happen as a transition compared to this massive change which, you know, you're talking about and just anticipating that dramatic impact it has on families when something like that happens, you know, multiplied milkmen times a thousand, right, in terms of all the people who are going to be impacted. So it's an important discussion to have, I know, from my own family experience.

As we modernize the infrastructure, put sensors on the roads, it's going to be very expensive. We already have an incredible infrastructure backlog in the United States in terms of investment that should be made to upgrade our roads, our bridges, our transit.

How would you suggest that we pay for this? Should this be a Federal program, state by state, or should the individual, you know,—what's your recommendation, Ms. Quigley? Who pays?

Ms. QUIGLEY. So I would like to reiterate that I truly believe again technology is the new asphalt and that by investing in technologies, we have the ability to actually get more capacity out of certain corridors with a higher rate of return on investment.

We look to the Feds to be our partners certainly in funding but we can take a look at the pots of money. Are there opportunities for shifting away from additional lane miles and instead enhancing corridors with these new technologies that will produce the same or enhanced capacities?

Senator MARKEY. So are you seeing again just a continuation of the same Federal-state-local partnership with more money just flowing over into these new modern technologies?

Ms. QUIGLEY. I think that's a great question, and I think the answer is yes and yet there's more to be done, as well. I think that the traditional partnerships or certainly in funding approaches are things we need to consider, but we also from the Feds not only need funding but we also need help in terms of the regulatory environment, making sure that we can move these things forward efficiently, and then, to the extent possible, a partnership in terms of best practices and ways to really enhance and educate us as to how we move this forward efficiently so we are not investing inappropriately in yesterday's technology, yesterday's infrastructure.

Senator MARKEY. OK. Great. Thank you. Now as we move in this direction, as we digitize our roads, our bridges, our tunnels perhaps, Mr. Raycroft, who knows, it's going to cause the creation of a massive amount of information about every person who's driving. It's going to raise privacy issues and it's going to raise cybersecurity issues, right?

So would any of you like to talk about those issues and how we should address them in an anticipatory fashion heading toward this massive potential benefit but also in the digital era, there's a sinister side to the cyberspace, as well. How do we build in the protections for people to make sure that they're not harmed and their privacy is not compromised?

Ms. TOLSON. So I'll respond to that first. I think it is that there is an ever-present threat and it will continue to persist to have bad actors out there and it is a top priority for, I think, all of us to ensure that as we expand the use and identifying data of locations and processes and all the things that makes, you know, our economy flow, that we protect those.

In everything that we look at, we want to make sure that you're following this, you're following the standards that are out there, and that you're doing the job that all of us take from a technology standpoint very seriously and ensuring that those are going to hold up and protect you and that you have a resilience in that, which is why, you know, the Port Optimizer is FedRAMP-approved, certified, and we follow all those types of things, but I think this is a topic that will not die down and we need to be very diligent on ensuring that we've got NIST standards that continue to evolve and that they are executed.

Senator MARKEY. Anybody else?

Mr. SANFORD. So for cybersecurity, from our point of view, I think the biggest worry would be if a third party were to gain control of the ship as it, let's say, entered U.S. waters. We have a series of cybersecurity built into the systems from the base level, from their design. Constantly, it's monitoring itself but also we see that control of the ships would be passed over to a local area specifically to ensure that the ship was under control of a U.S. person while it enters the water to reduce the risk for cybersecurity of somebody trying to use it for nefarious acts.

Senator MARKEY. OK. Thank you. Thank you, Mr. Chairman.

The CHAIRMAN. Thank you, Senator Markey.  
Senator Cantwell.

**STATEMENT OF HON. MARIA CANTWELL,  
U.S. SENATOR FROM WASHINGTON**

Senator CANTWELL. Thank you, Mr. Chairman, and thank you and the Ranking Member for holding this important hearing.

It's so important that we keep moving ahead on technology and my state obviously, Washington, is so excited writ large because we see so many applications every day that are cost effective. So we love the Smart Cities Program and we love that Spokane is working diligently on better street lighting and that everybody from our utilities there, like Vista and Itron and others are working together to really help lower costs and drive efficiency. So we like that and want to see that continue.

We just had this article come out about electric planes and the fact that even the aviation sector is looking at electrification, which is one of the things I wanted to ask the panel about, is just, you know, I know we have somebody here from Rolls-Royce and thank you for that focus on the maritime sector because we have to drive efficiencies into the maritime sector, as well, and there are some good security systems that people are working on to make sure that those protections are—nobody can override your system or make it more cyber secure.

But how big do you see the transportation sector, the rest of the transportation sector, maritime, aviation, transit, and the continued electrification of that as a big economic opportunity to drive efficiencies into our system and growth opportunities for the U.S.? Anybody who wants to take that?

Ms. QUIGLEY. So I can address it from the transit agency perspective, and it sounds like you're very knowledgeable, as well, from the transit agency perspective.

When autonomous vehicles and electric vehicles have become synonymous pretty much. We know that electric vehicles will be the autonomous vehicles. The computer can control an electrically powered system much better than through a fossil fuel-type system.

I think that the efficiencies that come from electric vehicles, the ability to operate quieter, cleaner energy, allows us also to get into communities that we formerly were challenged in terms of getting into. A lot of communities don't want to embrace public transit. It is loud. It does create noise.

When you have an electric vehicle, you create an environment that is very friendly toward neighborhoods and so we look forward to eventually adopting more electric vehicles. Right now in Las Vegas, the environment and the amount of hours that we demand out of our vehicles has precluded us from being able to migrate toward electric vehicles. They still have a bit of maturation to do before we'll be able to do that.

Mr. SANFORD. So I am a marine guy, so I know a little bit about the aero as far as electric work we're doing, but from the marine side, we currently have our autonomous auto-crossing technology being employed on zero-emission flow electric ferries in the Nordic countries for going fjords, improving efficiency of those ferries that way. We can get the longest life out of the battery power and without having to have anything and we also just started a full new battery electric system for ships to improve efficiency on it. So

that's where we believe the industry's going is to a full electric as far as marine industry.

Mr. RAYCROFT. I just wanted to add that when we design the hyperloop system, we are designing it to be fully electric with zero-direct emissions. We found that this was desirable by our customers when we did a study engaging with the Ports of L.A. and Ports of Long Beach to study the goods movement out of the port. That was a very important criteria for any technology that we brought into the area. We feel that's very important and for all of our projects, we're ensuring that our impact on the grid is sustainable and what we do to the existing grid, the existing grid can tolerate the power needs of our system.

Ms. TOLSON. So I had mentioned in my written and oral statements about the emissions that will be reduced through use of digital tools as the Port Optimizer just from idling trucks and lowering all of those types of things.

Also, another part of the business, we build locomotives, and we're working on hybrid systems for that and, you know, the impact of going from a diesel locomotive to a hybrid and the emissions that you will get through using the newer locomotives plus what we're moving to the future will be a big impact and a positive way to the environment.

Senator CANTWELL. Well, I thank all of you for your answer.

Mr. Chairman, thank you for the hearing. I don't know what our intent as a committee is after this, but I just think that the Government needs to harness the information age, as well, and what you just discussed are a lot of applications where we help cities or regions do that and by making these investments drive down the cost of delivering services and that's a key thing for us as well as the private sector.

We want everything to become more efficient. So I hope that our committee and maybe that other committee that you serve on with me, the Finance Committee, we could keep looking at ways to move forward and keep incenting smart cities and other transportation applications because I really do think that they—I mean, not only as you said, Mr. Sanford, the Scandinavians are already working on this and have had some really great success in the maritime sector and we want to continue to match that.

Thank you.

Ms. QUIGLEY. I'd just like to say thank you to the Senator, as well. I'm getting familiar with your Interagency Council on Smart Cities and very much appreciate the focus on partnering and peer learning as part of that.

The CHAIRMAN. Thank you, Senator Cantwell.  
Senator Klobuchar.

**STATEMENT OF HON. AMY KLOBUCHAR,  
U.S. SENATOR FROM MINNESOTA**

Senator KLOBUCHAR. Well, thank you so much, Chairman Thune, for this hearing and thank you, as well. It's good to see Senator Cortez Masto, Marie, in the place of honor. Thank you. As well as Senator Nelson for scheduling this hearing.

I'll start out at home. A lot of questions have been asked. I was looking over my questions. They all said someone else asked them, but so no one asked about Duluth, Minnesota, so I'll start there.

So the Port of Duluth is the largest and busiest port on the Great Lakes, hosting about 1,000 vessels and an average of 35 million short tons of cargo per year. The port plays an important role in the region's economy and support industries from ag to manufacturing.

In March of last year, a new intermodal terminal opened for Canadian National Railway and Duluth Cargo Connect to improve the flow of freight in and out of the port.

Ms. Tolson, as port traffic increases, what new technology solutions can help to support the flow of intermodal cargo?

Ms. TOLSON. Thanks for the question. We actually are in a development phase and partnering with BNSF on a solution that will actually further optimize intermodal yards and terminals.

This is a system that brings more automation into those yards so again you don't move things more times than you need to. It's similar to what I described in the Port Optimizer tool. We have a system already that does this. It's an older system that we're adding more functionality so that as these ports experience growth, further growth in intermodal traffic, which is up by about 25 percent year over year, it's growing tremendously and has a big impact on the ports, it's bringing those types of solutions that have automation into the actual yards themselves, have the port communities themselves that can share that information that also helps them organize and plan and get visibility into how to make the flow of goods move smoothly and quicker.

Senator KLOBUCHAR. Thank you. And along these same lines of commercial vessels, Mr. Sanford, adequate education and training is crucial to help ensure that marine engineers have the necessary skills to safely operate these vessels.

As the technology changes, it's important that the training keeps pace. Advances in the safety technology will only have a positive impact if mariners know how to use the technology.

What steps do you believe will be necessary to ensure that mariners receive adequate training in the new vessel technology?

Mr. SANFORD. So I believe focusing on the maritime academies will be important. My brother-in-law is a captain on an oil tanker. So I'm very well aware of the aspects of what the technology will be doing and what improvements will be created and necessary training.

I've done work at Mass Maritime, so I've worked with that group and known a lot of sailors and I think that's a starting area, and then when you go more to the able seamen and the people executing the technologies, you're going to continue needing the engine training and maintenance of all the ships, though there will be a reduced number of them. That will be supplied but that will be done on shore. So the transfer of at-sea work maintenance to shore-side work will need to be increased and the infrastructure at the ports to be able to do that.

Senator KLOBUCHAR. Very good. See, I started with these port things because I knew that Nevada and South Dakota wouldn't

have as much to one-up me on the ports, so really thought I'd go for that.

But I did have one other question and that's as the—we've seen this technology, this competitive agenda that we need for the country, I believe, really focuses a lot on this training and the infrastructure being up-to-date, but you also need the way to carry this technology, and Senator Fischer and I had recently signed into law the MOBILE NOW Act and it would require the FCC to explore ways to provide incentives for wireless carriers to lease unused Spectrum to rural or smaller carriers and we are going to see the demand for Spectrum increasing as we see more of this technology, especially in rural areas.

Ms. Tolson, how are the communications needs changing? What can we do to improve the coverage of data capacity of the networks? Anyone can answer this, but it's really just focused on the fact that if we're going to start using precision agriculture and we're going to have all this updated transportation, we're going to need the capacity and the data capacity to make it work.

Ms. TOLSON. Absolutely. And it is really important as we expand back to the amount of information that we're generating every day, especially, you know, advancement of IoT and devices and everything that's connected. The needs of the rural areas especially are going to have is back to having access to the broadband, you know, the 3550 and up, so that they can actually have the secure networks, they have the bandwidth, and they can afford to do the investment. They've already started to make sure that those are in place in places that they need them which might not be the case if you're a big telco or others that doesn't have that kind of incentive.

So it's important to us that we continue to have that availability, that they can bid on those types of things, that they can actually create that and do the investment that they're all willing to make to make that a reality in those areas.

Senator KLOBUCHAR. OK. Very good. Thank you.

The CHAIRMAN. Thank you, Senator Klobuchar.

Senator Gardner.

**STATEMENT OF HON. CORY GARDNER,  
U.S. SENATOR FROM COLORADO**

Senator GARDNER. Thank you, Mr. Chairman, and thank you to the witnesses.

You probably have been frustrated by the number of witnesses coming in from other hearings. Just when you thought you were finished, one more question. So I apologize for being that guy. You were that person, too. That's right, that's right.

But I do thank you because in Colorado, we've seen significant growth over the past several years, particularly along the I-25 corridor, from Pueblo, Colorado, to Fort Collins, Colorado, where a vast majority of the population in the state lives, and you would think by perhaps some of the traffic we face, that damn traffic is actually one word in Colorado and we have to address solutions to that.

So, Mr. Raycroft, in your written testimony, you talk about partnerships Virgin Hyperloop One is forging to bolster its technology.

You even recognize, I believe, Ms. Quigley for her local leadership to advance hyperloop.

You also touched on Hyperloop One's efforts in Colorado, talked a little bit about that with the Colorado Department of Transportation, Aecom, an engineering firm, to advance the hyperloop.

Colorado had other initiatives in place, like its RoadX Program, that tries to take advantage of different approaches to transportation solutions because, look, when you have a state that has some pretty awesome mountains that you have to travel through, around or by, with a lot of traffic, you're going to have to find solutions that include ideas other than just drilling holes through them again because of the cost and the environmental concerns that that can bring with it.

So could you talk a little bit about how that partnership is working with the public and private partnerships and the sectors there?

Mr. RAYCROFT. Yes. It's been working out great. I think it's an exemplary case of us working with partnerships, working with government, with both CDOT as well as with the private sector and Aecom to develop that feasibility study.

We are looking to build a system that really connects the state from the south near Colorado Springs up to Fort Collins and then with a spur that would go out to the mountains. We could see that being a later phase of that project and so far we are evaluating what the transformative impact would be within the state if we could deploy that system.

We look forward to continuing that discussion and exploring how we could deliver that project through a public-private partnership because that will be the method we use to deploy these projects around the country.

Senator GARDNER. You talked about the Front Range and we talked about the mountains and the mountains, of course, have a lot more tourism and recreational opportunities than perhaps, say, the Eastern Plains.

How would hyperloop affect or this type of a technology solution or any future technological innovation in transportation, how is it going to address those truly rural areas that maybe don't have a recreation or tourism economy but are a farm economy and how does transportation solution innovation affect them?

Mr. RAYCROFT. From a connectivity and accessibility standpoint, we think that this will be a huge step forward to enable businesses that could locate along the Front Range to have access to whether it's labor pool, whether it's their supply chains or companies they interact with that are in Denver. We think that that's very powerful.

And then as far as the interaction with from more of an environmental standpoint, we are studying that in detail of how our structure, elevated structure could follow potential existing rights-of-way to minimize the impact to local communities.

Senator GARDNER. And so I fly into Denver International Airport. I land. I get on the train, the A Train, and I take it to downtown or take it somewhere, but I want to get on a hyperloop to take it over to the mountains. How does the interface work? How will it work?

Mr. RAYCROFT. So right now, we're in detailed discussions with the airport, for example, where we're talking about how we could be integrated into that A line station to make this a true multimodal statewide connectivity solution.

Senator GARDNER. Very good. And if you talk to folks back home, and you've heard it, too, in Colorado in your work, the congestion of traffic, we know the impact it has on families and their time at home. In Colorado, time means everything, time with family, time to be outside, time to be at the soccer games, and obviously it has an impact on our economy, as well. As the roads tighten up, the congestion tightens up, it has an impact on freight, mobility, economy.

Department of Transportation's projected that in the year 2040, the number of vehicles making daily trips in the I-25 corridor, which is already congested, could increase by 60 percent. It's a corridor that, as I've said, is already seeing significant congestion.

So you mentioned the feasibility study for hyperloop in Colorado in your written testimony. Are you still on track to release that this fall? Is that the plan?

Mr. RAYCROFT. Yes. That is the plan. We're very excited to share the results.

Senator GARDNER. I'm looking forward to it, too. Thank you. Thanks for being part of the solutions.

Mr. RAYCROFT. Thank you, Senator.

Senator GARDNER. I guess it's up to me now. We may have an additional Senator who's coming to join this. So I appreciate that.

I don't know if Senator Cortez Masto or Klobuchar, if you have some questions that you would like to follow up with.

Senator CORTEZ MASTO. Absolutely. Are you kidding? This is a great conversation, and I've said this before and we touched on it a little. I'm going to open it up to the panelists because, as we buildout this infrastructure that we've talked about that is so necessary for this emerging technology, we have a great opportunity to incorporate within to that the cybersecurity piece at the same time.

Senator Markey talked a little bit about that. I don't know if you can elaborate for us. As you're looking at this emerging technology, what are you doing in particular to address that cybersecurity piece of it and how should we at a Federal level be working with you to help address those issues? Tina, let me start with you.

Ms. QUIGLEY. Sure. I'll go ahead and comment that certainly cybersecurity is one of the most important things to consider as you're deploying this technology.

We feel that using tests, smaller pilot programs is one of the safest ways to start to advance new technologies, while at the same time keeping it within a geo-fence, very safe area that you can monitor and learn from in case of hacking, in case of risks that you're exposing the public to.

So I very much am a believer in and appreciate our state's help in doing these small pilot programs to vet and test before anything is taken larger.

Senator CORTEZ MASTO. So when you're talking about that vetting and testing, that is including addressing the cybersecurity piece?

Ms. QUIGLEY. It is, exactly, and that's specifically what I'm talking about as related to this, yes.

Senator CORTEZ MASTO. OK. And is there anything at a Federal level we should be doing to support and assist?

Ms. QUIGLEY. Well, I do believe that as part of the AV START Act that there is quite a bit of conversation related to cybersecurity.

Senator CORTEZ MASTO. That's right.

Ms. QUIGLEY. Yes. We do appreciate the Feds taking some leadership on that.

Senator CORTEZ MASTO. Great. Thank you. Anyone else on what you're doing on cybersecurity piece?

Mr. RAYCROFT. Yes. From our perspective, as I mentioned, safety is our first priority. We think cybersecurity is a very crucial element of that and we know that those risks will persist, as Laurie mentioned earlier.

So what we're doing is we're ensuring that we're following the best industry practice. We're also working according to NIST and making sure that we're with the most modern policy framework around this and we're also engaging third-party testers that can come in and try to poke as many holes as they can and so from that standpoint, we're just trying to prevent and ensure that if something did happen, we can respond to it quickly to ensure safety on our system.

Senator CORTEZ MASTO. OK. And let me finally—data collection. As this emerging technology—as you continue to test it and look at it for use in everyday jobs and employers use it, you're collecting data to some extent.

Can you address the data collection piece of it and the privacy piece, how you secure that, as well, and is there a privacy issue involved in any of this that you have addressed or are looking at or anticipate being something that we should be looking at for the future?

Ms. QUIGLEY. Well, I'll address that. We collect vast amounts of data, but I can assure you that all the data that we collect is anonymized. It is truly just telling us that somebody used the road, what time of day, what conditions, traffic conditions. Absolutely nothing is tied to personal ownership of that particular movement.

Senator CORTEZ MASTO. Thank you.

Ms. TOLSON. And for us, we don't have personal information. This is all cargo-related. So it's less of a concern from a privacy consumer's perspective, but, you know, securing the data is very important for us and we've got measures in place that make sure that the viewers or the personas of people who work and have access have it just for the data that they're allowed to actually have access to.

Senator CORTEZ MASTO. Thank you. Thank you.

Senator GARDNER. Excellent job, Senator Cortez Masto. Thank you very much.

And Senator Blumenthal, who is the last last last, I'm sure.

**STATEMENT OF HON. RICHARD BLUMENTHAL,  
U.S. SENATOR FROM CONNECTICUT**

Senator BLUMENTHAL. Thanks, Mr. Chairman.

Ms. Quigley, I'd like to ask you about the NTSB investigation into self-driving vehicles, specifically the self-driving shuttle crash in Las Vegas. Would you agree that it would be helpful to have the results of that investigation, in fact, very valuable in informing legislation about self-driving or autonomous vehicles?

Ms. QUIGLEY. I would say that it's important to move forward, of course, with the NTSB investigation and learn more about the incident, but I also think that it's equally important that we continue to test and deploy again in these safe environments. This particular shuttle operates in a geo-fenced half mile loop at very slow speeds, but it's only through these small tests and deployments and dipping our toe in the water, that we really start to learn how these vehicles interact in these live environments.

We can test in petri dishes and test in closed environments but really until it's out there, you're never going to really be able to progress, we believe, the technology further without learning now how it operates.

Senator BLUMENTHAL. But wouldn't you agree, Ms. Quigley, that the results of that investigation would be valuable to this committee, to our colleagues, in—

Ms. QUIGLEY. I would.

Senator BLUMENTHAL.—working on that legislation?

Ms. QUIGLEY. I would agree.

Senator BLUMENTHAL. And maybe we should postpone voting until we have the results of that investigation?

Ms. QUIGLEY. Again, I would champion that we do test and deploy in small safe geo-fenced environments just to really see how these vehicles are acting in live conditions, but I think they're both important.

Senator BLUMENTHAL. Do you think the recommendations of the NTSB ought to be swiftly implemented?

Ms. QUIGLEY. I do.

Senator BLUMENTHAL. Ms. Tolson, last month, as you know, the Environmental Protection Agency and the National Highway Traffic Safety Administration proposed a rollback of the Clean Air/Clean Car Standards.

You mentioned in your written testimony that GE has focused on renewable energy, reducing costs for consumers and increasing fuel efficiency. Those actions and this Administration seems to be at odds with industries and companies like GE that are trying to do the right thing, preventing climate change and protecting public health and benefiting consumers and creating jobs.

I wonder if you could tell the Committee how have existing fuel economy standards resulted in innovation within GE and the electric vehicle market?

Ms. TOLSON. So I'll answer that, you know, to my knowledge base but we very much focus on across many of our sectors and including our renewables business in finding ways that we can actually, you know, get more clean and efficient energy.

As I mentioned earlier, we're also working on having a hybrid system within locomotives which will have a big impact, but I believe that, you know, reducing our standards for clean air are probably working in the wrong direction in that we continue to find ways to further advance technologies that will, regardless of the

standards, continue to march down that path of output that doesn't harm the environment, that we have more efficient use of fuel so you use less.

As a matter of fact, in locomotives, we've got a cruise control system, for example, that saves 200 million gallons of diesel fuel a year. So it's really at the core of all we think about as far as, you know, innovations and continuing to march down a path of bringing those two, you know, industries, critical infrastructure industries that we all experience and interact with every day. So it's important to us.

Senator BLUMENTHAL. Have these rollbacks in the standards stifled innovation?

Ms. TOLSON. You know, I can get back to you with more details on that. This is a little bit more out of my depth. I don't know what the direct impact is. I can imagine that they've had done, but I'll have to get back to you on that.

Senator BLUMENTHAL. Thank you. My time has expired anyway. So I would appreciate your getting back to us.

Thank you, Ms. Tolson and all of the members of the panel.

Senator GARDNER. Thank you, Senator Blumenthal. Thanks to the witnesses for your time and testimony today.

That concludes the hearing. The record will remain open for two weeks. Members are asked to submit their questions for the record and your homework assignment is to respond to those questions in writing as soon as possible to the Committee which will be made again a part of the record.

Thank you very much for your attendance today.

Senator BLUMENTHAL. Mr. Chairman, if I might just ask—

Senator GARDNER. Take back the gavel.

Senator BLUMENTHAL. I ask that a statement from the Advocates for Highway and Auto Safety be included in the record.

Senator GARDNER. Without objection.

Senator BLUMENTHAL. Thank you.

[The information referred to follows:]

PREPARED STATEMENT OF CATHERINE CHASE, PRESIDENT,  
ADVOCATES FOR HIGHWAY AND AUTO SAFETY

**Introduction**

Advocates for Highway and Auto Safety (Advocates) is a unique coalition of public health, safety, and consumer organizations, insurers and insurance agents that promotes highway and auto safety through the adoption of Federal and state laws, policies and regulations. Advocates works to prevent crashes, deaths and injuries through the advancement of safer vehicles, safer drivers and passengers, and safer roads and infrastructure.

**Motor Vehicle Deaths Remain Unacceptably High**

According to the Federal government, each year motor vehicle crashes kill tens of thousands of people and injure millions more at a cost to society of over \$800 billion.<sup>1</sup> According to the latest statistics from the National Highway Traffic Safety Administration (NHTSA), 37,461 people were killed on our Nation's roads in 2016.

<sup>1</sup>The Economic and Societal Impact of Motor Vehicle Crashes, 2010 (Revised), HS 812 013, U.S. DOT, NHTSA (May 2015 (Revised)), available at <http://www-nrd.nhtsa.dot.gov/Pubs/812013.pdf>; (NHTSA Cost of Motor Vehicle Crashes Report).

This is an increase of over five percent from 2015,<sup>2</sup> and it follows a seven percent increase from 2014 to 2015.<sup>3</sup>

### **Advocates Consistently Promotes Proven Technology to Save Lives and Prevent Injuries**

Advocates has always enthusiastically championed vehicle safety technology and for good reason; it is one of the most effective strategies for preventing deaths and injuries. NHTSA has estimated that since 1960, over 600,000 lives have been saved by motor vehicle safety technologies.<sup>4</sup> In 1991, Advocates led the coalition that supported bipartisan legislation that included airbag technology in the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991.<sup>5</sup> As a result, by 1997, every new car sold in the United States was equipped with a front seat airbag and the lives saved have been significant. Over the last decade airbags saved approximately 2,500 lives annually,<sup>6</sup> and have saved an estimated 47,625 lives since 1987, according to NHTSA.<sup>7</sup>

Advocates continued to build on this success by supporting additional lifesaving technologies as standard equipment in all vehicles in other legislation and regulatory proposals. These efforts include: tire pressure monitoring systems;<sup>8</sup> rear outboard 3-point seat belts;<sup>9</sup> electronic stability control;<sup>10</sup> rear seat belt reminder systems;<sup>11</sup> rearview cameras;<sup>12</sup> brake transmission interlocks;<sup>13</sup> seat belts on motorcoaches;<sup>14</sup> and, electronic logging devices for commercial motor vehicles (CMVs).<sup>15</sup> These safety advances have saved hundreds of thousands of lives and many have been accomplished because of bipartisan leadership of Members of the Senate Commerce Committee.

Additionally, crash avoidance systems, such as automatic emergency braking (AEB), are critical to the development of autonomous vehicles (AVs).<sup>16</sup> This system uses on-board sensors such as radar, cameras or lasers to detect an imminent crash, warns the driver and applies the brakes or increases the braking effort if the driver does not take sufficient action. Research performed by the Insurance Institute for Highway Safety (IIHS) has revealed that AEB decreases front-to-rear crashes that cause injuries by 56 percent.<sup>17</sup> These already impressive safety benefits will be increased by implementing a Federal performance standard for AEB and requiring that all new vehicles be equipped with this technology.

### **The Emerging Technology of Autonomous Vehicles Requires Sensible Safeguards**

Advocates believes that AVs have the potential to make significant and lasting reductions in the number of deaths and injuries that occur each year on our Nation's roads. However, deploying AVs before they can be safely operated on public

<sup>2</sup>Traffic Safety Facts Research Note, 2016 Fatal Motor Vehicle Crashes: Overview, NHTSA, Oct. 2017, DOT HS 812 456.

<sup>3</sup>National Center for Statistics and Analysis, 2015 Motor Vehicle Crashes: Overview, Report No. DOT HS 812 318, NHTSA (Aug. 2016).

<sup>4</sup>Lives Saved by Vehicle Safety Technologies and Associated Federal Motor Vehicle Safety Standards, 1960 to 2012, DOT HS 812 069 (NHTSA, 2015); See also, NHTSA AV Policy, Executive Summary, p. 5 endnote 1.

<sup>5</sup>Pub. L. 102-240 (Dec. 18, 1991).

<sup>6</sup>National Center for Statistics and Analysis, Lives Saved in 2015 by Restraint Use and Minimum-Drinking-Age Laws, NHTSA, Report No. DOT HS 812 319 (Aug. 2016); National Center for Statistics and Analysis (2017, October). Lives saved in 2016 by Restraint Use and Minimum-Drinking-Age Laws (Traffic Safety Facts Crash Stats) Report No. DOT HS 812 454, Washington, DC: NHTSA.

<sup>7</sup>Traffic Safety Facts 2015, Lives Saved by Restraint Use, and Additional Lives that Would Have been Saved at 100 Percent Seat Belt and Motorcycle Helmet Use, 1975–2015, DOT HS 812 384, NHTSA (2017); National Center for Statistics and Analysis (2017, October). Lives saved in 2016 by Restraint Use and Minimum-Drinking-Age Laws (Traffic Safety Facts Crash Stats) Report No. DOT HS 812 454, Washington, DC: NHTSA.

<sup>8</sup>Transportation Recall Enhancement, Accountability, and Documentation (TREAD) Act, Pub. L. 106-414 (Nov. 1, 2000).

<sup>9</sup>Anton's Law, Pub. L. 107-318 (Dec. 4, 2002).

<sup>10</sup>Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), Pub. L. 109-59 (Aug. 10, 2005).

<sup>11</sup>*Id.*

<sup>12</sup>Cameron Gulbransen Kids Transportation Safety Act of 2007, Pub. L. 110-189 (Feb. 28, 2008).

<sup>13</sup>*Id.*

<sup>14</sup>Moving Ahead for Progress in the 21st Century (MAP-21) Act, Pub. L. 112-141 (Jan. 3, 2012).

<sup>15</sup>*Id.*

<sup>16</sup>80 FR 62487 (Oct. 16, 2015).

<sup>17</sup>IIHS, Real-world benefits of crash avoidance technologies Fact Sheet (May 2018).

roads and without commonsense government oversight and industry accountability is not only reckless and ill-advised, but it will also substantially reduce public confidence in this new technology.

*Experts and Industry Agree that the Widespread Deployment of Autonomous Vehicles is Decades Away*

The pending AV START Act (American Vision for Safer Transportation through Advancement of Revolutionary Technologies Act, S. 1885) is being rushed through the Senate to facilitate the large-scale sale of experimental AV technology. The speed at which this legislation is being advanced is not aligned with the reality that AVs are a long way from being ready for prime time.

In fact, a number of auto industry executives have publicly stated that fully autonomous vehicles are still likely decades away. For example, Ford Motor Co. CEO Bill Ford, Jr. commented, “There’s been a lot of over-promising and I think a lot of misinformation that’s been out there. It’s really important that we get it right, rather than get it quickly.”<sup>18</sup> Toyota Research Institute CEO Gill Pratt stated, “It’s a mistake to say that the finish line is coming up very soon. Things are changing rapidly, but this will be a long journey.”<sup>19</sup> And, Nissan’s Senior Vice President of Connected Vehicles and Mobility Services Ogi Redzic remarked, “Say a 2021 target is the example. What they may be saying is in a little, geofenced area with certain speed and conditions. If you ask generic statements, like ‘when will all cars be driverless?’, well of course we are talking about the very distant future.”<sup>20</sup> The primacy of the technology was also underscored by a recent report by IIHS.<sup>21</sup> The report stated, a “production autonomous vehicle that can go anywhere, anytime isn’t available at your local car dealer and won’t be for quite some time. We aren’t there yet.”<sup>22</sup>

*The Public is Deeply Skeptical about the Safety of Autonomous Vehicles*

Numerous public opinion polls show strong public skepticism and reticence about AVs.<sup>23</sup> Those doubts are warranted based on the recent crashes as well as the past conduct of automakers. Over the last few years, automakers have hidden from the American public and regulators safety defects which have led to numerous unacceptable and unnecessary deaths and injuries and the recall of tens of millions of vehicles.<sup>24</sup> Consumer acceptance of AV technology is critical to its success and to fully realizing the lifesaving potential of AVs. Right now families know that when they go into auto showrooms to buy a new car, the Federal government has protections in place to ensure their safety. Similar oversight and regulation are needed for AVs to both assure and safeguard consumers, especially when considering recent the auto industry history of defects and cover-ups.

To provide some examples of the numerous recent surveys, in July of 2018, Advocates commissioned an independent public opinion poll<sup>25</sup> that showed intense apprehension regarding the widespread deployment of AVs with 69 percent expressing concern about safety. In a May 2018 poll commissioned by the American Automobile Association (AAA), 73 percent of American drivers said they would be too afraid to ride in a fully self-driving vehicle, up from 63 percent in late 2017.<sup>26</sup> A Reuters/Ipsos poll found that 67 percent of Americans were uncomfortable with the idea of riding in self-driving cars.<sup>27</sup> Lastly, in a May 2018 Public Policy Polling/Consumer Watchdog poll, 80 percent of respondents agreed that Federal and state governments should regulate driverless vehicles for the safety of riders, pedestrians and

<sup>18</sup> CBS News, Bill Ford on self-driving cars, his company’s future and the cost of Trump’s tariffs (Jun. 20, 2018).

<sup>19</sup> David Welch and Gabrielle Coppola, Don’t Worry, Petrolheads. Driverless Cars Are Still Years Away, Bloomberg News (Jan. 8, 2018).

<sup>20</sup> Craig Duff, Nissan says autonomous cars still have a long way to go, news.com.au (Feb 15, 2018).

<sup>21</sup> IIHS, Status Report, Reality Check: Research, deadly crashes show need for caution on road to full autonomy (Aug. 7, 2018).

<sup>22</sup> *Id.* at pg. 4.

<sup>23</sup> Advocates for Highway and Auto Safety, Public Opinion Polls Show Deep Skepticism About Autonomous Vehicles (June 2018).

<sup>24</sup> United States Department of Transportation, NHTSA, Docket No. NHTSA–2015–0055, Coordinated Remedy Program Proceeding; NHTSA, safecar.gov, Vehicle Owners, Consumer Alert: GM Ignition Switch Recall Information; U.S. v. Volkswagen, Case. No. 16–CR–20394 (E.D. Mich.).

<sup>25</sup> ORC International, CARAVAN Public Opinion Poll, July 2018

<sup>26</sup> American Automobile Association (AAA), Driverless Cars Are a Tough Sell to Americans, May 2018.

<sup>27</sup> Reuters and Ipsos, Reuters and Ipsos Poll poll of 2,592 participants conducted between Jan. 11–18, 2018, January 2018.

other drivers.<sup>28</sup> Clearly, the public needs assurances that they will be safe driving in and around AVs, yet the AV START Act falls short of establishing safeguards to accomplish this.

*The Safe Operation of Autonomous Vehicle Systems Has Yet to be Proved*

The artificial urgency to deploy immature AVs is disconnected from public opinion as well as the reality that serious and fatal crashes have revealed significant flaws in this still developing technology. On May 7, 2016, in Williston, Florida, a Tesla Model S on “Autopilot” struck and passed beneath a semitrailer killing the driver.<sup>29</sup> On January 22, 2018, in Culver City, California, another Tesla Model S operating on “Autopilot” collided with a parked fire truck that was responding to the scene of a separate crash.<sup>30</sup> Remarkably, neither the Tesla driver nor any first responders were injured.<sup>31</sup> On March 18, 2018, in Tempe, Arizona, an Uber test vehicle operating on self-driving mode struck and killed a pedestrian walking a bicycle.<sup>32</sup> Then, just a few days later on March 23, 2018, in Mountain View, California, a Tesla Model X operating on “Autopilot” collided with a safety barrier resulting in the death of the driver.<sup>33</sup> According to the National Transportation Safety Board (NTSB) preliminary report on the crash, the vehicle was being operated under “Autopilot”, had moved out of the lane of travel on its own and accelerated to 70 miles-per-hour (MPH) before colliding with the barrier.<sup>34</sup> The collision and subsequent intense fire closed the freeway for at least five hours.<sup>35</sup> On May 29, 2018, a Tesla Model S operating on “Autopilot” struck a parked police vehicle in Laguna Beach, California.<sup>36</sup> Late last month on August 25, 2018 in San Jose, CA, a Tesla Model S collided with a fire truck that was stopped in the far right lane with its emergency lights activated. The NTSB has investigated or is investigating all of these crashes except the last two.<sup>37</sup>

In addition to the tragic crashes that have already happened involving autonomous systems, data accumulated from the limited miles traveled also paints an alarming picture. In 2016, the latest year for which final data is available, on average a person was killed in a traffic collision every 84.7 million miles traveled on U.S. roads.<sup>38</sup> Before the fatal crash in Arizona, Uber had reportedly logged two million autonomous miles as of the end of 2017 and was predicted to accrue another one million miles over the next 100 days.<sup>39</sup> Based on a simple evaluation of this data, the autonomous Uber had one fatality in three million miles; that is a fatality rate 28 times that of human drivers. This analysis highlights just how little proof there is that these systems are safe. While it must be stated that the Uber crash is a single data point and may not be necessarily indicative of future performance statistically, if we are going to ignore this data point, then AV manufacturers must likewise stop touting the millions of miles their AVs have driven as evidence of their safety, as they are currently doing in the voluntary safety self-assessments filed with NHTSA. The fact is that the industry has yet to prove the safety of these systems and has yet to even agree upon a metric or method for comparing the safety of these systems, yet they are pushing to allow these vehicles into showrooms and

<sup>28</sup> Consumer Watchdog, As Americans Hit the Road for Memorial Day, Consumer Watchdog Poll Finds Voters Want Congress to Apply the Brakes on Driverless Cars, May 2018.

<sup>29</sup> National Transportation Safety Board, Collision Between a Car Operating With Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida, Report No.: NTSB/HAR-17/02 (Sep. 12, 2017) (NTSB Tesla Crash Report).

<sup>30</sup> Peter Valdes-Dapena, Tesla in Autopilot mode crashes into fire truck, CNN Tech, (Jan. 24, 2018).

<sup>31</sup> *Id.*

<sup>32</sup> Everett Rosenfield, Tempe police release video of deadly Uber accident, CNBC (Mar. 21, 2018).

<sup>33</sup> David Shephardson, U.S. opens probe into fatal Tesla crash, fire in California, Reuters (Mar. 27, 2018).

<sup>34</sup> National Transportation Safety Board, Preliminary Highway Report, HWY18FH011, Jun. 7, 2018.

<sup>35</sup> *Id.*

<sup>36</sup> Brittny Mejia, Tesla in Autopilot mode crashes into parked Laguna Beach police cruiser, L.A. Times (May 29, 2018).

<sup>37</sup> Tatiana Sanchez and Annie Sciacca, Tesla crashes into San Jose fire truck on Highway 101, The Mercury News (August 27, 2018)

<sup>38</sup> National Center for Statistics and Analysis. (2017, October). 2016 Fatal Motor Vehicle Crashes: Overview. (Traffic Safety Facts Research Note. Report No. DOT HS 812 456). Washington, D.C.: NHTSA.

<sup>39</sup> Carzon, B., Uber’s Self-Driving Cars Hit 2 Million Miles As Program Regains Momentum, Frobes, (Dec. 22, 2017).

onto the roads. Moreover, these numbers pale in comparison to the more than three trillion miles traveled by human drivers on U.S. roads each year.<sup>40</sup>

Similar misdirection about safety performance data has been used in response to recent crashes involving AVs. After the 2016 fatal Tesla crash in Florida, the NHTSA Office of Defects and Investigation (ODI) issued a report which included an analysis of data supplied by Tesla that showed “that the Tesla vehicles crash rate dropped by almost 40 percent after Autosteer [a feature of the Autopilot system] installation.”<sup>41</sup> However, included in the ODI report was a critical footnote that the crash rates reported were “for all miles travelled before and after Autopilot installation and are not limited to actual Autopilot use” (emphasis added).<sup>42</sup> Despite this clear statement by NHTSA, Tesla continues to mischaracterize the ODI analysis in response to subsequent fatal crashes involving vehicles operating under the “Autopilot” system.<sup>43</sup> NHTSA has since clarified again that the effectiveness of the “Autopilot” system was not evaluated in its prior investigation, refuting the claims by Tesla.<sup>44</sup> Moreover, Tesla was removed as a party to the NTSB investigation of the second fatal crash involving one of its vehicles shortly after a March blog post once again made this same claim.<sup>45</sup>

These types of details matter when it comes to AVs, particularly when evaluating claims that are made to support their introduction. Some members of the industry assert that waiting for AV technology to be perfect would be “the enemy of the good.”<sup>46</sup> In some cases, they point to a report of the same title by the Rand Corporation (RAND) to bolster this argument.<sup>47</sup> In fact, the RAND report concluded that allowing the deployment of AVs, which have a safety performance that is just 10 percent better than that of the average human driver, would save more lives than waiting for a perfectly safe AV.<sup>48</sup> However, the critical underpinning of this statement, which is being widely missed in the use of this report, is that these vehicles are in fact demonstrably better, even in some minute amount, than human drivers—this is a fact which has yet to be proved. Again, the industry and regulators have not even agreed upon the proper metrics for evaluating the safety performance of an AV, let alone requirements for operation which would assure that these vehicles are ten percent, one percent, or even a tenth of a percent better than the average human driver.

*Minimum Performance Standards Have Both Immediate and Long Term Benefits for Nascent Safety Technologies*

Advocates has always supported the introduction of safety technologies once its benefits have been identified and verified. Often additional advantages arise out of the widespread implementation of the base technology. For example, Advocates evaluated an abundance of research and data demonstrating that installing a rearview camera in passenger vehicles would help to prevent backover crashes and resultant deaths and injuries, often to young children and disabled persons.<sup>49</sup> Advocates, together with others in the safety community especially KidsAndCars.org and the remarkable families of backover victims, then fought for a decade in total to obtain a rearview camera requirement for all new vehicles, which took effect on May 1, 2018. The IIHS conducted research, published in their November 17, 2016 Status Report, demonstrating additional benefits of rearview cameras such as reducing property damage crashes during backing, and assistance with backing maneuvers such as parking.<sup>50</sup> Furthermore, if a video sensor stream was required, including additional driver assistance technologies such automatic rear braking, parking guidance and automated parking assistance, even more advantages could be realized.

Similarly, Advocates supported equipping vehicles with anti-lock braking systems (ABS), which helps a driver to maintain control of the vehicle when braking on slip-

<sup>40</sup> National Center for Statistics and Analysis. (2017, October). 2016 Fatal Motor Vehicle Crashes: Overview. (Traffic Safety Facts Research Note. Report No. DOT HS 812 456). Washington, D.C.: NHTSA.

<sup>41</sup> NHTSA Office of Defects Investigation, ODI Resume: Investigation PE 16–007.

<sup>42</sup> NHTSA Office of Defects Investigation, ODI Resume: Investigation PE 16–007.

<sup>43</sup> Tesla, An Update on Last Week’s Accident, Mar. 30, 2018.

<sup>44</sup> Reuters, ‘Effectiveness’ of Tesla self-driving system was not assessed in probe: U.S. traffic safety agency, May 2, 2018.

<sup>45</sup> Levin, A., Beene, R., Tesla Was Kicked Off Fatal Crash Probe by NTSB, April 12, 2018.

<sup>46</sup> David Strickland, We Can’t Afford to Put Up Any More Roadblocks on Self-Driving, Morning Consult (Dec. 1, 2017).

<sup>47</sup> *Id.*; Kalra, N., Groves, D., The Enemy of the Good: Estimating the Cost of Waiting for Near-perfect Automated Vehicles, RAND Corp., 2017.

<sup>48</sup> *Id.*

<sup>49</sup> Vehicle Backover Avoidance Technology Study, Report to Congress, NHTSA (Nov. 2006).

<sup>50</sup> Insurance Institute for Highway Safety (IIHS), Rearview cameras reduce police-reported backing crashes, Status Report, Vol. 51, No. 9 (Nov. 17, 2016).

pery surfaces. ABS has also resulted in wide ranging benefits. In fact, ABS is the base technology for electronic stability control (ESC) which helps to prevent rollover and loss of control crashes and is attributed to having saved more than 7,000 lives since 2011.<sup>51</sup> The applications which are in ABS and ESC are also an underlying technology for AVs. A critical component of both of these safety successes is a Federal standard that ensures these technologies have a specific level of performance so that consumers can have confidence in the technology as well as familiarity with a new feature of their vehicle. Federal standards also pave the way to build public acceptance and use of these technologies which magnifies the safety benefits. Effective government oversight and performance standards are critical to the success of new safety technologies placed into motor vehicles.

Moreover, examples of the success of effective standards and oversight of automated systems fly over our heads every single day. According to the U.S. Bureau of Transportation Statistics, 741 million passengers traveled on domestic flights in 2017.<sup>52</sup> The tragic April 2018 death of a Southwest Airlines passenger was the first U.S. commercial airline fatality since 2009.<sup>53</sup> Over that same span of time (2010–2017), nearly 5.4 billion passengers travelled safely through our skies. The Federal Aviation Administration (FAA) estimates that airline pilots use automated systems 90 percent of the time while flying.<sup>54</sup> Meanwhile, on our roads from 2010 to 2017, crashes claimed the lives of approximately 275,000 road users.<sup>55</sup> The Federal government, particularly the U.S. Department of Transportation (DOT), has experience in developing standards and implementing effective oversight of autonomous systems in transportation. While adaptation for governing AVs on roads is necessary, this is not an entirely new concept. The U.S. DOT would do well to coordinate with other departments and its own agencies, and make the best use of its past research, current regulations, and the latest technologies to set standards ensuring the safe introduction of AVs.

#### **Proper Government Oversight is Needed for the Safe Deployment of Autonomous Vehicles**

Over fifty years ago, Congress passed the National Traffic and Motor Vehicle Safety Act of 1966 because of concerns about the death and injury toll on our highways.<sup>56</sup> The law required the Federal Government to establish minimum vehicle safety performance standards to protect the public against “unreasonable risk of accidents occurring as a result of the design, construction or performance of motor vehicles.”<sup>57</sup> While motor vehicles have changed dramatically since that time and will continue to do so in the future, the underlying premise of this crucial law and NHTSA’s safety mission have not.

Unfortunately, NHTSA has chosen to issue only “voluntary guidelines” for the development of AVs.<sup>58</sup> Voluntary guidelines are not enforceable because they are not legally binding, and, therefore, are inadequate to ensure safety and protect the public. Manufacturers may unilaterally choose to deviate from the guidelines or ignore them entirely at any time and for any reason including internal corporate priorities such as cost or marketing considerations.

#### *The AV START Act Fails to Ensure Public Safety*

Compounding NHTSA’s inaction are the deep flaws of the AV START Act. Advocates opposes the bill in its current form as it falls well short of the oversight and

<sup>51</sup>Webb, C. N. (2017, March). Estimating Lives Saved by Electronic Stability Control, 2011–2015. (Traffic Safety Facts Research Note. Report No. DOT HS 812 391). Washington, D.C.: NHTSA.

<sup>52</sup>U.S. Bureau of Transportation Statistics, Annual Passengers on All U.S. Schedules Airline Flights (Domestic & International) and Foreign Airline Flights to and from the United States, 2003–2017.

<sup>53</sup>Gardner, L., Southwest passenger dies in first U.S. airline fatality since 2009, April, 17, 2018, Politico.

<sup>54</sup>Federal Aviation Administration, Office of the Inspector General, Audit Report: Enhanced FAA Oversight Could Reduce Hazards Associated with Increased Use of Flight Deck Automation, Report Number AV–2016–013, Jan. 7, 2016.

<sup>55</sup>National Center for Statistics and Analysis. (2017). A Compilation of Motor Vehicle Crash Data from the Fatality Analysis Reporting System and the General Estimates System. (Traffic Safety Facts 2015. Report No. DOT HS 812 384). Washington, D.C.: NHTSA. National Center for Statistics and Analysis. (2017, October). 2016 Fatal Motor Vehicle Crashes: Overview. (Traffic Safety Facts Research Note. Report No. DOT HS 812 456). Washington, D.C.: National Highway Traffic Safety Administration. National Center for Statistics and Analysis. (2018, May). Early estimate of motor vehicle traffic fatalities for 2017 (Crash•Stats Brief Statistical Summary. Report No. DOT HS 812 542). Washington, D.C.: NHTSA.

<sup>56</sup>Pub. L. 89–563 (Sept. 9, 1966).

<sup>57</sup>Title 49, U.S.C. Sec. 30102.

<sup>58</sup>NHTSA, Automated Driving Systems 2.0: A Vision for Safety (Sep. 12, 2017).

accountability necessary to ensure public safety. The legislation unnecessarily takes aim at the current Federal regulatory scheme protecting those traveling on America's roads that has been in place for decades.

Furthermore, for the Senate to fully consider all of the public safety implications associated with the mass deployment of AVs, the AV START Act should not move forward until the ongoing multiple investigations by the NTSB of the serious and fatal crashes involving AVs noted above are completed. Our Nation's foremost investigatory body has highly regarded expertise and will issue recommendations that should help guide Congress as it sets our Nation's first AV policy which will likely set the stage for years.

We urge the Senate to adopt the following reasonable improvements to the bill, which will ensure public safety and industry accountability, while still allowing for the development and deployment of AVs:

- *Reduce the Size and Scope of Exemptions:* Section six of the AV START Act will allow potentially millions of vehicles to be deployed into the public domain that are exempt from existing critical Federal Motor Vehicle Safety Standards (FMVSS). Providing broad statutory exemptions from the FMVSS for AVs is both unnecessary and unwise. There is already a statutory process in place for manufacturers to seek an exemption from the FMVSS. Moreover, Section 24404 of the Fixing America's Surface Transportation (FAST) Act<sup>59</sup> permits auto manufacturers to test or evaluate an unlimited number of vehicles exempt from one or more of the FMVSS.<sup>60</sup> Additionally, the exemption provision in current law, 49 USC Section 30113(a), provides that manufacturers may receive an exemption from compliance with the FMVSS for the sale of 2,500 vehicles to be sold in the United States in any 12-month period. No evidence has been presented to show that the development and deployment of AVs requires wholesale exemptions for an untold number of AVs from critical Federal safety standards that are essential to protecting public safety.
- *Prohibit Crashworthiness and Occupant Protection Exemptions:* The legislation currently contains no prohibition on AVs receiving an exemption from crashworthiness or occupant protection standards which protect the vehicle's passengers. Such exemptions can diminish the level of occupant protection that has been established through years of research under the existing regulations.<sup>61</sup> Prohibiting such exemptions will in no way inhibit the development of AV technology but will ensure that passengers of AVs are properly protected in a crash.
- *Strike Provision Allowing Vehicle Systems to be Turned Off:* Section seven of the AV START Act drastically alters current Federal law which prohibits manufacturers from rendering safety systems, such as the steering wheel and brake pedals, inoperable. This provision is a dangerous change in settled law because it would allow automakers to turn off safety systems while the AV is being driven by the computer. This could unnecessarily dilute safety at the discretion of the manufacturer and sets a precedent of Congress allowing manufacturers to unilaterally circumvent many of the existing safety standards. Currently, automakers cannot turn off safety systems without government oversight.
- *Require Sufficient Documentation in NHTSA Submission:* Section nine of the AV START Act requires manufacturers of AVs and AV technology to submit to NHTSA a Safety Evaluation Report (SER) that details the development of the technology and its expected performance in real world conditions. While Advocates supports the mandatory submission of such information, this provision as currently written only directs manufacturers to "describe" their AV systems. In the absence of a legislative directive to require that sufficient information and data are included in the SER, manufacturers are permitted to continue submitting slick marketing brochures such as those already released by three manufacturers<sup>62</sup> instead of providing data and documentation that will allow the public and NHTSA to accurately evaluate the safety of the technology.
- *Provide for Adequate Consumer Information:* The AV START Act should ensure that consumers are given essential information about an AV. Every manufacturer should be required to provide each consumer with information about the capabilities, limitations and exemptions from safety standards for all vehicles

<sup>59</sup> Pub. L. 112-141 (Dec. 4, 2015), codified at 49 U.S.C. § 30112(b)(10).

<sup>60</sup> Exempt vehicles under this provision may not be sold or resold to the public.

<sup>61</sup> For example, removing the steering wheel should not eliminate the requirement to protect the occupant from injury using safety systems such as airbags.

<sup>62</sup> Waymo, Waymo Safety Report: On the Road to Fully Self-Driving (Oct. 2017); General Motors, 2018 Self-Driving Safety Report (Jan. 2018); Ford, A Matter of Trust—Ford's Approach to Developing Self-Driving Vehicles (Aug. 2018).

sold in the U.S. at the time of sale. This information should be made available to consumers from day one, even before NHTSA issues a rule. NHTSA should also be required to establish a public website with basic safety information about AVs for consumers and for use in safety research. This online database would be similar to the [safercar.gov](http://safercar.gov) website that NHTSA maintains to inform the public about safety recalls applicable to their vehicle. This would enable consumers to enter their VIN to obtain critical information about their AV such as the level of automation, any exemptions granted by NHTSA from the FMVSS, and the operational design domain which includes limitations and capabilities of each autonomous driving system with which a vehicle is equipped. Such a database will be critical for consumers who purchase AVs, whether first-hand or as a pre-owned vehicle, and will also allow NHTSA and other research groups to perform independent evaluation of the comparative safety performance of AV systems.

- *Compel AVs to Capture Necessary Crash Data:* The NTSB in their investigation of the fatal Tesla crash in Florida noted that event data recorders (EDRs) are not required nor would current standards mandate the capturing of data necessary to evaluate the performance of AVs. The AV START Act does not require that this critical safety data generated by AVs will be recorded, shared or even provided to NHTSA and the NTSB for critical crash investigations. It is also essential that the legislation require all crashes involving AVs be reported immediately to NHTSA by manufacturers.
- *Direct Final Rules for Minimum Performance Standards:*
  - *Cybersecurity:* A failure to adequately secure AV systems and to protect against cyber-attacks could endanger AV passengers, non-AV motorists, pedestrians, bicyclists and other vulnerable roadway users. It could also clog roads, stop the movement of goods and hinder the responses of emergency vehicles. The real possibility of a malevolent computer hack impacting hundreds or thousands of AVs, perhaps whole model runs, makes strong cybersecurity protections a crucial element of AV design. Yet, Section 14 of the AV START Act merely requires manufacturers to have a cybersecurity plan in place with no minimum standards of protection or effectiveness. Instead, the legislation should require NHTSA to establish a minimum performance standard to ensure cybersecurity protections are required for AVs of all levels. Considering the recent record of high-profile cyber-attacks,<sup>63</sup> allowing manufacturers merely to have a cybersecurity plan in place is grossly inadequate to ensure that AVs are protected against potentially catastrophic cyber-attacks and breaches.<sup>64</sup>
  - *Driver Distraction:* In AVs that require a human to take control from the AV system (Levels 2 and 3), the automated driving system must keep the driver engaged in the driving task. Research demonstrates that even for a driver who is alert and performing the dynamic driving task, there is a delay in reaction time between observing a safety problem and taking appropriate action.<sup>65</sup> For a driver who is disengaged from the driving task during autonomous operation of a vehicle, that delay will be longer because the driver must first be alerted to re-engage, understand the situation, and then take control of the vehicle before taking appropriate action. The failure of the automated driving system to keep the driver engaged in the driving task during the trip was identified as a problem by the NTSB Tesla crash investigation. The NTSB found that the Tesla “Autopilot” facilitated the driver’s inattention and overreliance on the system, which ultimately contributed to his death.<sup>66</sup> The “Autopilot” was active for 37 minutes of the 41 minute trip and the system detected hands on the steering wheel only 7 times for a total of 25 seconds.<sup>67</sup> The NTSB also found that these problems are widespread across manufacturers with similar systems.<sup>68</sup> The AV START Act fails to address this serious safety problem, yet technology to discern distraction and provide alerts is already available. NHTSA should be directed to establish a minimum performance standard to ensure driver engagement throughout the trip.

<sup>63</sup> Stacy Cowley, *Equifax Breach Exposed Data From 2.5 Million More People Than First Disclosed*, N.Y. Times, Oct. 3, 2017 at B2.

<sup>64</sup> Chester Dawson, *The Dangers of the Hackable Car*, Wall St. J., Sep. 17, 2017.

<sup>65</sup> Human Factors, Koppa, R.J., FHWA, Ch.3, Sec. 3.2.1 Perception-Response Time.

<sup>66</sup> NTSB Tesla Crash Report.

<sup>67</sup> *Id.*

<sup>68</sup> *Id.*

- *Electronics Systems*: Motor vehicles and motor vehicle equipment are powered and run by highly complex electronic systems and will become even more so with the future deployment of autonomous driving systems. Interference from non-safety systems can affect the electronics that power critical safety systems if they share the same wiring and circuits. For example, in one reported instance a vehicle model lost power to its dashboard lights when an MP3 player was plugged in and used.<sup>69</sup> Similar to FAA requirements to protect the electronics and their functions in aircraft under any foreseeable operating condition,<sup>70</sup> NHTSA should require minimum performance standards for the electronics in all motor vehicles, particularly AVs. However, the AV START Act fails to direct NHTSA to develop and issue performance standards for the electronics systems of modern motor vehicles.
- *AV "Vision Test"*: In order for an AV to properly interact with its surrounding environment, it must not only detect other vehicles and roadway infrastructure but also other participants using our Nation's transportation systems including pedestrians, bicyclists, wheelchair users, construction workers in work zones, first responders providing assistance after crashes, and law enforcement officers directing traffic. A failure to properly detect and react to any of these could have tragic results. AVs and automated driving systems must be subject to objective testing to ensure that they properly detect other road users, as well as pavement markings and infrastructure, can correctly identify the type of object that has been detected, and can then also respond properly and safely. Therefore, the AV START Act should direct the Secretary of Transportation to initiate a rulemaking proceeding to require automated driving systems, including SAE Level 2 automated driving systems, to meet a minimum performance standard for detecting and reacting to the AV's driving environment.
- *Safety and Accessibility for People with Disabilities*: The long-term promise of AVs to improve mobility for those with disabilities is significant. However, the AV START Act fails to ensure safety and access to all members of the disability community who have varying needs.
- *Include Level 2 AVs*: The AV START Act does not include Society of Automotive Engineers (SAE) Level 2 AVs, which require a human driver to monitor their performance and be available to take over the driving task when necessary, like the Tesla vehicles which have been involved in several crashes. During a September 12, 2017, hearing on the 2016 crash conducted by the NTSB, deadly failures of Tesla's Level 2 "Autopilot" system were readily identified.<sup>71</sup> The NTSB found that similar problems also exist in other Level 2 AVs across many manufacturers.<sup>72</sup> In the near term, Level 2 AVs will likely comprise a majority of the passenger vehicle AV fleet. Proper safeguards to curb Tesla-like failures must be put in place. Level 2 AVs should be subject to all safety critical provisions in the AV START Act.
- *Do Not Preempt State Action in the Absence of Federal Regulations*: It is the statutory mission of NHTSA to regulate the design and performance of motor vehicles to ensure public safety which, in modern day terms, includes AVs and automated driving system technology. However, in the absence of comprehensive Federal standards and regulations to govern the AV rules of the road, the states have every legal right, indeed a duty to their citizens; to fill the regulatory vacuum with state developed proposals and solutions for ensuring public safety. Section three prohibits this state action.

### **U.S. DOT Requires Sufficient Funding and Authority to Properly Regulate Vehicle Safety**

As emerging technologies are developed and deployed, the U.S. DOT is already facing and will continue to confront unique challenges which warrant additional tools and funding to protect against potentially catastrophic defects and failures. NHTSA should be granted imminent hazard authority to expedite the grounding of vehicles that the agency has identified as having a potentially dangerous, widespread problem or when it detects a cybersecurity threat that could lead to inordinate crashes, deaths and injuries. Additionally, because of the potential serious nature of software defects that could imperil safety in thousands of vehicles, the ability

<sup>69</sup> General Motors, LLC, Receipt of Petition for Decision of Inconsequential Noncompliance, NHTSA, 79 FR 10226, Feb. 24, 2014.

<sup>70</sup> 14 CFR 25.1309.

<sup>71</sup> *Id.*

<sup>72</sup> *Id.*

to levy enhanced penalties is essential. The unacceptable level of current motor vehicle crashes, fatalities and injuries combined with the demands being placed on NHTSA with regard to AV technology necessitates an increase in agency funding.

Today, 95 percent of transportation-related fatalities and 99 percent of transportation injuries involve motor vehicles on our streets and highways.<sup>73</sup> Yet, NHTSA receives only one percent of the overall DOT budget.<sup>74</sup> NHTSA will be required to take on new significant responsibilities under the driverless car legislation. In order to efficiently execute all of these tasks, an office dedicated to AV safety should be established within NHTSA. The protection of public safety should not be compromised and progress should not be slowed because the agency does not have adequate technical expertise, organization, resources and funding to oversee the development and deployment of AVs.

### **Many Significant Obstacles and Uncertainties Remain Regarding the Safe Deployment of Emerging Technologies**

AVs will be operating on public roads, therefore ensuring that our Nation's infrastructure can accommodate the safe and successful deployment of AVs is essential. "Stand-alone" AVs (those that will not communicate with other vehicles) will be limited by the capability of the on-board sensors and therefore, will largely suffer from the same types of limitations that afflict human drivers.

With the advent of AVs, more emphasis must be placed on consistency of road design, and consideration must be given to the effects variations can have on autonomous technology. While a human driver can see a unique situation and interpret those circumstances fairly well, an AV may not be able to do the same. As the Senate Committee on Environment and Public Works Ranking Member Senator Tom Carper (D-DE) discussed during the June 13, 2018 hearing, "Innovation and America's Infrastructure: Examining the Effects of Emerging Autonomous Technologies on America's Roads and Bridges", research has already shown that minor distortion of a sign can result in havoc for AVs, causing stop signs to be interpreted as speed limit signs, a confusion which can have serious and even potentially fatal results.<sup>75</sup> Additionally, roadway deterioration and delayed repair, which are common occurrences on existing infrastructure, will have a negative impact on AV operation.

Claims made by the AV industry that the introduction of these vehicles will reduce congestion, improve environmental quality, and advance transportation efficiency may amount to nothing more than fanciful theories.<sup>76</sup> Instead, AVs may bring about so-called "hyper-commuters" who work from their vehicles on long commutes thereby making living further from offices and/or city centers more palatable. Likewise, the possibility of empty AVs adding substantial miles on the roads as they re-position autonomously after dropping off riders could undermine many of the benefits claimed.<sup>77</sup>

#### *Connected Vehicle Technology Has the Potential to Augment Safety*

Connected vehicle technologies allow a vehicle to send and receive communications with other vehicles (vehicle-to-vehicle (V2V)) and the infrastructure (vehicle-to-infrastructure (V2I)). These messages can relay information ranging from the relative location and direction of motion of other vehicles to warning messages that traffic lights are about to change or weather conditions are soon to be encountered. These systems will likely help fill in gaps in the performance of AVs. For instance, V2V communication can provide safety applications for advanced driver-assistance systems (ADAS) such as Left Turn Assist (LTA) and Forward Collision Warning (FCW). LTA warns drivers to the presence of oncoming, opposite-direction traffic when attempting a left turn. FCW warns drivers of stopped, slowing or slower vehicles ahead. In a 2017 Notice of Proposed Rulemaking to require V2V technology, NHTSA noted that "[b]ecause of V2V's ability to provide vehicles with information beyond a vehicle's range of perception, V2V is the only source of information that supports applications like Intersection Movement Assist (IMA) and Left Turn Assist (LTA). These applications have the unique ability to address intersection crashes,

<sup>73</sup> National Transportation Statistics 2015, U.S. DOT, RITA, BTS, Tables 2-1, and 2-2 (2017).

<sup>74</sup> Budget Highlights Fiscal Year 2018, U.S. DOT.

<sup>75</sup> Evtimov, Ivan & Eykholt, Kevin & Fernandes, Earlene & Kohno, Tadayoshi & Li, Bo & Prakash, Atul & Rahmati, Amir & Song, Dawn. (2017). Robust Physical-World Attacks on Machine Learning Models.

<sup>76</sup> Self-Driving Coalition For Safe Streets, FAQs.

<sup>77</sup> Bliss, L., Even Shared Autonomous Vehicles Could Spell Traffic Disaster, Citylab, May 10, 2017.

which are among the most deadly crashes that drivers currently face in the U.S.”<sup>78</sup> Advocates filed comments in support of requiring V2V because of the technology’s ability to help prevent serious crashes.<sup>79</sup> However, despite the identified safety benefits of V2V technology, this rule is languishing at DOT.

#### *Autonomous and Connected Trucks*

The emergence of experimental autonomous commercial motor vehicles (ACMV) and their interactions with conventional motor vehicles demand an enhanced level of Federal and state oversight to ensure public safety. It is imperative that CMVs be regulated. For the foreseeable future, regardless of their level of automation, ACMVs must have an operator with a valid commercial driver’s license in the vehicle at all times. In addition, critical safety regulations administered by the Federal Motor Carrier Safety Administration (FMCSA) such as those that apply to driver hours-of-service, licensing requirements, entry level training and medical qualifications must not be weakened. Advocates outlined safety concerns and recommendations for ACMVs in a September 12, 2017 letter to the Committee, which is attached.

Advocates is also concerned with a number of issues presented by truck platooning. In order to achieve any efficiency benefits, the trucks in a platoon must operate much closer together than is current practice. This presents very real safety concerns. Issues such as vehicle maintenance may hamper the ability to execute these types of operations outside of controlled experiments. In real-world scenarios, realities of brake and tire maintenance as well as vehicle loading can all affect handling capability. Currently, one in five heavy vehicles inspected at the roadside are placed out of service for vehicle issues, a large number of which are related to brakes or tires.<sup>80</sup> Moreover, until the first vehicle in a platoon is operated by a verifiably safe automated driving system, the safety of the platoon relies on the lead human driver. There are also questions concerning the interaction of platoons with other road users, including the ability of other vehicles to pass a platoon safely or navigate between them if need be in order to reach an exit or enter a road safely.

#### *Rural Considerations*

There are many unique transportation characteristics present in rural America that will affect the performance of, and access to, emerging technologies. Necessary infrastructure such as broadband connectivity and up-to-date mapping may be limited. Maintenance of roadway markings, signs and pavement may vary. Unpaved roads in rural areas could increase sensor fouling which could degrade or prevent safe operation. More consideration must be given to this complex issue before AVs can be deployed on a large scale.

#### **Conclusion**

Every day on average 100 people are killed and 6,500 more are injured in motor vehicle crashes in the U.S. Advocates has consistently promoted technology to reduce this unacceptable death and injury toll. So too, does Advocates proffer that automated technology has the potential to make significant and lasting reductions to this public health epidemic. However, AVs should not be prematurely deployed and sold before they can be safely operated on public roads and without common-sense government oversight in place. Serious and fatal crashes involving AVs which have already occurred reveal significant flaws in this still developing technology. In sum, the path to the safe and effective introduction of AVs requires government oversight, transparency and a comprehensive regulatory framework in all aspects from vehicle standards to infrastructure design.

Senator GARDNER. Thank you, and again the Committee thanks you.

The hearing is adjourned.

[Whereupon, at 11:42 a.m., the hearing was adjourned.]



<sup>78</sup> NHTSA, Federal Motor Vehicle Safety Standards; V2V Communications, Notice of Proposed Rulemaking (NPRM), Jan. 12, 2017, 82 FR 3854.

<sup>79</sup> Advocates for Highway and Auto Safety, Comments, NHTSA–2016–0126–0473, May 19, 2017.

<sup>80</sup> FMCSA, Roadside Inspection Out of Service Rates (Jul. 27, 2018).