Governors Staying Ahead of the Transportation Innovation Curve

• A POLICY ROADMAP FOR STATES

NGA
NATIONAL GOVERNORS ASSOCIATION

AHEAD OF THE CURVE
INNOVATION GOVERNORS

Foreword

As a result of new, advanced and connected technologies, our world is rapidly changing. Amazing technologies are transforming our daily way of life and altering how businesses and industries operate every moment of every day. Given the vast and ever-changing implications for our citizens and economies, governors are looking for ideas to help leverage the opportunities these new technologies present while also tackling the challenges to stay "Ahead of the Curve."

I am honored to have been chosen by my peers as the 2017–18 chair of the National Governors Association (NGA). I selected technology innovation – new products and processes that improve quality of life or deliver new value – as the theme for my Chair's Initiative, **"Ahead of the Curve: Innovation Governors."** This initiative engaged thought leaders and technology experts from across the country to examine how governors and the citizens we govern can stay one step ahead of the rapidly advancing technologies that impact the daily lives of residents and businesses in our states.

Ahead of the Curve focused on two areas: transportation and energy – areas which I have watched change the economy and quality of life for the better in my home state of Nevada. During the past year, we have gathered governors and their staffs to examine opportunities related to innovative energy and transportation technologies, explored the impacts of these technologies on other sectors such as healthcare, education and public safety and considered implications for the workforce, cyber security and advanced communications systems.

These are complex, yet very important topics. I hope the two roadmaps NGA has developed this year, on transportation innovation and on energy innovation, will provide ideas for how governors can support innovation and remain ahead of the curve for years to come.

Nevada Governor Brian Sandoval
NGA Chair, 2017–2018

Executive Summary

The United States is experiencing a transportation technology revolution that is moving us toward a future that is increasingly autonomous, connected, electric and shared. The revolution promises many benefits but also raises challenges and concerns. Governors have a key role to play in preparing their states for a smooth transition to this new world of transportation. They can work alongside other state officials, federal and local governments, technology providers and others to advance innovation and stay ahead of the curve.

Several new technologies and technology applications are becoming widespread across the country: ride-hailing and car-sharing activated by smartphone applications; electrified transportation, including vehicles, ferries, bicycles and scooters; connected and autonomous vehicles (AVs); and unmanned aerial vehicles (UAVs), or "drones." In addition, advanced communications networks are facilitating connected systems and the use of big data and analytics to support new transportation technologies.

Many states are seeking to advance the use of these new technologies alongside existing technologies, to achieve public policy goals such as: improved safety and mobility, enhanced economic development and quality of life, more efficient logistics that lower costs and emissions for improved public health and reduced land use.

As with any technology transformation, however, states are experiencing concerns including more related to uneven safety impacts as the system transitions; workforce impacts; accessibility and disparity risks; privacy; cyberthreats; and various technology limitations, including the widespread availability of advanced communications networks.

States face several challenges as they seek to address these concerns and reap the benefits of new transportation technology. One overarching challenge is that the existing regulatory structure and related incentives have not kept pace with new technology. Moreover, modernizing the system calls for new market structures and financing mechanisms because states face huge shifts in their traditional sources of infrastructure funding, which are tied to gasoline taxes, registration and driver violation fees and parking charges. There may also be gaps in the skill set of the current workforce, which may not be familiar with new technologies. Finally, consumers may not be comfortable with the pace of change and the amount of choice they are being offered.

Governors can help prepare their states to embrace transportation innovation by pursuing the following seven strategies:

- **Support technology innovation.**
- **Modernize legislation, regulations and incentives.**
- **Provide funding and financing mechanisms to drive technology deployment.**
- **Prepare the workforce.**
- **Update communications networks and data systems.**
- **Address cyberthreats.**
- **Educate citizens about the benefits and risks of technological innovation.**

To effectively pursue those actions across various technologies, governors will need to engage a range of actors in the public and private sectors, including transportation officials (including those involved in planning and motor vehicle regulations), insurance

Transportation Technology Transformation Highlights

Ride-hailing and Car-sharing:

- In 2015, there were 1.5 million car-sharing users and 22,000 vehicles in North America. By 2021, there are estimated to be 6 million users in North America.[1]
- Ride-hailing services are available in 50 states, plus Guam and Puerto Rico.
- In 2017, the two largest ride-hailing companies provided nearly 4.5 billion trips worldwide.[2]
- The ride-hailing industry currently is valued at $36 billion.[3]
- By 2030, it is estimated that the industry will be valued at $285 billion, with 97 million trips daily.[4]

Electric Vehicles (EVs):

- EV sales grew by 26% between 2016 and 2017.[5]
- Approximately 200,000 EVs were sold in the U.S. in 2017.[6]
- As of April 2018, U.S. EV sales had seen 31 months of consecutive year-over-year monthly growth.[7]
- Nine global manufacturers and 26 Chinese manufacturers have announced plans to expand EV offerings in the next five to 10 years.[8]
- In total, a projected 40 million to 70 million EVs will be on the road globally by 2025.[9]

Connected and Autonomous Vehicles:

- Several automated features (lane departure, adaptive cruise control, blind spot detection, active breaking) are available in vehicles today, with higher levels of more autonomous vehicles (AVs) coming.
- By 2040, there will be an estimated 33 million Level 4 (high automation) or Level 5 (full automation) AVs sold worldwide, with 7.4 million sold per year in the United States.[10]

Drones:

- More than 1 million drones are registered in the United States.[11]
- By 2021, there is projected to be more than 6 million drones in the United States.[12]

regulators, public utility commissioners, legislators, local officials, first responders, consumer advocates, utility executives, technology and equipment providers, network service providers, financial institutions, academia and public sector researchers and advocates. They may also want to pursue "unlikely" partners, such as those in the insurance industry, which will be grappling with new liability issues, and the health care industry, which is seeking ways to partner to provide patients with better access to health care.

The pace of technology adoption has been accelerating over the past decade.[13] It took about 100 years for landline telephones to reach widespread adoption, just 48 years for the adoption of electric power and 30 years for the adoption of color TV. More recently, it's taken just a decade for widespread use of cell phones, smartphones and tablets.[14]

Figure ES1 illustrates the pace of adoption for a range of several popular technologies. The steeper lines in recent years demonstrate the accelerating pace. Governors are well positioned to help their state's regulatory, workforce and communications systems adjust to this new pace by examining how they can update compliance-driven policies with performance-driven alternatives, adopt more data-driven governance and engage more stakeholders with greater transparency.[15]

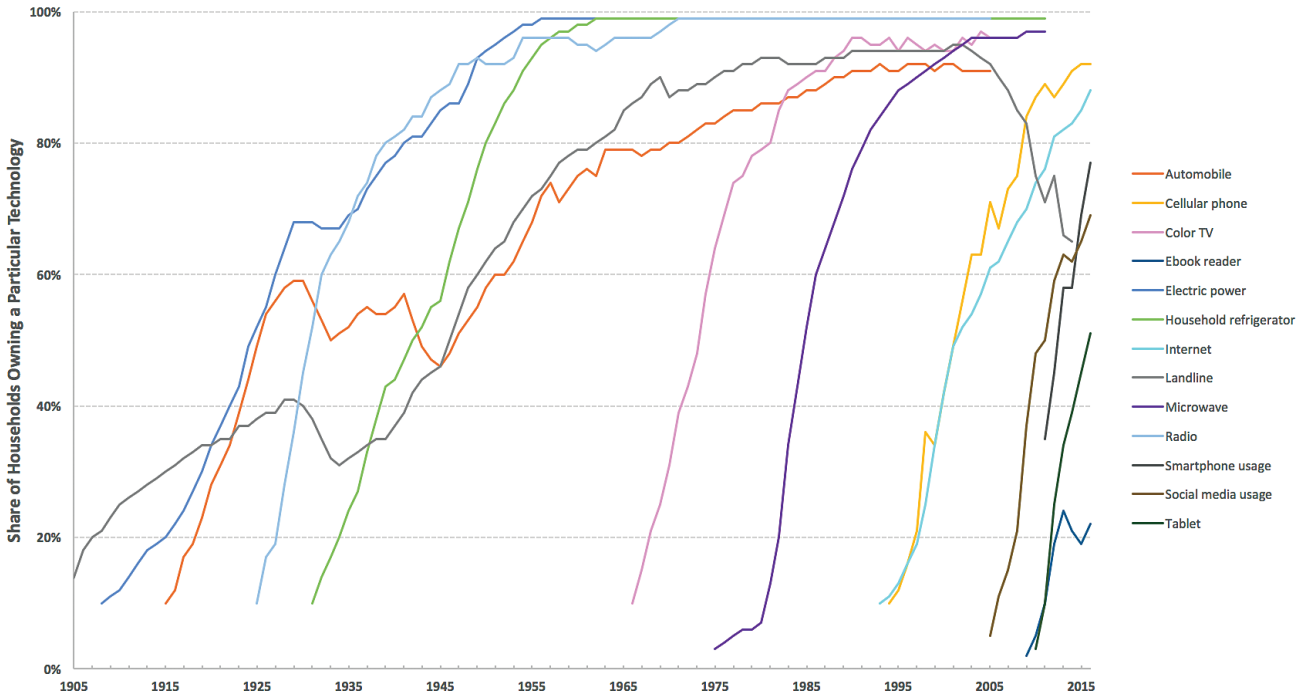

FIGURE ES1: Each curve on this chart represents the span (in years) of technology adoption. The steeper the curve, the more rapid the adoption rate. In recent years, the curves have become steeper than in the past.

Source: Desjardins, J. (2018). A brief history of technology. Retrieved from https://www.weforum.org/agenda/2018/02/the-rising-speed-of-technological-adoption

States are the laboratories of innovation; there is no one-size-fits-all approach to becoming an innovation governor. This roadmap presents a range of pathways to consider: Governors can take actions that fit within their state's context and help them stay ahead of the curve.

STAYING AHEAD OF THE TRANSPORTATION INNOVATION CURVE: STRATEGIES FOR GOVERNORS

Given the unique characteristics of each state, the following are possible strategies governors can consider as they pursue their policy objectives and adapt to transformations in the transportation system.

Support technology innovation:

- ✓ Appoint, convene and empower agencies or working groups to explore the adoption of modern technologies, gather input from stakeholders inside and outside of government, and make any recommendations publicly available.
- ✓ Pursue executive action to enable technology diffusion through state and regional planning, and harmonize rules, policy and procedures across agencies.
- ✓ Enable agencies, municipalities and universities to study, test and pilot emerging technologies.
- ✓ Direct state agencies to assess the possibility of partnering with the private sector to fully capitalize on private sector expertise and capacity while saving taxpayer dollars.
- ✓ Use innovative financial mechanisms to encourage the growth of high-tech industries.

Modernize legislation, regulations, and incentives:

- ✓ Modernize antiquated state standards and policies through legislative and regulatory changes.
- ✓ Encourage rate structures for EVs to influence consumer behavior and incentivize charging at the optimal time, such as during off-peak hours or when large amounts of renewable energy are available.
- ✓ Offer consumers and businesses incentives to use or purchase EVs or install charging stations.

Provide funding and financing mechanisms to drive technology deployment:

- ✓ Explore mileage-based user fees (MBUFs).
- ✓ Adjust existing taxes for inflation.
- ✓ Examine toll revenue.
- ✓ Consider ride-hailing fees.
- ✓ Examine EV fees.
- ✓ Review monetization of assets.

Prepare the workforce:

- ✓ Partner with the private sector to identify skills gaps and workforce availability. Work with educational institutions to ensure training programs are available to fill skills gaps in the short and long terms.
- ✓ Engage with students to get them excited about technology and thinking about the future of transportation.

Update communications networks and data systems:

- ✓ Ensure that agencies are investing in technology alongside infrastructure, ensure that investments are compatible with industry, and anticipate future needs.
- ✓ Designate a point person or agency for broadband deployment in the state, and set goals for expansion.
- ✓ Engage stakeholders, and identify state property for the development of communications.
- ✓ Enter into data-sharing agreements with the private sector.
- ✓ Promote the importance of data in government through structures such as a chief data officer, and ensure that state agencies are sharing and using data across silos.

Address cyber threats:

- ✓ Build cyber planning into all governance levels in coordination with law enforcement and homeland security; continuously evaluate and upgrade skills, systems and planning to respond to emerging threats; and focus on cyber hygiene.
- ✓ Promote the creation of a robust security program that focuses on data sensor integration, enabling an improved security posture to protect, detect and respond to security threats.

Educate consumers about the benefits and risks of technological innovation:

- ✓ Increase awareness of the benefits of new and forthcoming transportation technology.
- ✓ Assuage fears of infringing on citizens' privacy by putting in place policies that prevent improper use of technology.

Contents

Introduction

The world is changing rapidly because of amazing new advanced and connected technologies. These technologies are transforming our way of life and altering how businesses and industries operate. From how we heat and cool our buildings to the cars we drive, we are witnessing what some have declared the "Fourth Industrial Revolution."[16] Given the implications for their citizens and economies, governors are looking for ways to take advantage of the opportunities these new technologies present and tackle challenges to stay ahead of the curve. They want to know about proactive measures, partnerships and policies that can help them be "innovation governors."

The 2017-2018 National Governors Association (NGA) Chair, Nevada Governor Brian Sandoval, selected technology innovation – new products and processes that improve quality of life or deliver new value – as the theme for his NGA Chair's Initiative. The *Ahead of the Curve: Innovation Governors* initiative examined ways governors can help citizens, businesses and the public sector prepare for the technological transformation of the economy. It highlighted how governors and those they govern can stay one step ahead of the rapidly advancing technologies that affect the daily lives of residents and businesses. The initiative focused on the transportation and energy sectors as the two leading areas of innovation and explored how the innovations and disruptions in these sectors raise new considerations for governors in other critical areas such as education, workforce, health care, safety and security.

The initiative was informed by the ongoing experiences of Nevada and other states. Additional input was provided at an experts' roundtable in Reno, Nevada, in May 2017, and a listening session in Washington, D.C., in June 2017. These meetings included a cross-section of thought leaders from state government, business, think tank, research and academic organizations.

The initiative was launched at the NGA 2017 Summer Meeting in Providence, Rhode Island. The launch featured a session with Elon Musk, CEO of Tesla and SpaceX, to discuss the impact of disruptive technologies such as electric and autonomous vehicles (AVs), renewable energy generation and artificial intelligence (AI). Subsequently, NGA hosted two national summits – an Energy Innovation Summit in Denver, Colorado, in October 2017 and a Transportation Innovation Summit in Las Vegas, Nevada, in January 2018 – to explore innovative trends and state policy strategies in energy and transportation. Those summits engaged more than 150 officials from 39 states and nearly 300 participants. The NGA 2017 Winter Meeting continued to engage governors, featuring a conversation with IBM CEO Ginni Rometty to discuss the effect emerging technologies like AI and blockchain will have on the future workforce. To help visualize the data on technology innovation, NGA developed a set of "story maps" that combine maps with text, images and multimedia content to tell the story of specific transportation and energy technologies and the foundational communications networks and related policy actions to date.

For more information, please visit www.ngaahead.org.

How the roadmaps were developed

This roadmap and a companion document on energy innovation were developed through extensive research and consultation with senior state officials and experts in the fields of transportation and energy and insights gathered through previous NGA activities.[a] They were informed by the two national summits, governors' discussions and the story maps described above. In addition, NGA held an experts' roundtable in San Jose, California, in April 2018, where an array of public and private sector stakeholders provided feedback on the draft versions.

Using the roadmaps

The roadmaps are designed to guide governors and senior state policy officials as they prepare their states for changes associated with technology innovation in the transportation and energy sectors. Each roadmap describes leading new technologies and the related benefits, concerns and challenges that policymakers can expect to encounter, and then highlights existing efforts to address concerns and overcome challenges to reap the benefits. The roadmaps are policy development tools, and states can use the portions of the roadmaps that apply to their unique situations and needs. The transportation innovation roadmap helps governors prepare for the transition to an automated, connected, electric and shared (ACES) system, with effective strategies that enhance public safety, mobility, economic development and sustainability.

[a] To access electronic copies of both roadmaps, visit **www.NGAAhead.org.**

Authors

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The roadmap is the result of the National Governors Association Center for Best Practices (NGA Center) Environment, Energy and Transportation Division's work as part of the 2017-2018 Chair's Initiative of Governor Brian Sandoval of Nevada, *Ahead of the Curve: Innovation Governors,* which aimed to identify solutions for governors to stay ahead of the rapidly advancing technologies that impact the daily lives of residents and businesses in their states.

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The authors of this report also thank Ryan McGinness and Tyler Klimas of Governor Brian Sandoval's Washington, D.C. office, who provided valuable advice during the formation and reviews of roadmap drafts, as well as Brielle Stander from the NGA Center and NGA Scholar Bradley Nelson for their research contributions. R. Kirk Jonas, PhD, Director, NGA Center for Best Practices, provided important oversight and input into the intiative and roadmap development.

About the National Governors Association

The National Governors Association (NGA) is the nation's oldest organization serving the needs of governors and their staff. The NGA Office of Government Affairs serves as the collective voice of the nation's governors in Washington, D.C., while the NGA Center for Best Practices (NGA Center) – a separate 501(c)(3) organization – functions as a combination think tank and consultancy to help states advance policy objectives by implementing evidence-based best practices. The Environment, Energy and Transportation Division – which produced this publication – is located within the NGA Center.

Acronyms

ACRONYM	DEFINITION
4G LTE	Fourth Generation Long-Term Evolution
5G	Fifth Generation
AAMVA	American Association of Motor Vehicle Administrators
ACM	American Center for Mobility
ADA	Americans with Disabilities Act
AFIG	Alternative Fuels Incentive Grant
AI	Artificial Intelligence
ACES	Automated, Connected, Electric and Shared
AFV	Alternative Fuel Vehicle
AV	Autonomous Vehicle
BEV	Battery Electric Vehicle
BLS	U.S. Bureau of Labor Statistics
CAV	Connected Autonomous Vehicle
CDOT	Colorado Department of Transportation
CHEAPR	Connecticut Hydrogen and Electric Automobile Purchase Rebate
CI	Connecticut Innovations
CO_2	Carbon Dioxide
DC	Direct Current

ACRONYM	DEFINITION
DMV	Department of Motor Vehicles
DOE	U.S. Department of Energy
DOT	Department of Transportation
DSRC	Dedicated Short-Range Communications
EIA	U.S. Energy Information Administration
EMT	Environmental Mitigation Trust
EPA	Environmental Protection Agency
ESCC	Electricity Subsector Coordinating Council
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FCV	Fuel Cell Vehicle
FMVSS	Federal Motor Vehicle Safety Standards
GPA	Guam Power Authority
GPS	Global Positioning System
HD	High Definition
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
IPP	Integration Pilot Program
IT	Information Technology
K-12	Kindergarten Through Grade 12
Mbps	Megabits per Second
MBUF	Mileage-Based User Fee
MDOT	Michigan Department of Transportation
MEDC	Michigan Economic Development Corporation
MnDOT	Minnesota Department of Transportation
MOU	Memorandum of Understanding
MPH	Management and Performance Hub
NGA	National Governors Association
NGV	Natural Gas Vehicle
NHTSA	National Highway Traffic Safety Administration
NPO	Nonprofit Organization
ODOT	Ohio Department of Transportation
OEM	Original Equipment Manufacturer
PennDOT	Pennsylvania Department of Transportation
PHEV	Plug-in Hybrid Electric Vehicle
PPP	Public-Private Partnership
RSU	Roadside Safety Unit
RTC	Regional Transportation Commission
STEM	Science, Technology, Engineering and Mathematics
TCO	Total Cost of Ownership
TNC	Transportation Network Company
TOU	Time of Use
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
UC Davis	University of California, Davis
UNR	University of Nevada, Reno
USDA	U.S. Department of Agriculture
V2X	Vehicle to Infrastructure
VASC	Virginia Smart Communities Working Group
VMT	Vehicle Miles Traveled
WYDOT	Wyoming Department of Transportation

Background

The past several years have seen rapid advancements in transportation technology. From apps on our phones that facilitate greater mobility and a proliferation of drones in our skies to more affordable and longer range electric vehicles (EVs) and the deployment of connected and autonomous vehicles (AVs) on our streets, we are on the cusp of a transportation revolution. The future of transportation will ultimately entail all these technologies for an autonomous, connected, electric and shared (ACES) transportation future that will reshape our lives, our country and our world.

The future of transportation is ACES

The United States is witnessing the onset of a momentous transportation transition period whereby as much as one-quarter of all auto passenger miles traveled in 2030 is projected to be part of a shared fleet of autonomous, electric vehicles.[17] Such a rapid and momentous change brings with it the promise of compelling benefits as well as several concerns and challenges that policymakers will need to address.

An ACES future for the United States promises lower traffic fatalities and injuries, making our streets safer; improved access to mobility, enhancing economic development and quality of life; more efficient logistics and lower vehicle emissions, thus improving public and environmental health; fewer vehicles on the road, reducing congestion and the related emissions and productivity deficits; decreases in household and business transportation costs; and a reduction in the need for parking, freeing land for more beneficial uses.

Accompanying the benefits are concerns regarding the risks associated with the transition. Public concerns about safety could slow the deployment of new technologies, and privacy issues stemming from the unprecedented amount of data AVs and drones collect could spark a backlash. An ACES future could upend job markets as current occupations are reduced or eliminated. New industries or jobs may be created, as well, helping offset lost jobs. State and local revenue streams face significant disruption or depletion because of new technologies. The increase in automation and lower cost of travel could increase vehicle miles traveled, leading to additional pollution and congestion. In addition, not all citizens may be able to reap the benefits equitably.

Challenges include the need to overhaul regulatory systems that are decades old, realign federal and state roles, update communications networks, modernize infrastructure systems, maintain affordability, address cybersecurity risks, reassess insurance and liability provisions and create new data access frameworks.

Addressing and overcoming the concerns and challenges with new, connected technologies will require intensive planning and preparation by state government officials, public flexibility and support from the private sector.

Technologies

Four technologies will drive transformation of the transportation sector: (1) ride-hailing and car-sharing, (2) electrification, (3) AVs and (4) drones.

RIDE-HAILING AND CAR-SHARING

Mobile technology has enabled people to access new transportation options with the tap of a button. In the past five years, ride-hailing[b] and car-sharing[c] have grown into a multibillion-dollar industry. Companies such as Lyft, Uber, Via, Zipcar, Maven and car2go are changing how we access transportation. They have introduced a new way for people to participate in the sharing economy as drivers, riders or both.

Ride-hailing companies are active throughout the country, with at least one service available in all 50 states plus **Guam,**[18] **Puerto Rico** and the District of Columbia. Uber and Lyft are the two largest companies, having facilitated a combined nearly 4.5 billion trips in 2017.[19] The growth of the ride-hailing sector has spread across the world: Analysts value the less-than-decade-old ride-hailing industry at $36 billion and project that it will grow to $285 billion by 2030, with 97 million trips taken each day.[20]

Building off the ride-hailing platforms, ride-sharing is being introduced in urban environments as an even lower cost, congestion- and emission-reducing alternative to individual rides. Each platform is different, but ride-sharing systems such as uberPOOL, Uber

[b] On-demand automobile travel in a driver's personal vehicle, usually facilitated through an app or website.
[c] On-demand access to a fleet of vehicles spread throughout a city.

Express POOL, Lyft Line and Via are essentially modern versions of carpooling that use an algorithm to analyze drivers, routes, pickup and drop-off locations and potential additional riders to look for optimal matches.[21] In some cases, riders may be directed to walk a short distance to a specific pickup spot instead of being picked up at their current location.[22] Some services have fixed routes and pickup locations, earning the moniker "microtransit" because of the similarity to existing transit services; some services mimic existing transit routes in an attempt to add new flexible mobility options to heavily travelled corridors.[23]

Initially developed as a hyper-local and flexible alternative to rental cars, car-sharing has eliminated the need for some individuals to own their own vehicles and is increasingly popular in cities and on college campuses. Riders can use their smartphone to check the availability of, reserve and unlock a vehicle. In many cases, the car-sharing company charges for the time the vehicle is used. The rates cover gas, insurance and maintenance; in some cases, an annual fee is charged. One study estimated that in North America in 2015, there were 1.5 million car-sharing users, with 22,000 vehicles. The same study projected that by 2021, North America will see a four-fold increase in the number of registered car-sharing service users, totaling 6 million users.[24]

Electric Vehicle Terminology

Several EV technologies exist today. In this report the term "EV" refers to two technologies: battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). BEVs are powered exclusively by an electric battery and PHEVs are powered by a combination of an electric motor and a gasoline engine. Both recharge by plugging-in to an electricity source.

ELECTRIFIED TRANSPORTATION

Since the first Ford Model T rolled off an assembly line in 1908, the gasoline-powered, internal combustion engine (ICE) has propelled most vehicles manufactured and driven in the United States. Currently, only a small portion of the U.S. fleet is electric, but U.S. EV sales grew by 26 percent between 2016 and 2017, with nearly 200,000 vehicles sold in 2017 alone, marking 31 months of consecutive year-over-year monthly sales growth as of April 2018.[25]

This trend is not an aberration, either: As of April 2017, nine global original equipment manufacturers (OEMs)[26] and 26 Chinese OEMs had announced plans to produce or significantly expand their EV models over the next five to 10 years. Collectively, these commitments could lead to 40 million to 70 million EVs on the road by 2025 (Figure 1).[27]

Three factors are influencing the growth of EV sales: declining vehicle costs, greater customer choice and ongoing efforts to address so-called "range anxiety." Recent advancements in battery technology are exerting downward pressure on prices, while economies of scale from higher production levels and fuel costs as low as $0.03 per mile for EVs (compared with $0.09 to $0.13 per mile for internal combustion energy (ICE) vehicles)[28] are reducing total cost of ownership (TCO) over the lifetime of the vehicle. Today, 15 models of EV are available from major manufacturers that cost below $30,000 after incentives. At this price point, EVs are cost competitive with comparable ICE vehicles, making widespread adoption more plausible.[29] The number of EV models offered is expected to continue to grow to more than 40 by 2020, enabling greater customer choice and increasing the possibility that consumers will find a vehicle to match their needs.[30]

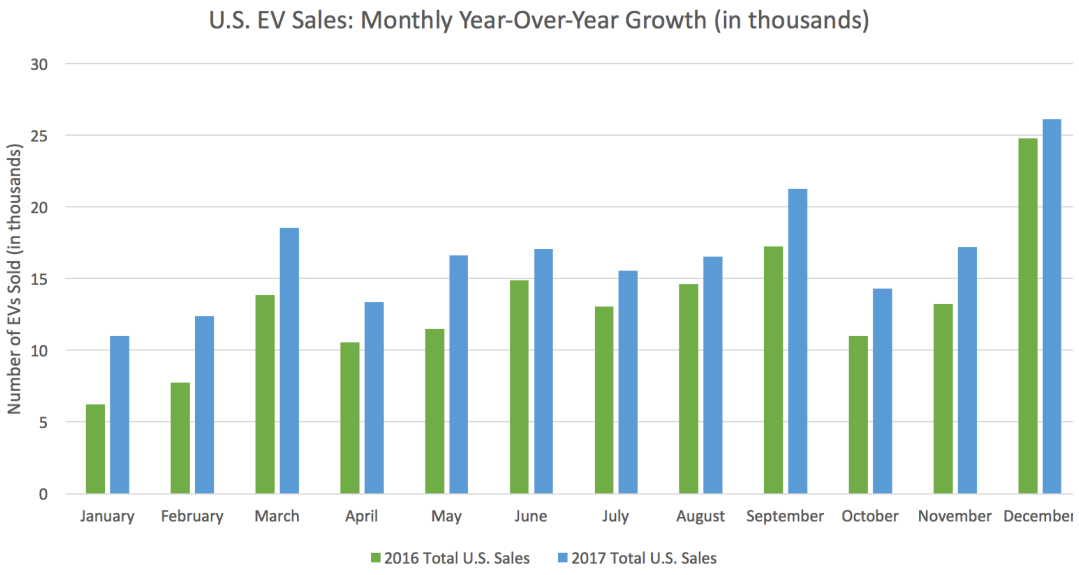


FIGURE 1: Monthly year-over-year EV sales in the United States. More EVs were sold each month in 2017 compared to 2016.

Source: Loveday, S. (2018, January 3). December 2017 plug-in electric vehicle sales report card. InsideEVs. Retrieved from https://insideevs.com/december-2017-plugin-electric-vehicle-sales-report-card

A key barrier to EV adoption is range anxiety: the perception among consumers that charging infrastructure is insufficient, limiting where they can travel and possibly stranding them with a depleted battery. This concern was understandable for early vehicles and infrastructure, but in recent years, both the distance an EV can travel on a single charge and the number of publicly available charging stations have increased significantly. For instance, **Nevada** recently completed the first phase of the Nevada Electric Highway, an initiative to strategically develop public EV charging infrastructure across the state. Efforts to expand EV supply equipment (EVSE) will continue as electric utilities become increasingly interested in developing new opportunities for load growth and as new investments enabled by the Volkswagen Clean Air Act Civil Settlement come to fruition. States are also exploring regional planning approaches to more effectively deploy infrastructure. For example, the governors of eight western states, including **Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah** and **Wyoming**, have signed an MOU to coordinate the development of a regional EV charging networks.[31]

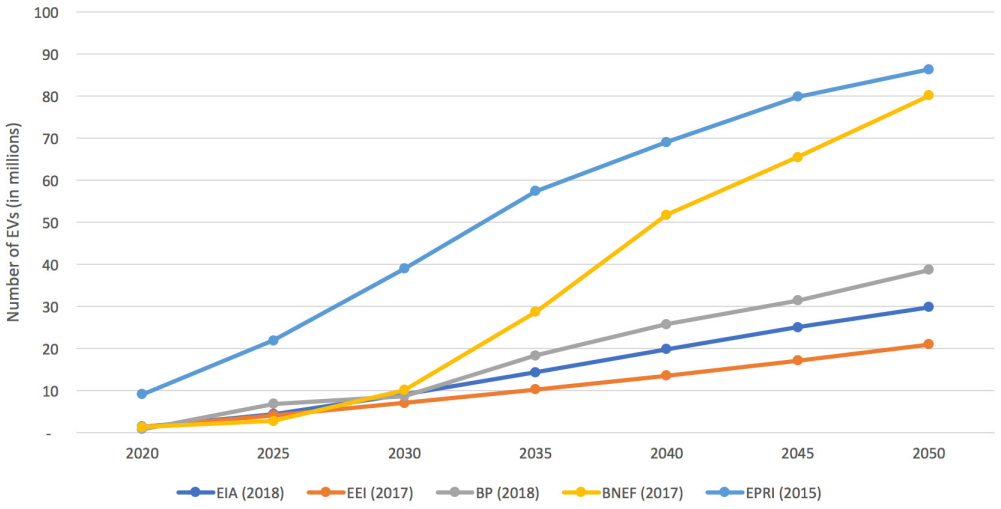


FIGURE 2: Collection of leading EV adoption forecasts in the United States, ranging from 20 million to 86 million by 2050. Data adapted from the U.S. Energy Information Administration (EIA), Edison Electric Institute, BP, Bloomberg New Energy Finance and Electric Power Research Institute.

Source: Annual Energy Outlook 2018: Transportation Sector Key Indicators and Delivered Energy Consumption. (2018, February 6). Retrieved from U.S. Energy Information Agency website: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=7-AEO2018&cases=ref2018&sourcekey=0; Cooper, A. & Schefter, K. (2017, June). Plug-in Electric Vehicle Sales Forecast Through 2025 and the Charging Infrastructure Required. Retrieved from: http://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20PEV%20Sales%20and%20Infrastructure%20thru%202025_FINAL%20(2).pdf; BP Energy Outlook: 2018 Edition. (2018, February). Retrieved from: https://www.bp.com/en/global/corporate/energy-economics/energy-outlook.html; Bloomberg New Energy Finance Electric Vehicle Outlook 2017 (2017, July). Retrieved from: https://data.bloomberglp.com/bnef/sites/14/2017/07/BNEF_EVO_2017_ExecutiveSummary.pdf; Alexander, M. (2015, December). Plug-in Electric Vehicle Projections: Scenarios and Impacts. Retrieved from: https://www.epri.com/#/pages/product/000000003002005949/?lang=en

Electrification of freight and transit has also been targeted because of the large number of vehicle miles traveled and low fuel efficiency. In addition, the electrification of port terminal equipment and idling vessels that draw electricity from shore power rather than auxiliary engines while loading and unloading cargo at berth offer opportunities for significant reductions in harmful air pollutants.[32]

To encourage and manage the benefits and challenges of the electrification of the transportation sector, states need smart policies. States should consider cost and equity concerns as well as adequate electricity grid investments to reap the promised economic and environmental benefits. Finally, states can consider ways to increase the share of miles and trips that EVs complete that do not rely on increased EV sales. Options include policies that reduce barriers to using EVs in ride-hailing and ride-sharing platforms.[35]

Volkswagen Clean Air Act Civil Settlement

An important funding source to encourage EV adoption has emerged with the Volkswagen Clean Air Act Civil Settlement. In 2015, the Environmental Protection Agency (EPA) resolved a civil enforcement case against Volkswagen for cheating on federal emissions tests. A $14.7 billion settlement against Volkswagen was reached, with $2.7 billion allocated to establish the Environmental Mitigation Trust (EMT).[33] States receive a portion of the funds from the EMT, prorated based on their vehicle population, for emissions-reduction efforts and can use up to 15 percent on public charging infrastructure. Eligible mitigation expenditures include a variety of transportation and electrification projects, including marine transport and port operation electrification.[34] Although the EMT is a substantial financing opportunity for states, critical planning decisions remain to maximize value.

Beyond Electric Cars

Electrified transport encompasses three growing modes of transportation: electric bicycles (ebikes), electric scooters and electric ferries. The rise of ebikes and electric scooters in urban areas built on the success of bike-sharing[d] and represents the increasing diversity of personal mobility devices. In the United States alone, roughly 35 million trips were taken in 2017 on bike-sharing systems, a 25 percent increase from 2016.[36] States are adopting electric ferries to capture many of the same benefits that EVs offer – namely, reducing harmful emissions, achieving cost savings and minimizing fuel price uncertainty.[e] Washington is currently in the process of evaluating the potential of converting several existing ferries to hybrid electric propulsion systems. The Washington Department of Transportation (DOT) conducted an initial life cycle cost analysis of the retrofit and found cost savings ranging from 1 percent to 25 percent contingent on the number of ferries and docks converted as well as future diesel prices.[37]

[d] Bike-sharing systems enable the short-term, shared use of bicycles at affordable prices. These systems can be fixed, with bicycles locked into docking stations situated throughout a given region, or "dockless," with users locating and unlocking bicycles through their smartphone global positioning system. Bike-sharing systems can be publicly or privately operated.

[e] A fringe benefit is the elimination of engine noise, which benefits aquatic ecosystems.

Hydrogen Fuel Cell Vehicles

Hydrogen fuel cell vehicles (FCV), like EVs, use an electric propulsion system. However, FCVs store and combine hydrogen with oxygen to generate electricity, emitting warm water vapor in the process.[38] FCVs can refuel in less than 10 minutes and have a range of 300 miles. Although federal and state incentives for FCVs exist, affordability and a lack of refueling infrastructure[f] are key factors contributing to the technology's slow adoption.[39]

[f] As of May 2018, the DOE's Alternative Fuels Data Center indicates that the only public FCV fueling stations are in California, concentrated around San Francisco and Los Angeles. Additional stations are planned or under construction in Hawaii and several northeastern states.

CONNECTED VEHICLES AND AVS

Technology innovators, both in and outside of the traditional automobile industry are helping steer us toward a new transportation frontier of driverless cars, buses and trucks. Advances in telematics, sensors and machine learning means that AVs are no longer the stuff of science fiction. Vehicles on the market today employ Level 1, driver-assisted features, and hundreds of connected vehicles and AVs are being tested in states such as **Nevada, Arizona, Michigan, California, Pennsylvania** and **Massachusetts** as well as in countries like Singapore, Japan, South Korea, Israel, Germany, the United Kingdom and Canada.[9] (See Figure 3 for a description of the six levels of automation). The number of AVs being tested continues to increase, but recent incidents have raised concerns about the safety of drivers, pedestrians and other road users in the period during which autonomous and non-autonomous vehicles share the road.

At the 2017 NGA Summer Meeting in Providence, Rhode Island, Elon Musk made news when he predicted that "almost all cars produced will be autonomous in 10 years" and that in 20 years, "there will not be a steering wheel… It will be like having a horse."[40] Although the initial numbers of AVs on the road will be small, the growth trajectory is predicted to be significant. A recent projection estimates that in 2021, Level 4 (High Automation) and Level 5 (Full Automation) AVs will reach individual buyers for the first time, and sales will surpass 51,000 worldwide. By 2040, 33 million AVs are expected to be sold worldwide, with total U.S. volumes of AV sales expected to reach 7.4 million units per year.[41]

A good deal of attention has been focused on the vehicles themselves, but optimal deployment of AVs will require smarter streets, with infrastructure connected to other infrastructure and to the traveling vehicles. Vehicle-to-vehicle and vehicle-to-infrastructure (collectively referred to as vehicle-to-everything or V2X) technology as well as the prevalence of connected vehicles will become mainstream before full deployment of AVs because of the slow turnover of vehicles on the roads. V2X technology and connected roads will enable many vehicles to travel closer together while improving safety for passengers, pedestrians, bikers and other vulnerable users. Traffic-control devices traditionally deployed to enhance safety for human drivers will need to be enhanced to effectively interact with sensors on AVs.

Many states are proactively installing products and equipment to prepare for the deployment of connected vehicles and AVs. For example, states are installing more visible and durable pavement markings optimized for the sensors on AVs on many roads to guide current traffic and prepare for AVs. As infrastructure is upgraded with V2X technology and connected vehicles and AVs become more common on the roads, the data produced in the transportation sector will increase exponentially. From the cameras, radar and LiDAR installed on the AVs to the radios, receivers, processors and switches installed along the roads, data will become simultaneously critical to safety and potentially burdensome to states. AVs will not be able to function without producing, accessing and transmitting massive quantities of data, with projections that data transmission rates will reach 4,000 gigabytes per day per car.[43]

[9] In 2017, USDOT designated 10 Autonomous Vehicle Proving Ground locations, meant to encourage testing and information sharing on automated vehicle technologies, but testing is not limited to these locations. For more information, see U.S. Department of Transportation. (2017, January 19). *U.S. Department of Transportation designates 10 automated vehicle proving grounds to encourage testing of new technologies* [Press release]. Retrieved from https://www.transportation.gov/briefing-room/dot1717

LEVELS OF AUTOMATION[42]

The Society of Automotive Engineers has established a scale of vehicle automation, ranging from Level 0 to Level 5. "Level 1" refers to vehicles with driver-assistance technology, such as automatic braking, which is included in many vehicles today. "Level 5" refers to vehicles that can operate autonomously in all driving conditions and may not have a steering wheel.

0	1	2	3	4	5
No Automation	**Driver Assistance**	**Partial Automation**	**Conditional Automation**	**High Automation**	**Full Automation**
Zero autonomy; the driver performs all driving tasks.	Vehicle is controlled by the driver, but some driving assist features may be included in the vehicle design.	Vehicle has combined automated functions, like acceleration and steering, but the driver must remain engaged with the driving task and monitor the environment at all times.	Driver is a necessity, but is not required to monitor the environment. The driver must be ready to take control of the vehicle at all times with notice.	The vehicle is capable of performing all driving functions under certain conditions. The driver may have the option to control the vehicle.	The vehicle is capable of performing all driving functions under all conditions. The driver may have the option to control the vehicle.

FIGURE 3: Automation levels produced by the Society of Automotive Engineers.

Source: Automated Vehicles for Safety. Retrieved from U.S. National Highway Traffic Safety Administration website: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

DRONES

From large reconnaissance aircraft to small quadcopters for sale to the public, unmanned aerial vehicles (UAVs) – "drones," as they are commonly known – are an increasing presence in our airspace. According to the Federal Aviation Administration (FAA), more than a million commercial and noncommercial drones are registered in the United States, with estimates ranging as high as 6 million registered drones by 2021.[44]

Drones are currently used in a variety of public and private activities, including agriculture, real estate, film, first responders, insurance and infrastructure inspection, with potential future uses such as delivery services.[45] These applications can create efficiencies, lower costs and remove workers from hazardous or dangerous situations. A 2016 report estimates the global market for commercial drone applications at more than $127 billion and identified infrastructure, agriculture and transport as the industries with the greatest market potential.[46] As commercial drones gain approval to perform more functions, state, local and federal regulators are beginning to grapple with how drones and traditional aircraft can share the increasingly crowded sky.

State Actions on AVs may be Affected by What Comes Out of the Federal Government, Whether that is the National Highway Traffic Safety Administration (NHTSA) or Capitol Hill

Vehicle safety is regulated at the federal level, but states have regulatory authority over traffic safety, licenses, insurance and vehicle operations to protect road users. States must exert this authority without stifling innovation and coordinate with other governmental entities. NHTSA released highly autonomous vehicle guidance in 2017 and is slated to release updated guidance in 2018, but congressional action could preempt many existing state laws and executive orders if written too broadly. Balanced versions of congressional legislation would make the federal government solely responsible for regulating AV design, construction and performance, while states could still regulate the sale, distribution, repair or service of AVs as well as licensing, liability and traffic laws.

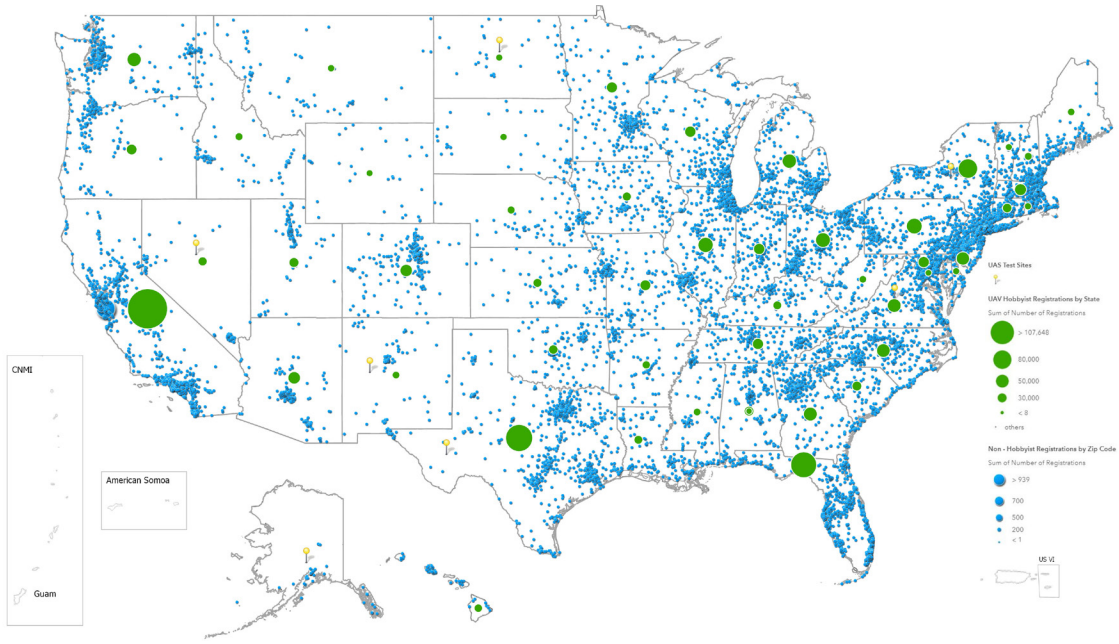
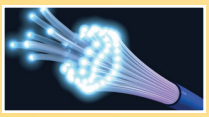


FIGURE 4: The number of drones registered in each state: blue dots are registered hobbyist drones and the green circle represent the number of registered non-hobbyist drones. The larger the green circle, the greater the number. Pin icons represent UAS testing sites.

Source: Federal Aviation Administration. (2017). FAA aerospace forecast: Fiscal years 2017–2037. Retrieved from: https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2017-37_FAA_Aerospace_Forecast.pdf

The Role of Communications Networks and Connectivity



To advance the speed at which people and goods move along the road safely, a critical piece of enabling infrastructure is required: a robust broadband network. Individuals, vehicles and the built environment need to transmit and receive substantial quantities of data to interact with each other. The two main categories of broadband transmission are physical or fixed broadband and mobile or wireless broadband. In regions with deficient connectivity, new infrastructure investments and policies to facilitate deployment are necessary to capture the beneficial network effects of ubiquitous connectivity. Given the diversity of needs, topography and markets across the country, no single best approach to deploying broadband exists.

Physical Broadband Networks

The four prevalent types of physical broadband networks, with varying connectivity speeds, applicability and associated costs, are:

- ***Buried fiber:*** Fiber-optic cables that require construction equipment to be buried and can transmit information at high speeds; the larger the strand count, the greater the bandwidth (i.e., transmission speed) the fiber route can sustain; active strands are called "lit fiber," and unused strands are called "dark fiber."[h]
- ***Aerial fiber:*** Like buried fiber but with cables strung along poles rather than buried; can take advantage of existing utility poles instead of digging new holes but is more exposed to natural damage.
- ***Coaxial cable:*** Mature technology developed in the early 20th century consisting of a copper wire encased in insulation; stable, reliable and inexpensive, but speeds are slower than fiber.[47]
- ***Microwave:*** Fiber-optic cables run to a telecommunications tower that uses a microwave transmitter to broadcast data to microwave relays that rebroadcast to expand coverage to customers with microwave receivers.

Mobile Broadband Networks

Mobile networks transmit broadband over the wireless spectrum. The Federal Communications Commission (FCC) has authority to allocate spectrum for specific, nongovernmental purposes and grants licenses for its use under Title III of the Communications Act of 1934.[48,i] Mobile networks have evolved over time, with data-transfer speeds increasing with each new iteration. The mobile broadband technologies of note for the transportation sector include:

[h] "Dark fiber networks" are separate, private networks controlled by the client rather than a network provider.
[i] The National Telecommunications and Information Administration administers spectrum for federal use.

- ***Fourth-Generation Long-Term Evolution (4G LTE):*** 4G LTE, often referred to simply as "LTE," is a wireless telecommunications technology standard considered a type of 4G with relatively fast connection speeds, enabling users to transmit and receive data at rates comparable to a home wireless connection. These speeds may be inadequate for transportation technologies, which require instantaneous data exchange.
- ***Fifth Generation (5G):*** Although not yet fully defined, 5G uses a high-frequency band of the wireless spectrum to exchange large quantities of data at very high speeds. High-frequency waves can travel more limited distances than the lower frequency used in 4G networks and have difficulty when encountering walls, buildings and other obstacles.
- ***Dedicated short-range communications (DSRC):*** DSRC uses a spectrum that FCC specifically allocates for intelligent transportations systems to improve vehicle safety and mobility applications. DSRC is a short- to medium-range wireless communication that permits high data-transmission rates and relies on roadside units connected to a fiber network.

Three categories describe where the network is connected:

- ***Middle-mile:*** Provides broadband to one or more centralized facilities, enabling last-mile providers to deliver internet access.
- ***Last-mile:*** Provides internet access to end-user devices, often in a home or business.
- ***Community anchor institution:*** Generally public institutions such as schools or libraries that receive a broadband connection and serve as a point of access.

In 2016, 92.3 percent of the total U.S. population had access to fixed terrestrial broadband at speeds of 25 megabits per second (Mbps) download/3Mbps upload.[j,49] Within this access-to-broadband statistic is the additional statistic that 30.7 percent of Americans living in rural areas lack access to fixed terrestrial broadband at comparable speeds. Although traditionally slower than fixed broadband and incompatible with the needs of some advanced technologies, mobile LTE offers connectivity speeds of 10Mbps/3Mbps to 87.3 percent of the United States. A current push to roll out 5G, which promises speeds significantly higher than current mobile LTE offerings (and some fixed broadband, as well), is underway, but permitting challenges have slowed the large-scale deployment of small-cell infrastructure to ensure the seamless use of the network. This gap in service means that roughly 40 million Americans lack access to mobile LTE services.[k] Although the price of service is not considered, it is likely a major factor resulting in only 53.3 percent of Americans adopting fixed broadband services in 2016.

Although the discussion of digital divide often and rightly focuses on disparities between urban and rural areas, the digital divide of those in urban areas unconnected to the internet is no less critical. For example, one study found that 18.74 percent of New York City's total population is unconnected and that unconnected urban populations nationwide represent 79.24 percent of total unconnected citizens in the United States.[50]

The benefits of overcoming the current connectivity divides to enable widespread AV adoption in the United States are substantial; estimates have found that a high penetration of AVs could reduce emissions by 40 to 90 percent, cut travel time by almost 40 percent, reduce delays by roughly 20 percent and decrease traffic death by 21,700 per year, saving $447 billion annually.[51] Critically, the benefits of access to high-speed connectivity extend well beyond the transportation sector, enabling innovation and the delivery of goods and services across the public and private arena in an increasingly connected society. Consequently, investment in broadband infrastructure has a multiplier effect, exponentially influencing the social and economic welfare of a state.

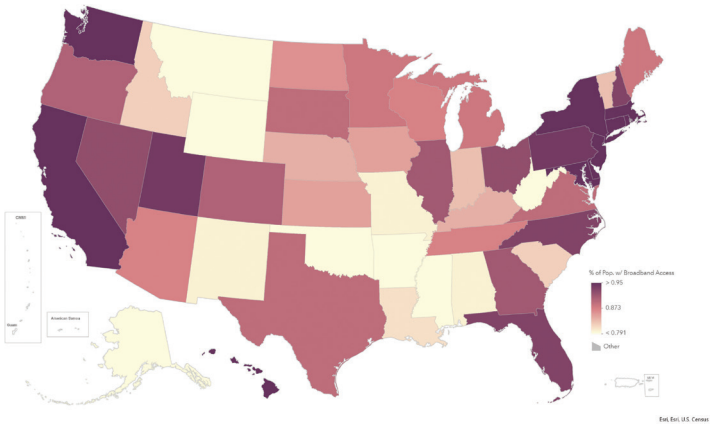


FIGURE 5: Percentage of each state's population with access to physical broadband networks. The darker the shading, the greater percent of the population with access to broadband.

Source: Federal Communications Commission. (2018, February 2). 2018 Broadband deployment report (GN Docket No. 17-199). Retrieved from: https://apps.fcc.gov/edocs_public/attachmatch/FCC-18-10A1.pdf

Figure 5 shows the percent of each state's population with access to broadband communication infrastructure. The darker shading signifies that a greater portion of the population has access to broadband. Importantly, a state with high broadband penetration overall may still have poor rural connectivity, which could impede transportation communication on rural roads. The data originated from FCC's Form 477, a form all broadband providers are required to file with the FCC biannually on where they offer internet access service.[52] While these data represent the best available information, concerns about its accuracy have been raised, and efforts to improve U.S. broadband data, both fixed and wireless, are underway.[53]

[j] FCC has found that fixed broadband speeds of 25Mbps/3Mbps meet the statutory definition of "advanced telecommunications capability," "enabl[ing] users to originate and receive high-quality voice, data, graphics, and video telecommunications." 47 U.S.C. § 1302(d)(1).

[k] Access is defined at the census block level rather than the household level, meaning that the whole block is labeled covered if a provider offers service anywhere in the census block.

Benefits, Concerns and Challenges of Transportation Innovation

Ride-hailing and car-sharing

The arrival of ride-hailing and car-sharing in mainstream society can bring benefits but carries challenges and concerns about impacts on existing infrastructure and economic disparities.

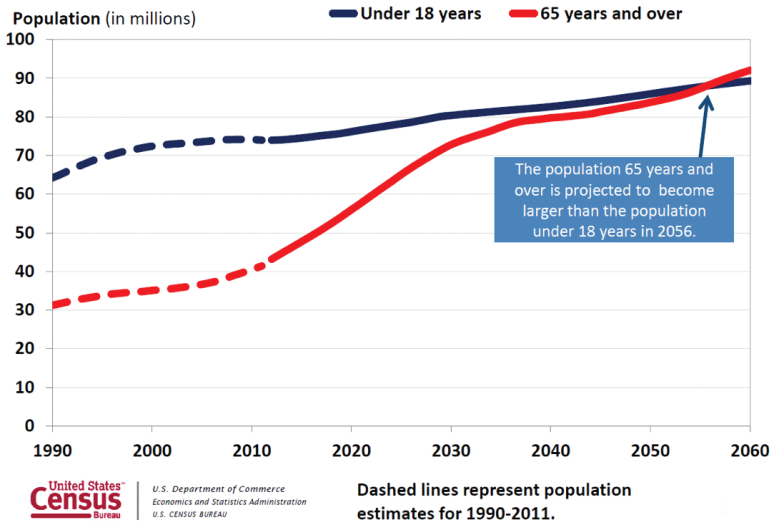


FIGURE 6: U.S. Census chart projects and compares future under 18 and over 65 population segments.

Source: Ortman, J. M. (2012, December 14). A look at the U.S. population in 2060. Retrieved from: https://www.census.gov/newsroom/cspan/pop_proj/20121214_cspan_popproj.pdf

BENEFITS FROM RIDE-HAILING AND CAR-SHARING

- ***Increased mobility:*** Greater access to flexible, on-demand transportation solutions, such as ride-hailing and car-sharing, will expand freedom of movement for the disabled, elderly and those without access to fixed-route transit or with access to transit that does not serve their intended destination. Federal data show that nearly 20 percent of Americans, or 57 million individuals, have a disability and that 6 million individuals with disabilities have difficulty getting the transportation they need.[54] America's elderly population is projected to grow as a percentage of total population, with the percentage of Americans over 65 year of age increasing from 14 percent in 2012 to 22 percent in 2060.[55] Ride-hailing is already improve access to health care, with Uber and Lyft introducing centralized dashboards from which health care providers can assign nonemergency medical transportation for their patients.[56] In addition to improved access to health care facilities, the removal of transportation barriers through ride-hailing and car-sharing can expand potential job markets, provide access to more fresh food sources and help alleviate the sense of isolation those lacking mobility often feel. There are also potential benefits of AVs complementing existing transit systems by filling the "first-mile/last-last" gap in many public transportation systems.

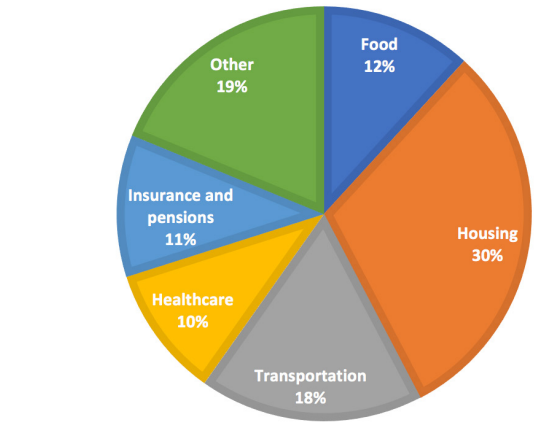


FIGURE 7: Average annual married couple household expenditures by major component.

Source: U.S. Department of Labor, Bureau of Labor Statistics. (2017, August 29). Consumer expenditures–2016 [Press release]. Retrieved from https://www.bls.gov/news.release/cesan.nr0.htm

- ***Convenience and time savings:*** Americans are busier than ever, with more than half (56 percent) of working parents saying that it is difficult for them to balance the responsibilities of their job with those of their family.[57] Users' ability to access transportation with the tap of a button from wherever they are increases transportation options and convenience and may reduce stress and travel time.
- ***Reduced costs:*** U.S. Bureau of Labor Statistics (BLS) data show that on average, a married couple spends close to 18 percent of their income on transportation, the second highest component of consumer expenditures (excluding 'other').[58] With cars sitting dormant for more than 90 percent of the day,[59] ride-hailing and ride-sharing have the potential to eliminate personal vehicle ownership – or at least the need for more than one vehicle per household – and result in significant household savings by reducing transportation expenses, such as vehicle cost, maintenance, fuel and insurance.

CONCERNS THAT RIDE-HAILING AND CAR-SHARING RAISE

- ***Accessibility and disparity:*** Those who benefit most from ride-hailing and car-sharing may be the least likely to be able to access the technology. An urban-rural divide exists today, and that divide is likely to persist because the low population density in rural areas makes it difficult to support large fleets of ride-sharing drivers. Moreover, states do not require that transportation network companies (TNCs)[l] provide coverage of specific areas, unlike the taxi industry, which is often assigned specific geographic service areas to ensure coverage. Some elderly and low-income individuals may lack credit or debit cards, smartphones or internet access or may not understand how to use the ride-hailing apps. As a result, they must rely on non-Americans with Disabilities Act (ADA) paratransit services, which are limited in availability, often unreliable and expensive for governments to operate. Unlike taxi services in many markets, TNCs are not required to ensure availability of handicap-accessible vehicles, which puts individuals who have mobility impairments at a significant disadvantage when seeking rides and often results in their being referred to taxi or ADA paratransit services, which require advanced scheduling and longer waits. The limited number of handicap-accessible vehicles in ride-hailing fleets has led to claims of discrimination by disability-rights organizations.[60,m]

- ***Vehicle miles travelled (VMTs) and congestion:*** In 2016, driving in the United States topped 3.2 trillion VMTs, the fifth straight year of increased mileage on public roads throughout the nation.[61] As ride-hailing has increased in popularity, the overall need for cars has declined, but cities are seeing traffic worsen. Studies have shown that increasing VMTs and congestion are partially the result of trips being made in ride-hailing vehicles that would otherwise have been made on foot, by bike or on transit as well as more vehicles on the road waiting for passengers. New York City is one of the few locations that receives extensive data from ride-hailing operators; a recent report analyzing those data from 2013 to 2017 found that during this period, total passenger trips increased 15 percent, and the number of miles for-hire vehicles traveled increased by 36 percent, possibly pointing to lengthier trips and more cars traveling without passengers. In addition, average speeds during business hours in the city dropped to six miles per hour, a 15 percent decrease from 2010.[62] A study conducted in Boston and a larger study of seven cities conducted by the University of California, Davis (UC Davis) Institute for Transportation Studies reached similar conclusions – namely, that ride-hailing is likely to contribute to growth in VMTs (Figure 8).[63] Rising VMTs are concerning because of increased congestion, which makes travel less time efficient, produces higher emissions and strains infrastructure. The data on this concern are still evolving but have led some to examine approaches that support greater use of ride-sharing, and increased use of EVs in ride-hailing fleets.

- ***Transit operations:*** Many state and local governments have invested heavily in new transit systems over the past decade, but those investments are at risk of becoming underutilized as ride-hailing and car-sharing become more popular. The same studies that found that ride-hailing is increasing VMTs and congestion in urban areas concluded that ride-hailing negatively affects the use of most forms of transit. A UC Davis study showed that after using ride-hailing, transit usage by those same individuals in major cities decreases by an average of 6 percent, specifically attracting Americans away from bus and light rail. The study also found that 49 to 61 percent of trips people made with a ride-hailing service they would either not have made at all or they would have made by walking, biking or transit.[64] Similar results were found in Boston, where 12 percent of ride-hailing passengers said they would have walked and 42 percent would have taken transit if ride-hailing were not an option.[65] As individuals are enticed away from transit, the revenue collected at the farebox will decline. A **Massachusetts** study found that "the average ride-hailing trip represents 35 cents of lost fare revenue for the [Massachusetts Bay Transportation Authority]."[66]

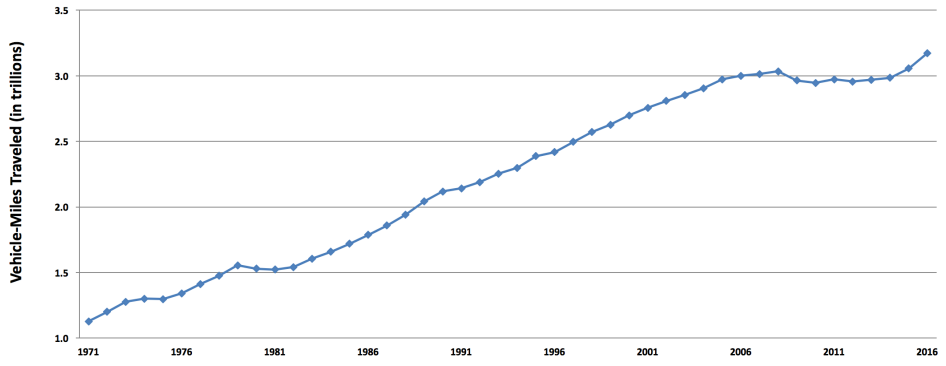


FIGURE 8: Annual VMT in the United States

Source: U.S. Department of Energy, Alternative Fuels Data Center. (2016, August). Annual Vehicle-Miles Traveled in U.S. Retrieved from: https://www.afdc.energy.gov/data/10315

[l] "Transportation network companies" is the term many state statutes use to refer to ride-hailing companies.

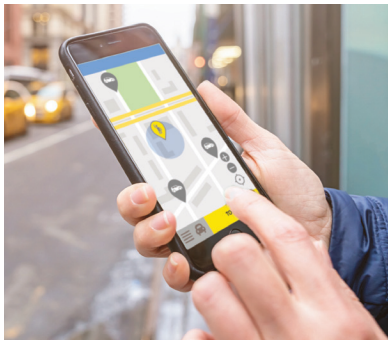
[m] For further information about efforts to improve non-ADA paratransit services through ride-hailing operations, please see the case study on Massachusetts in this report, on page 47.

Declining transit usage will affect farebox recovery, thereby increasing state and local subsidies for transit services, and may lead to deferred maintenance or expansions as well as service reductions, disproportionately affecting the lower income communities and populations most dependent on existing transit.

- ***Personal vehicles:*** The movement toward shared vehicle fleets may reduce personal vehicle ownership, threatening auto sales and employment at auto dealerships. With 16,708 new car dealerships directly creating more than 1.1 million jobs,[67] the automobile dealership industry will face significant changes as ride-hailing and car-sharing increase in popularity. Recent market research predicts that light vehicles sales will decrease annually through 2022, a trend that may accelerate as shared fleets become more prevalent.[68] There are conflicting opinions as to the impact on the automobile production industry because companies may shift their business model to focus on providing mobility services in addition to producing the vehicles.
- ***Revenue reduction:*** Increased use of ride-hailing or shared fleets could affect traditionally stable revenue streams that state and local agencies have used to support transportation operations and capital projects. Fewer purchases of personal vehicles could reduce taxes from motor vehicle sales and result in fewer vehicle registrations and the correlated registration fees. These are substantial revenues for state government, with states collecting more than $17 billion in motor vehicle registration fees alone in 2013.[69] Finally, sharing vehicles reduces the number of parking spaces required, potentially eliminating revenue from parking tickets and reducing parking fees collected at surface lots and garages – an important source of revenue for local governments. For example, in 2016, New York City collected $545 million from parking violations and another $393 million from parking fees.[70] Importantly, the revenue from parking can back municipal bonds, which are used to finance public infrastructure projects.
- ***Stranded assets:*** Parking and ground transportation fees are airports' largest revenue sources other than airline fees. The FAA reported that in 2016, $4 billion in fees collected for parking and ground transportation represented nearly 42 percent of the $9.6 billion in airport revenue from sources other than airline fees.[71] Because of their dependence on this revenue stream, the increased popularity of ride-hailing services may have major consequences for airports. Airports have reported that they are already seeing an impact, with a 5 to 10 percent reduction in the number of customers parking, up to a 30 percent decrease in the use of taxicabs and up to a 13 percent decline in rental car transactions – all while passenger volumes have increased.[72] At the same time, many airports have begun to impose fees on ride-hailing services that want to operate at the airport. Similar problems are surfacing in the private sector parking industry, with operators seeing declining revenue despite improved economies and employment.[73]
- ***Employee benefits:*** TNCs operating ride-hailing and ride-sharing services in the United States have come under criticism for not considering drivers to be employees and, as a result, not providing benefits such as unemployment insurance and health care. The TNCs' position has been and continues to be challenged in the courts, but the drivers face financial risks should they lose their job or be unable to drive. Beyond lacking benefits, drivers often receive lower pay than taxi drivers have seen in the past. Comprehensive data on this issue are limited, however, making broad analyses a challenge.

CHALLENGES ASSOCIATED WITH RIDE-HAILING AND CAR-SHARING

- ***Patchwork of regulations:*** Since ride-hailing services first began operations in **California** less than a decade ago, state and local governments have struggled with how (or whether) to regulate ride-hailing and car-sharing services. Some localities have attempted to put additional regulations on the services or block their operation, which has led several state governments, such as **Florida** and **Texas**, to enact legislation setting statewide regulations for TNCs rather than having a patchwork of confusing local laws.[74] As of June 2017, 48 states have passed some sort of TNC legislation to clarify the rules under which ride-hailing and ride-sharing companies operate.[75]
- ***Lack of data:*** Related to the issue of patchwork regulations, most jurisdictions lack data on TNC services to make informed judgements on issues. From how many drivers are on the road to how much passengers are charged, the number of rides and routes taken and where individuals are being picked up and dropped off, many states do not have access to useful data that can help inform government (and make the case to the public) determine where infrastructure investments are needed, which type of infrastructure states should invest in and which areas traditional transportation options underserve. TNCs have responded to requests for data to some degree. Uber has released Uber Movement, proactively publishing on the internet some anonymized trip analytics for specific cities,[76] and most recently entered into an agreement to share information on pickup and drop-off data for Washington, D.C.[77]



Electrified transportation

EV-enabling technology was first invented in the 1830s. Less than a century later, the technology appears poised for large-scale adoption, ushering in a host of associated economic, health and environmental benefits. These benefits are not guaranteed, however, and the technology's diffusion must be properly managed to address the equity, financial and infrastructure difficulties that may arise.

BENEFITS FROM ELECTRIFIED TRANSPORTATION

- ***Lowering and shifting emissions:*** In 2016, transportation sector carbon dioxide (CO2) emissions surpassed those of the power sector, becoming the nation's single largest source of CO2 emissions.[78] Electrifying transportation shifts emissions from the tailpipe to an electricity-generating source, where regulatory structures for pollution reductions exist and a change to less carbon-intensive resources is underway. The health benefits are potentially substantial, with studies suggesting that ICE vehicle emissions of nitrogen oxides (NOx), particulate matter and other pollutants can lead to respiratory diseases, premature death and cardiovascular morbidity.[79] Collectively, respiratory diseases in 2014 led to more than $160 billion in direct and indirect costs in the United States,[80] a growing trend as urban core populations soar alongside worsening air quality.[81] In addition, EVs are highly efficient at converting energy into motion, typically consuming less than half the energy an ICE vehicle uses.[82] Importantly, the environmental and health benefits from electrification can continue to improve over the vehicle's lifetime if the power sector continues to move toward cleaner sources of electricity.[83]

  The benefits of electrification are applicable to a range of vehicles as well as ports and airports, which can install electric-powered terminal equipment and ground support vehicles and provide energy to ships and planes in lieu of oil and diesel-powered engines.[84] For example, **California** requires that container ships, cruise ships and refrigerated cargo ships draw 80 percent of their energy needs from grid-based shore power by 2020 and 100 percent by 2030 to curb diesel particulate matter and nitrogen oxide.[85] Idling heavy-duty trucks are also major emitters at ports. Port operators are working with trucking companies and utilities to reduce truck emission while they are onsite. The Norfolk International Terminals in **Virginia**, a Port of Virginia facility, has several initiatives underway to take advantage of communication technology and efficiency software to limit unnecessary VMTs.[86] In addition, the ports of Los Angeles and Long Beach are exploring attaching cargo trucks to overhead electric lines rather than burning diesel while the vehicles are on site.[87]

- ***Minimizing household expenses:*** Analyses of the total cost of ownership (TCO) of EVs have found that EVs are cost competitive with and often less expensive than comparable ICE vehicles.[88] Other factors, such as purchase incentives and high gasoline prices, further reduce EVs' TCO relative to ICE vehicles. For example, the cost to "fill up" an EV can be as low as $0.03 per mile compared with $0.09 to $0.13 per mile for ICE vehicles.[89]

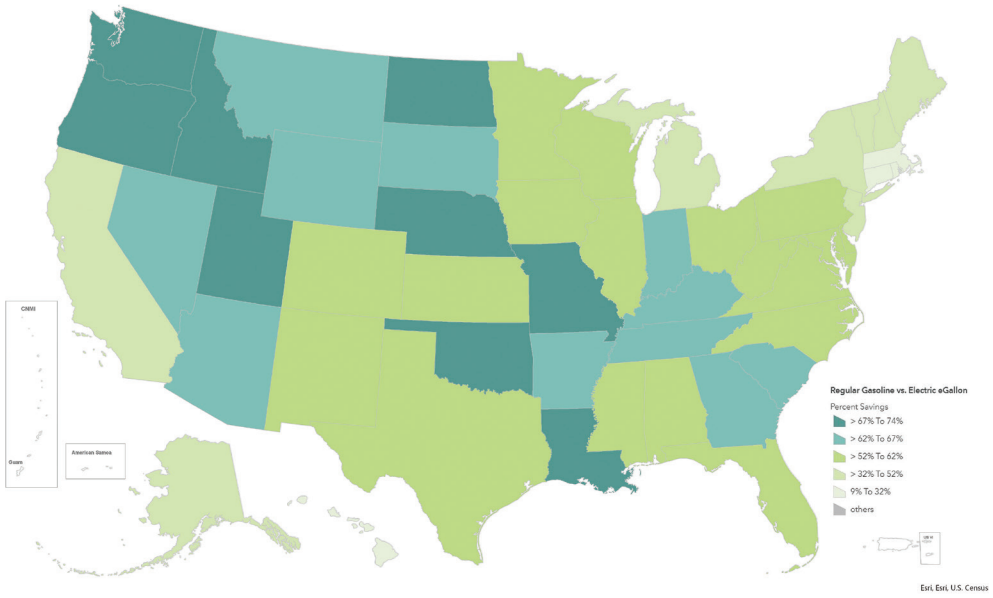


FIGURE 9: The average cost of gasoline per gallon is compared to an equivalent quantity of electricity by state. The cost saving from using electricity rather than gasoline is expressed as a percentage.

Source: U.S. Department of Energy. (2018, May 19). eGallon: Compare the costs of driving with electricity. Retrieved from: https://www.energy.gov/maps/egallon

- ***Electricity market benefits:*** Large-scale EV adoption has the potential to provide a substantial increase in electricity load that can help offset the trend toward stagnant or declining demand.[90] Adding load, particularly when the grid is underused, may benefit all customers by spreading fixed costs over a greater volume of sales without the need for new investments, reducing per-kilowatt-hour prices. In addition, if properly managed, EVs may serve as a large source of variable demand, complementing and allowing for more variable renewable energy on the grid. EV batteries could provide resiliency and reliability services similar to other forms of storage through vehicle-to-grid technology or from second-life applications.[91]
- ***Reducing petroleum dependence and localizing benefits:*** Shifting away from ICE vehicles reliant on the global oil market enhances national energy security by insulating the transportation sector against geopolitical risk and the potential volatility of global commodity prices (Figure 10).[92] Moreover, studies have shown that EVs can create local economic benefits from their use of power generated in state rather than from imported gasoline.[93]

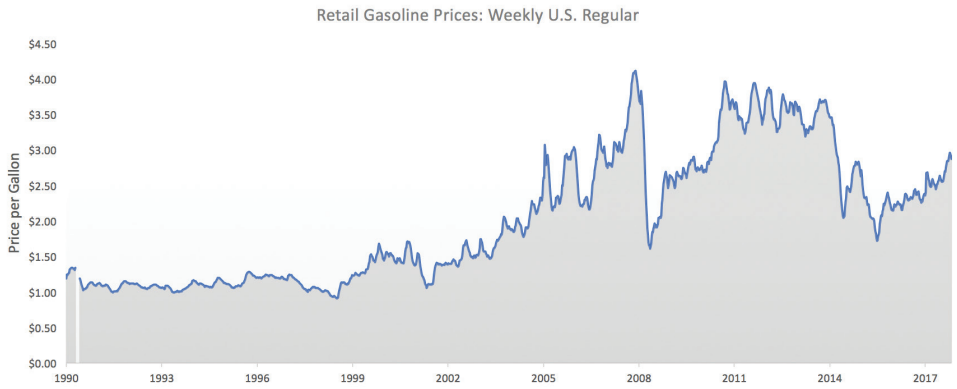


FIGURE 10: Weekly retail prices from 1990 to 2018 demonstrate the increasingly volatile nature of U.S. gasoline prices.

Source: Petroleum & other liquids. (2018, June 18). Retrieved from U.S. Energy Information Agency website: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epmr_pte_nus_dpg&f=w

CONCERNS THAT ELECTRIFIED TRANSPORTATION RAISE

- ***Obsolescence risk:*** EVSE installed today may not be the right type nor in the correct location to meet future needs, leading to duplicative costs for agencies, companies or utilities. For example, battery technology has advanced rapidly over the past decade, suggesting that EVSE investments based on current EV ranges and charging speeds may result in underused assets.
- ***Equity issues:*** EVs are predominantly purchased by higher income consumers.[94] Consequently, purchase incentives may be perceived as a taxpayer subsidy for wealthier citizens. In addition, utilities that construct EVSE and incorporate their cost into the rate base risk forcing customers who do not own EVs to finance costly infrastructure they are unable to use.
- ***Impact on oil markets:*** A large-scale shift to EVs will weaken downstream oil demand, potentially harming the viability of companies in the oil industry and disrupting job markets across the value chain. One study found that a quarter of the world's refineries could close by 2035 under certain scenarios, including heighted demand for EVs.[95] This possibility has not been lost on the oil and gas sector, with companies such as Shell and BP making investments in EVSE.[96]
- ***Revenue depletion:*** As the number of EVs on the roads increases, states are becoming increasingly concerned with the potential loss of tax revenue from declining motor fuel sales as well as taxes on fuel distribution and supply, whose proceeds fund transportation infrastructure. Consequently, 18 states have adopted annual fees for plug-in electric vehicles (EVs[n]).[97]

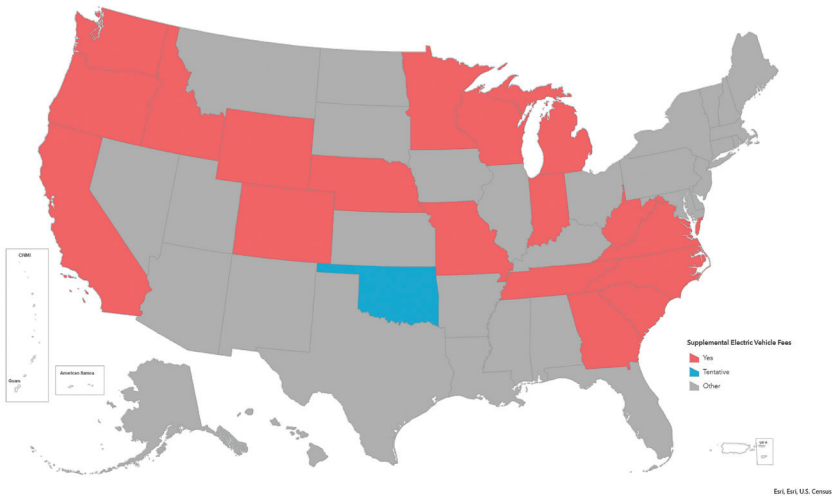


FIGURE 11: States in red have implemented an EV fee. Oklahoma is blue because the EV fees were struck down by the state supreme court.

Source: Hartman, K., & Dowd, E. (2017, September 26). State Efforts to Promote Hybrid and Electric Vehicles. Retrieved from http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx

[n] EVs include battery electric vehicles and plug-in hybrid electric vehicles.

- ***Resource constraints:*** Scaling demand for EVs may be tempered by inadequate global supply of raw materials for lithium-ion batteries, such as lithium, cobalt, copper and nickel. In the long term, if rapid nonlinear rates of adoption occur, current underinvestment in new mines and production lag may constrain mineral availability.[98] Geopolitical risk exists, as well, with roughly 50 percent of the world's cobalt mining concentrated in the Democratic Republic of Congo, and then predominately refined in China.[99] Future EV production will therefore depend on the political stability of and favorable trade policies with these countries.

CHALLENGES ASSOCIATED WITH ELECTRIFIED TRANSPORTATION

- ***System stress:*** Without careful planning, adequate technology and supportive rate design, EVs could strain distribution infrastructure and increase peak demand.[100] As more of the U.S. fleet becomes electrified, uncoordinated simultaneous charging by large concentrations of EVs could lead to demand spikes that may shorten the life of distribution transformers and undermine local grid reliability.[101]
- ***Affordability:*** Although EV prices have declined and TCOs are competitive, initial up-front costs remain high. This affordability gap is problematic for low-income consumers, who could benefit from the long-term savings but are unable to finance the initial purchase.
- ***Infrastructure deployment:*** The cost of installing a nationwide public EV charging network is considerable, with estimates suggesting that 8,000 additional direct current (DC) fast chargers are needed for a minimum level of coverage.[102] Home charging is often suggested as the solution to a lack of public EVSE, but less than half of all drivers have access to dedicated off-street parking.[103] Moreover, some infrastructure investment and ownership models have potentially harmful market and economic impacts. For example, if regulated utilities are permitted to build public EVSE, their monopolistic structure may grant them a competitive advantage over independent suppliers.[104]
- ***Cost considerations:*** Port electrification and onsite emission standards can become prohibitively expensive and may shift cargo volume to alternative, more emission-intensive channels. In addition, fewer shipments could affect a port's solvency, harming local economies.[105]
- ***Range anxiety:*** Although the deployment of EVSE has increased, infrastructure tends to cluster in regions with greater incentives and users, and access to public chargers is still insufficient.[106] Also contributing to range anxiety is poor consumer awareness of charging options and knowledge of the distance an EV can travel on a single charge (Figure 12).

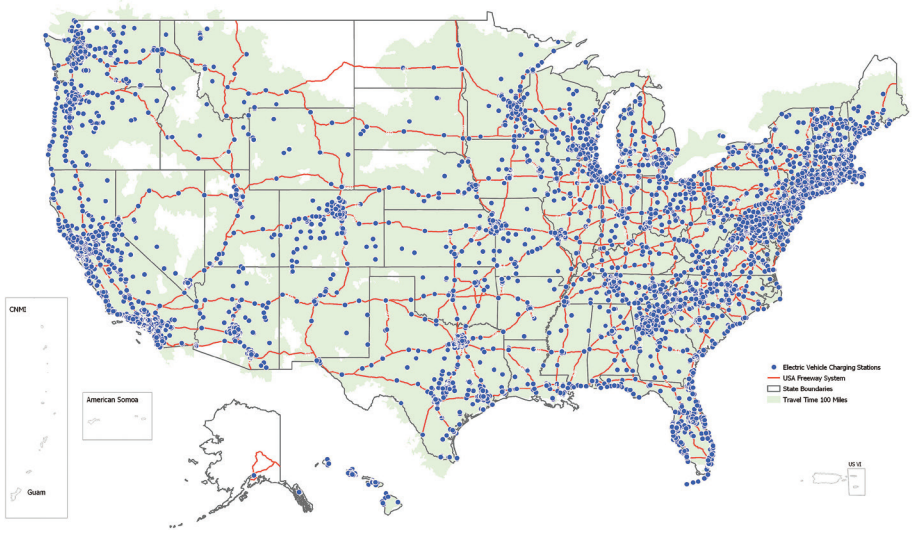


FIGURE 12: The green area is a 100-mile radius from the blue EV charging stations. The U.S. Freeway system is superimposed.

Source: Electric Vehicle Charging Station Locations. Alternative Fuels Data Center. Retrieved from U.S. Department of Energy website: https://www.afdc.energy.gov/fuels/electricity_stations.html

Connected and autonomous vehicles

The deployment of connected vehicles and AVs has the potential to provide a range of safety, economic and mobility benefits, but to overcome the challenges and concerns that accompany the technology, policy and planning efforts must be adjusted in close coordination with local, federal and private sector partners. In most cases, a benefit could quickly turn into a challenge or concern if effective policy and planning are not implemented.

BENEFITS FROM CONNECTED AND AUTONOMOUS VEHICLES

- ***Safety:*** Traffic fatalities have hit record levels in recent years despite state and federal attempts to improve roadway safety. According to NHTSA, 37,461 lives were lost on U.S. roads in 2016, an increase of 5.6 percent from 2015.[107] The largest increase

came in pedestrian deaths, with a total of 5,987 deaths – up 9 percent from 2015 and a staggering 46 percent increase from the record low of 4,109 pedestrian fatalities in 2009.[108] State public safety and transportation officials are responsible for ensuring that all users – drivers, passengers, motorcyclists, commercial drivers and pedestrians – have a safe experience on public roadways. AVs hold the potential to make those roadways markedly safer by addressing the 94 percent of crashes caused by human error.[109] At the same time, it is important the public understand that traffic fatalities will continue to occur in a future with AVs, just at a much lower level.

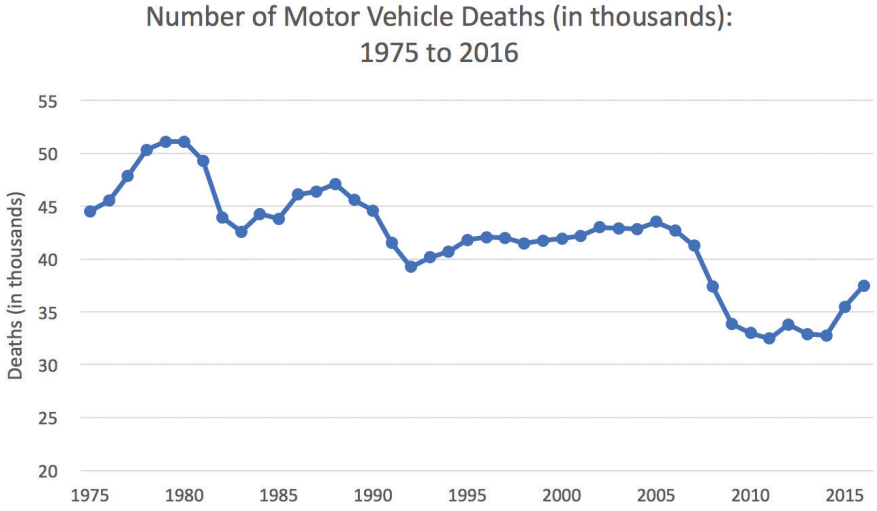


FIGURE 13: Total number of motor vehicle deaths from 1975-2016.

Source: Insurance Institute for Highway Safety Highway Loss Data Institute. (2017, December). General statistics: Crashes took 37,461 lives in the U.S. in 2016. Retrieved from: http://www.iihs.org/iihs/topics/t/general-statistics/fatalityfacts/overview-of-fatality-facts

- ***Mobility:*** As with ride-hailing and ride-sharing, AVs are predicted to greatly improve mobility for individuals who are unable to drive, including the elderly and individuals with disabilities. According to the most recent U.S. Census Bureau data, there are close to 7.3 million Americans over 16 years of age, or 2.3 percent of the country's population, with a visual disability.[110] AVs would allow individuals with visual disabilities to do something they may never have had the opportunity to do before but which most Americans take for granted: ride alone in a personal vehicle to a destination of their choosing. When paired with ride-hailing and ride-sharing fleets, the benefits of AVs could extend even further, to those unable to afford their own vehicle or who live in communities underserved by transit and taxi services.
- ***Productivity:*** Multitasking during the morning or evening commute was once solely reserved for those taking mass transit or being driven to their destination, but AVs will extend that benefit to "drivers," as well. With the ability to read emails, watch the news or entertainment programs or eat breakfast on the way to work, productivity could increase. The interior layout of AVs may allow for business meetings to occur on the road, and technology will likely encourage video-teleconferences from the vehicle, potentially making the AV an office on wheels.
- ***Efficiencies:*** Many industries have noted that AVs have the potential to increase efficiencies by enabling workers to take on more duties and lower driver-related stress. For example, the U.S. Postal Service has indicated that AVs could follow postal carriers as they walk their routes or meet them at optimal locations, thereby reducing the load they carry, the distance they walk and the time they spend parking and driving, increasing the completion speed of routes.[111] Even before the full deployment of AVs, V2X technology offers significant efficiency gains in the trucking industry, where trucks can connect wirelessly to each other and travel in tight platoon formations for long distances, thus reducing drag and fuel use. Research has found that widespread adoption of platooning operations for freight trucks in the United States could lead to a total annual savings of 1.5 billion gallons of petroleum-derived fuels (equal to 1.1 percent of U.S. oil imports) and emissions reductions of 15.3 million metric tons of CO2.[112]
- ***Congestion:*** With effective policies in place to manage VMTs, incentivize ride-sharing and reduce single-occupancy trips, congestion could be reduced through the introduction of connected vehicles and AVs that are able to travel closer together and in narrower lanes, maintaining safe speeds to avoid accidents that are frequently a cause of congestion on roadways. An additional benefit is reducing the need to expand highway infrastructure, enabling states to spend resources on the maintenance of existing assets, instead.
- ***Repurposed land:*** Abundant parking sometimes seems to be written into America's DNA, if not the zoning requirements in towns and cities across the country. Parking spaces take up an estimated 25,000 square miles of land nationwide, an area roughly the size of West Virginia, with up to 13 percent of all land devoted to parking in Los Angeles.[113] A shift to autonomous vehicles, especially as part of shared fleets rather than individually owned vehicles, will eventually reduce the need for substantial parking facilities or curb space reserved for parking spots throughout cities and suburban locations, freeing land for more productive uses, such as housing, open space or economic development, and providing the opportunity to improve the quality of life, resilience and sustainability of communities.

CONCERNS THAT CONNECTED AND AUTONOMOUS VEHICLES RAISE

- ***Sprawl:*** If not planned for, a significant benefit of AVs – reduced personal costs such as the time and stress associated with commutes – could lead to sprawl, increased VMTs and an uptick in emissions. The ability to work from the vehicle, watch videos, eat breakfast or even work out in the car, when paired with cheaper land or housing and lower living expenses outside a city, may lead to growth in the suburbs and population loss in urban areas, the reverse of what state and local governments have been trying to encourage through livable and walkable cities anchored by transit-oriented development.[114]
- ***Upended job markets:*** Several job markets could be upended and diverse employment sectors could face disruption because of AVs. The impact will be gradual, but taxi and ride-hailing drivers, transit providers and truck drivers may face the transformation, reduction or elimination of their jobs. The impact could be significant to the economy, with BLS data showing that nearly 4 million Americans are employed in the "motor vehicle operator" sector, including nearly 685,000 bus drivers, 1.7 million truck drivers, 858,000 delivery drivers and 188,000 taxi drivers or chauffeurs.[115] Connected vehicles and AVs will also have a direct effect on those employed in what is deemed the "crash economy," which includes personal injury lawyers, insurance, auto body repair shops and physical therapists and the medical profession. With safer vehicles and fewer crashes, the crash economy will lose a large portion of its business, but significant resources could be redirected to other sectors of the economy. In the medical field alone, crash injuries in 2012 totaled $18 billion in lifetime medical costs and $33 billion in lifetime work lost.[116]
- ***Revenue reductions:*** Like the rise of ride-hailing and ride-sharing, the deployment of AVs could devastate traditionally stable transportation-related revenue streams. AVs will follow the speed limit and obey traffic laws, reducing the number of tickets issued to drivers and shrinking an existing revenue stream for state and local government operations. If driver licenses are not required to ride in an AV, states will lose a steady stream of revenue used to support transportation operations and infrastructure investments, with states collecting more than $3 billion in driver license fees in 2013.[117] Rather than pay to park, AV owners may set their vehicle to circle the block or even return home until they are ready to depart, again reducing parking revenue and potentially leading to stranded parking assets unable to cover expenses. In addition, a shift away from personal vehicle ownership toward shared fleets of AVs would result in a decline in auto insurance premiums, which would directly affect the insurance premium tax that state governments collect.
- ***Transit operations:*** Ride-hailing and ride-sharing may have a negative impact on current transit ridership, but AVs may also reduce transit usage over the long term as Americans become more accustomed to traveling in an AV. Any shift away from transit will lead to lower farebox recovery, deferred maintenance or expansion and service reductions or elimination.
- ***Equity:*** Because of limited access to high-speed communications technologies like broadband and 5G wireless, rural areas may lag urban areas in the roll-out of AVs and will not see many of the benefits of connected vehicles. This divide may also extend to wealthy versus low-income communities, with wealthier communities having a greater ability to proactively upgrade infrastructure to include V2X technology and a larger number of households able to purchase AVs. Inequity will be evident in the benefits accrued from the use of AVs, as well, as white-collar workers may be able to work from the vehicles while blue collar and service workers will not.
- ***Technology interoperability:*** State and local government agencies are investing in V2X technology today based on what they believe the communications standards will be in the future. These investments are at risk should technological advancements continue to outpace state investments and investments today be incompatible with technology installed tomorrow. Interoperability uncertainty threatens the significant expenditure of time and resources state and local governments are making to improve safety.[o]
- ***Safety of vehicles on the road:*** A fully autonomous fleet is expected to significantly improve safety, but there will be a transition period during which AVs will share the road with older vehicles, and questions continue to linger about the safety of AV technology. The average total vehicle fleet turnover period is 15 years, meaning that roads will see a mix of legacy vehicles, connected vehicles and AVs for a long time, starting with V2X technology being included as a standard in vehicles and later the commercial availability of AVs. Incidents have shown that human drivers are getting into occasional accidents with AVs being safety tested on the roads, and this trend can be expected to continue as AV operations become more common.[118] In addition to concerns about a mixed fleet, recent incidents have raised concerns about the viability and safety of AV technology. A March 2018 fatal crash in Tempe, Arizona, the first involving an AV and a pedestrian, has spurred debate about the safety of existing AV technology and whether it is viable for full deployment. It also demonstrated the need to set expectations about safety and the benefits and risks of AV technology.[119]

[o] Numerous states, counties, cities and road operators (known as the "Coalition for Safety Sooner").

- ***Cyber risks:*** As vehicles and infrastructure become increasingly advanced and connected, more points of entry are created and the threat of cyberattacks rises. One potential danger is the damage a hacked AV could wreak. Another, possibly more insidious threat is the theft of user data, exposing consumers to ransomware or identity theft. For example, in 2015, cybersecurity researchers demonstrated how a Jeep vehicle could be hacked remotely over the internet to disable the transmission and brakes. Chrysler subsequently issued a recall for 1.4 million at-risk vehicles.[120] This exercise served as a wakeup call for the industry and led to auto manufacturers adopting much stronger cybersecurity postures, but it also demonstrates the possible hazards of greater vehicle connectivity.
- ***Data use and storage:*** Connected vehicles and AVs will collect and transmit massive amounts of data from an array of sensors and cameras. These data, whether they are images of the vehicle's surroundings or details about an individual's travel habits or discussions or activities while in the vehicles, will become extremely valuable to the private sector; to law enforcement, which could use the information as evidence of a crime that was committed near a vehicle; and to governments seeking insight into which infrastructure to prioritize for repair or replacement. Without controls in place to regulate or monitor use of the data that connected vehicles and AVs collect or legislative clarification over who "owns" the data telematic devices and AVs generate, fears over invasions of privacy will likely increase. The increased amount of data that connected vehicles and AVs transmit and collect will also put strains on the fiscal and infrastructure capacity of state agencies tasked with storing the data.
- ***Insurance and liability:*** With traditional automobiles, the operator of a vehicle is evident as the individual in the driver's seat responsible for control of the vehicle. With the testing and deployment of AVs, the issue of liability must be clearly articulated or replaced with a new insurance product entirely. Governors, insurance commissioners and state legislatures will need to consider whether and how to apply insurance coverage requirements to AVs to ensure that people or entities are held accountable for any damage or harm involving their AVs. The idea of automobile insurance may change entirely and no longer apply to the driver; rather, it may shift to a product liability package. Consumers may find themselves at a disadvantage dealing with a product liability case involving several large corporations with a role in developing an AV.

CHALLENGES ASSOCIATED WITH CONNECTED AND AUTONOMOUS VEHICLES

Red Flag Laws of the late 1800s

History can provide us with examples of how we have tried (inappropriately) to apply old rules to new technology on our roads and in our skies. This photo shows "Red Flag Laws" in practice in the United Kingdom in the late 1800s that were initially put in place for mobile steam engines based on fears of explosions. The laws limited vehicle speeds to two miles per hour in the city and required that the vehicle be preceded by a man on foot carrying a red flag to warn passersby. Although a different technology and posing no risk of steam engine explosions, the law was later applied to "road locomotives" (the early term for automobiles) in the early 1890s. It was repealed in 1896 in the United Kingdom but kept on the books in Vermont for several years, frustrating early users of automobiles in the United Kingdom and the United States.

- ***State-by-state laws and regulations:*** The U.S. economy is built on free interstate commerce, a concept enshrined in the U.S. Constitution. This notion led to the development of a transportation system that does not discriminate against vehicles crossing a state border: A car registered in state B can travel to state C the same way one registered in state D would. Each state sets laws and regulations for the licensing, registration and insuring of vehicles, but states have honored registrations and licenses from other states. As states begin to grapple with how to approach AVs, some are instituting restrictions on their operation, requiring special license plates or limiting their operation to specific areas, while others are treating AVs as a standard motor vehicle, allowing operation anywhere under any safe condition. A patchwork system for the operation of AVs could slow nationwide deployment, leading to the uneven accrual of benefits across the states. To try to reduce a nationwide patchwork of regulations, **California** and other states have been working through the Autonomous Vehicle Best Practices Working Group, hosted by the American Association of Motor Vehicle Administrators (AAMVA). The working group is providing states and other stakeholders with a venue in which to gather, organize and share information about the testing, use and regulation of AVs. It also released a best practices guide to assist state motor vehicle and law enforcement agencies seeking to address the testing or use of AVs.[121]
- ***Outdated state laws and regulations:*** Every state has laws and regulations prescribing requirements for the safe operation of automobiles, but as technology advances faster than the ability of

state regulatory agencies or legislatures to respond, those laws and regulations may end up hindering technological advancements or encouraging companies to operate in states that offer friendlier regulatory environments. **New York** garnered attention with a debate over a state law that requires drivers to keep one hand on the steering wheel, which could limit the use of AVs based on the definition of "driver."[122] Many states have regulations prohibiting video screens from being visible to drivers[123] as well as prohibitions against the consumption of alcohol by drivers and, in most states, passengers. These regulations are being questioned by the anticipated deployment of Level 5 (fully autonomous) AVs. One of the most glaring examples of a regulation that could hamstring future technology is the common requirement that drivers remain a reasonable distance behind other vehicles to allow for safe braking, also known as "following too closely" laws. **Pennsylvania** statutes include language requiring vehicles being driven in a caravan or motorcade to "allow sufficient space between each vehicle or combination of vehicles so as to enable any other vehicle to enter and occupy space without danger."[124] Even before Level 5 AVs are common on the roads, connected vehicle technology will allow for the safe platooning of vehicles; strictly applied, "following too closely" laws could prohibit the use of platooning on public roads, eliminating anticipated benefits to fuel efficiency and congestion.

- ***Federal approvals:*** States manage the operation of vehicles on public roadways, including speed, licensing, registration, insurance and liability, but the federal government regulates the minimum design, construction and performance of vehicles under the Federal Motor Vehicle Safety Standards (FMVSS).[125] Each car sold in the United States must meet FMVSS, which currently enshrines requirements for brake pedals, rearview mirrors and turn signals. Some AV developers have opted to retrofit FMVSS-compliant vehicles to conduct testing, but Level 4 and Level 5 AVs will be unlikely to reach the commercial market until NHTSA adjusts FMVSS to account for advances in AV technology.
- ***Communications networks:*** To fully realize the benefits connected vehicles and AVs offer, a critical piece of enabling infrastructure is required: a robust communications network. Vehicles and the built environment will need to transmit and receive substantial quantities of data to interact with each other with low latency, necessitating a network to facilitate communication. Large segments of the country lack the high-speed broadband required to provide the necessary connection for AVs and V2X technology, and those that do have access may find the network inadequate for transmitting the large amount of data produced. In addition to existing fixed and mobile broadband networks, private sector telecommunications companies are beginning to roll out 5G wireless technology. 5G "small cell" networks, which operate in a high-frequency band of the wireless spectrum, may also offer the rapid and stable connection required for safe operation of AVs and V2X technology.
- ***Infrastructure needs:*** States are struggling to find the fiscal resources to maintain the infrastructure as it exists today, so having to invest in new technology to retrofit existing roads, bridges and other infrastructure to accommodate AVs or connected vehicles will be difficult with current funding. Consequently, benefits will not accrue unless states can afford to make the necessary investments. Despite state actions to increase spending on infrastructure,[p] a responsibility it shares with the federal and local governments, the American Society of Civil Engineers projects that the average annual investment gap for surface transportation through 2025 is $110 billion per year. Adding investments for new technology or retrofits means an even larger gap and adds to the urgency of identifying additional funding streams to support infrastructure investment.
- ***Age of vehicles:*** Even as vehicles with built-in V2X technology become increasingly available and AVs begin to be sold commercially, there will be a transition period on the roads during which older vehicles are still in use but unable

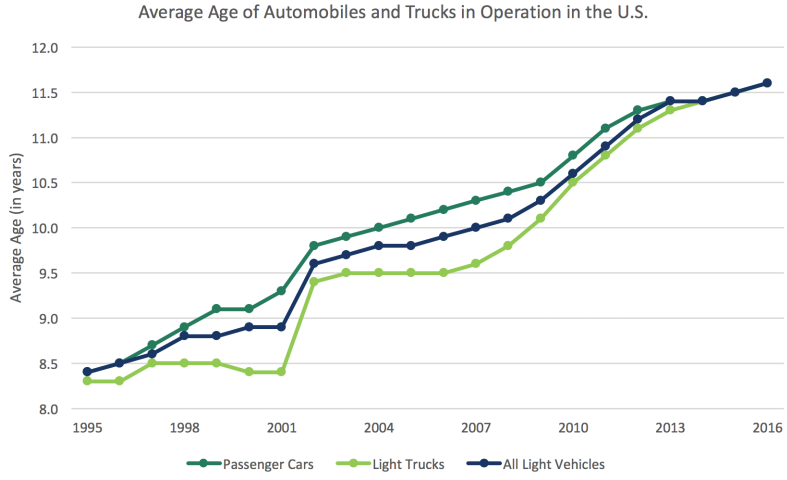


FIGURE 14: Average age of light duty vehicles in operation in the United States between 1995 and 2016.

Source: U.S. Department of Transportation, Bureau of Transportation Statistics. G Average Age of Automobiles and Trucks in Operation in the United States. Retrieved from: https://www.bts.gov/content/average-age-automobiles-and-trucks-operation-united-states; U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. (2017, October 2). Fact #997, October 2, 2017: Average Age of Cars and Light Trucks Was Almost 12 Years in 2016. Retrieved from: https://www.energy.gov/eere/vehicles/articles/fact-997-october-2-2017-average-age-cars-and-light-trucks-was-almost-12-years

[p] As of January 2018, 26 states have raised motor fuel taxes since 2013.

to communicate with connected vehicles, AVs or the roadside infrastructure. The transition period will be longer than it would have been in the past because the age of light vehicles in operation has been increasing over the past two decades, going from an average age of 8.4 years old in 1995 to 11.6 years old in 2016 (Figure 14).[126] At the current rate, it would take approximately 15 years to turn over the entire fleet, assuming no major changes in average vehicle age, general economic conditions or other factors. However, the increased use of vehicles in shared fleets may ultimately increase the turnover rate of automobiles and accelerate the deployment of new, technologically advanced vehicles.

- ***Science, technology, engineering and math (STEM) job openings:*** Rapid advancements in transportation technology and the proliferation of V2X equipment and AVs will increase the need for skilled candidates in STEM fields, especially in software development and AI. BLS projects that software development will be one of the fastest growing occupations through 2026, seeing nearly 31 percent growth in employment. Alternatively, parking enforcement is estimated to see one of the highest employment declines, at 35 percent.[127] The lack of qualified STEM employees may slow development of advanced technology and hinder government's ability to compete with the private sector for the recruitment of information technology (IT) and other STEM-related positions.
- ***Public distrust:*** Any new technology must win over the public based on its benefits before it can have widespread disruption on and by extension benefits to everyday life. Recent polling by Gallup shows that 54 percent of Americans say that they are unlikely to use AVs, 59 percent would be uncomfortable riding in AVs and 62 percent would be uncomfortable sharing the road with a self-driving truck.[128] Comfort level was markedly higher in younger respondents and college graduates. Large-scale deployment of AVs and capitalization on their potential benefits will require many Americans to overcome their apprehension of this technology.

Drones

As drones become increasingly prevalent for a variety of commercial and noncommercial uses, regulators at all levels of government must be prepared to coordinate and pursue policies that safeguard the public and protect privacy without stifling a promising technology.

BENEFITS FROM DRONES

- ***Lower costs:*** With the low costs of owning and operating drones equipped with high-definition (HD) cameras, the technology can be employed in many industries for tasks such as inspection, monitoring and filming, reducing costs and potentially increasing accuracy. One example is in the agricultural sector, where farmers are increasingly using drones for the precision application of farming inputs, mapping and surveying of farmland and crop spraying and monitoring.[129] These uses enable farmers to enhance productivity by efficiently allocating land, water, labor and fertilizer.[130]
- ***Improved safety:*** For engineers, construction workers, line repairmen and first responders, drones offer the prospect of safer working conditions. For example, Duke Energy is currently providing hurricane assistance to **Puerto Rico** by deploying drones to identify broken utility poles, uncover downed power lines buried under vegetation and string new lines over rough or inaccessible terrain. Not only are the drones proving safer than traditional methods, but they are also less expensive and faster.[131]
- ***Improved access and convenience:*** Companies such as Amazon and Google are aggressively pursuing autonomous drone delivery services to quickly and safely deliver products to customers' doorsteps.[132] These systems can cut transport costs and increase convenience for customers through same-day delivery offerings. The ability to offer same-day services is well suited to the medical and pharmaceutical industry, as well, enabling the timely delivery of medical supplies.[133] This convenience is significant for groups such as the elderly and individuals with disabilities, whose physical constraints often prevent them from accessing brick-and-mortar stores.
- ***Reduced congestion and emissions:*** Beyond convenience and access, substituting or supplementing delivery trucks with battery-powered drones offers the opportunity to reduce the number of vehicles on the road, improving traffic flow and reducing congestion. In addition, replacing ICE vehicles with drones can help electrify the freight industry and shift the point of emissions or reduce it entirely.[134]

CONCERNS THAT DRONES RAISE

- ***Security threat:*** The ease with which drones can be flown over or near-critical infrastructure, secure facilities or areas with high crowd density such as stadiums poses a significant public safety risk.[136] Weaponizing a drone to crash into spectators at an event or into transmission lines could be done remotely and unimpeded, particularly if the drone is small and flies low enough to evade radar detection.[q] Further, over-the-counter recreational drones can easily be equipped to carry explosives and have been used by drug cartels[137] and terrorist groups.[138] Adding complexity, drone access may be desirable at these locations, possibly for infrastructure inspection or to film an athletic event.[139]
- ***Smuggling:*** Drones have been used in numerous cases across the United States to deliver contraband to prisoners by flying overhead and remotely detaching packages.[140] In one instance, a South Carolina inmate escaped prison by using wire cutters that a drone delivered. Of grave concern is the possibility of firearms or other weapons being dropped into prison yards.[141] Drones are also being used along the U.S. border and throughout Latin America to transport illegal narcotics.[142] Their only limitations are the amount of weight they can carry and distance they can travel – two features the drone industry is working hard to improve.
- ***Congested airspace:*** Commercial and recreational drones may pose a hazard to conventional aircrafts. This hazard was recently demonstrated when a recreational drone collided with a U.S. Army helicopter in the airspace above New York City.[143] The Army helicopter suffered only minor damage, but future collisions could result in more costly or fatal outcomes. Drone interference during extreme weather events is also of concern and occurred recently in California and Arizona while first responders were attempting to control wildfires.[144]

Widespread Use of Drones by State DOTs

A 2018 survey by the American Association of State Highway and Transportation Officials found that 20 state DOTs – Alaska, Arizona, Colorado, Delaware, Georgia, Iowa, Maine, Mississippi, Montana, Nebraska, Nevada, New Jersey, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Utah and West Virginia – have incorporated drones into their operations. Another 15 state DOTs – Alabama, Connecticut, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Michigan, Minnesota, New Hampshire, South Carolina, Texas and Virginia – are actively testing or researching how best to incorporate the technology. The drones deployed in the 20 states are being used for photography, surveying, bridge inspections, emergency response, pavement inspections and traffic control, among other uses, and have been shown to improve safety and cut costs. A 2017 study by the North Carolina DOT showed that the use of a drone instead of traditional accident reconstruction techniques saved $9,300 for one accident investigation.[135] For more information about the use of drones by a DOT, please see the Minnesota case study on page 46.

- ***Upended job markets:*** Jobs may be affected as autonomous or semi-autonomous drones replace traditional labor. Labor demand could shift from low-skilled positions, such as delivery drivers, to high-skilled drone operators. One global study estimated that across industry, drones have a high likelihood of replacing $127.3 billion in services and labor.[145]

CHALLENGES ASSOCIATED WITH DRONES

- ***Regulatory burden:*** Current federal regulation on the commercial Operation and Certification of Small Unmanned Aircraft Systems, known as Part 107, prohibits the use of drones beyond the remote operator's line of sight, mandates one remote pilot for each drone, requires a certification for the pilot, specifies times and maximum altitudes for flying and prohibits drones from flying over individuals not participating in its operation over covered structures.[146] This highly prescriptive regulation has faced significant criticism, resulting in USDOT exploring ways to improve the regulation and launching an Unmanned Aircraft System (UAS) Integration Pilot Program (IPP) to accelerate the safe use of drones.[147] USDOT launched the IPP as an opportunity for state, local and tribal governments to partner with private sector entities, such as UAS operators or manufacturers, to accelerate safe UAS integration, the results of which will inform FAA as it works to craft new rules that allow more complex low-altitude operations. In May 2018, USDOT announced 10 awardees under the IPP, including the state DOTs in **Kansas, North Carolina** and **North Dakota**. During the recent spate of extreme weather events in Texas and California, Part 107 waivers were expedited to allow for the swift deployment of drones to assess damage and identify hazards "in real time at a time when minutes mattered."[148]
- ***Privacy and data retention:*** Public resistance to drones – specifically, their ability to covertly surveil individuals and the noise they generate – has led to altercations and backlash, potentially dampening deployment. Many inexpensive drones can fly above 400 feet and are small and easily maneuverable, enabling them to potentially surveil and collect information undetected. The potential for privacy invasion ranges from abusive surveillance practices to personal stalking.[149] In addition, drones can be equipped with high-resolution cameras and facial-recognition software, enabling them to monitor and collect data on an individual's activities and location. Arguments about who has access to and ownership of these data could arise and should be considered for legislative clarification.[150]

[q] Remote-controlled UAVs pose a similar challenge.

Federal Drone Regulations

As of May 2018, federal legislation is being explored to strengthen drone safety regulations. In addition, several potential solutions have been suggested, such as requiring that manufacturers "lock" drones until users register them and pass an introductory course on proper use or install software that prevents drones from being flown into restricted areas (also known as "geofencing").

Urban Air Mobility Solutions

Government is in the process of determining how to handle the introduction of drones into the airspace, but several companies are also pursuing urban air mobility services through the development of passenger-carrying electric vertical take-off and landing aircraft. Uber Elevate and Kitty Hawk are both looking to provide "air taxi services" in urban environments to reduce congestion and emissions, and commercial operations are possible within the next five years.

- ***Ownership and awareness:*** FAA has regulatory authority over U.S. airspace and maintains a nationwide drone registry. All drones must be registered, but the amount of information collected and the registration fee charged vary by drone size and use. A 2016 Inspector General report found that FAA's drone processing practices led to insufficient information collection and user education on federal regulations.[151] The report determined that FAA "has limited knowledge of where UAS actually operate and limited means to oversee… exempted operators." Further, an emphasis on education over enforcement has resulted in the "absence of a risk-based oversight system [where] FAA inspectors respond primarily to incidents only after they are reported." Since the report, FAA has made several changes, most notably requiring registration, but the inability to track drone use and effectively enforce regulatory compliance in real time is a persistent concern.

The Way Forward: Strategies for Governors

Because of the nature of our nation's transportation system and the authority states hold, governors are in the driver's seat when it comes to addressing the challenges and concerns these technological advances pose – and they are poised to capitalize on their benefits. The pace of technology adoption has been accelerating over the past decade; therefore, states must respond much more quickly than in the past.[152] The pace of technology adoption has been accelerating over the past decade.[153] It took about 100 years for landline telephones to reach widespread adoption, just 48 years for the adoption of electric power and 30 years for the adoption of color TV. More recently, it's taken just a decade for widespread use of cell phones, smartphones and tablets (see Figure 15). Governors can help their state's regulatory, workforce and communications systems adjust to this new pace of technology by examining how they can update compliance-driven policies with performance-driven policies, adopt more data-driven governance and engage more stakeholders with greater transparency.[154]

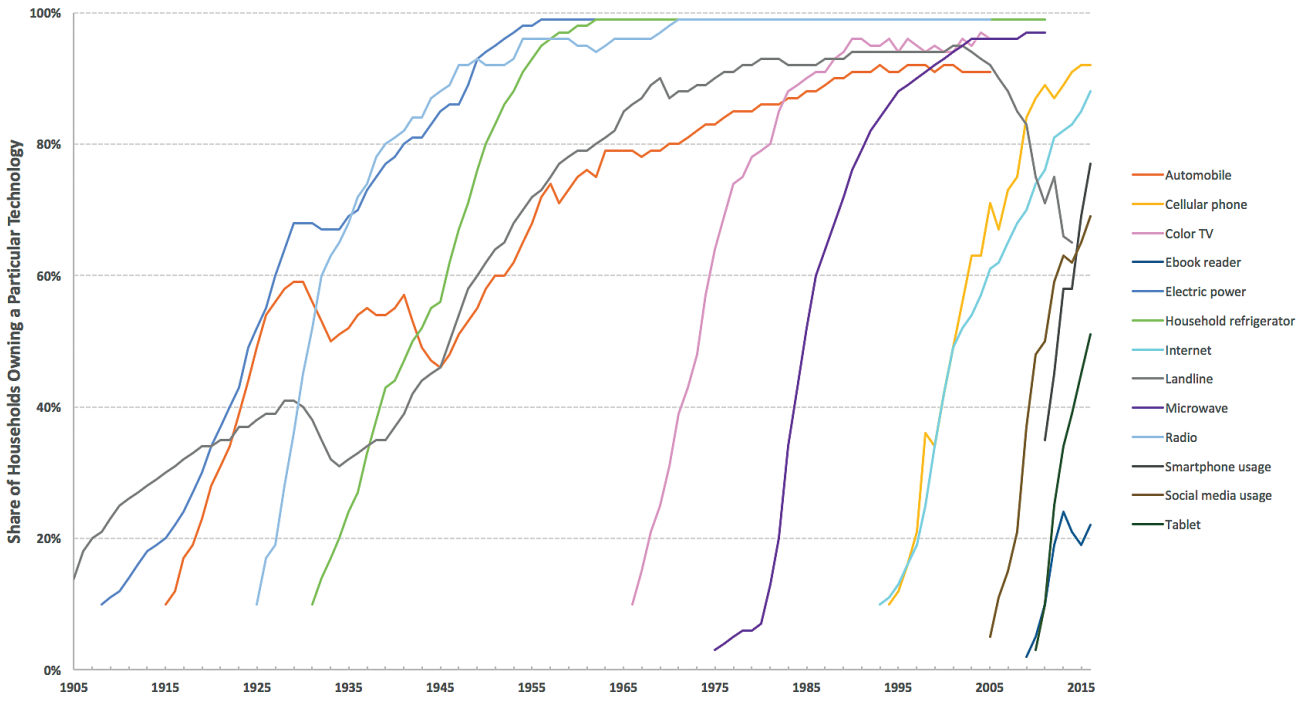


FIGURE 15: Each of the curves on this chart represents the span (in years) of technology adoption; the steeper the curve, the more rapid the adoption rate. In recent years, the curves have become steeper and steeper than in the past.

Source: Desjardins, J. (2018). A brief history of technology. Retrieved from https://www.weforum.org/agenda/2018/02/the-rising-speed-of-technological-adoption

Indeed, many states have taken steps to address new technologies, enacting legislation on drones, AVs and ride-hailing, and are encouraging the adoption of EVs. Governors can guide and drive measures to help their states stay ahead of the transportation innovation curve through the following seven strategies, alone or in combination:

- **Support technology innovation.**
- **Modernize legislation, regulations and incentives.**
- **Provide funding and financial mechanisms to drive technology deployment.**
- **Prepare the workforce.**
- **Update communications networks and data systems.**
- **Address cyberthreats.**
- **Educate citizens about the benefits and risks of technological innovation.**

To successfully develop and implement an appropriate strategy, a multistakeholder process is required. It is important to consider the key actors, across the public and private sectors and the roles they can play. Table 1 identifies several categories of actors that can be helpful in developing, supporting and implementing a transportation innovation strategy.

TABLE 1: Actors and the roles they can play in implementing a transportation innovation strategy.

Federal Government	State Government	Local Government	Private Sector	Nonprofit Organization
Congress	State legislature	Mayor and city council	Electric utilities	Community advocacy organizations and associations
U.S. Department of Transportation (DOT)	Public utility commission	County council	Construction company or contractors	Rural electric cooperatives
U.S. Department of Energy (DOE)	State department of transportation	Metropolitan planning organization	Network service providers	Academia
Environmental Protection Agency (EPA)	State energy office	City and county administrators and executives	Financial institutions	–
U.S. Department of the Interior (DOI)	State department of environmental quality	Municipal transit authority	Insurance providers	–
U.S. Department of Commerce (DOC)	State budget office	Local public works departments	Vendors	–
U.S. Department of Homeland Security (DHS)	State economic development or commerce department	Local departments of environmental quality	Logistics and transportation industry	–
Federal Energy Regulatory Commission (FERC)	State chief information/ technology official	Municipal/public power utilities	Technology providers	–
Federal Emergency Management Agency (FEMA)	State insurance commissioner	First responders	Equipment manufacturers	–
U.S. Department of Agriculture (USDA)	State motor vehicle administrator	Chief data officer	Energy service companies	–
National labs	Emergency management agencies	–	–	–
Military	National Guard	–	–	–
–	Public safety or highway patrol	–	–	–
–	State chief data officer	–	–	–

Support technology innovation

Innovative transportation technologies need to be explored, tested and enabled in support of state policy goals. Governors can help guide the consideration of trade-offs by ensuring that decision makers and stakeholders explore new technologies and direct action when needed. Governors can also promote policies and processes that facilitate deployment of these technologies, with agencies acting in an aligned manner toward common goals. Governors can do so in several ways:

OPPORTUNITIES FOR ACTION

- ✓ **Appoint, convene and empower agencies or working groups to explore the adoption of modern technologies, gather input from stakeholders inside and outside of government, and make any recommendations publicly available.**
- ✓ **Pursue executive action to enable technology diffusion through state and regional planning, and harmonize rules, policy and procedures across agencies.**
- ✓ **Enable agencies, municipalities and universities to study, test and pilot emerging technologies.**
- ✓ **Direct state agencies to assess the possibility of partnering with the private sector to fully capitalize on private sector expertise and capacity while saving taxpayer dollars.**
- ✓ **Use innovative financial mechanisms to encourage the growth of high-tech industries.**

- ***Appoint, convene and empower agencies or working groups to explore the adoption of modern technologies, gather input from stakeholders inside and outside of government, and make any recommendations publicly available.***
  - Several governors, including from **Massachusetts, Washington** and **Minnesota**, signed executive orders creating working groups or advisory councils with a diverse membership from inside and outside of government to study the issue of autonomous, automated and connected vehicles and the opportunities they may bring; recommend changes to state policies or regulations on issues such as insurance and licensing, connected vehicle technology and infrastructure; and direct agencies to pursue pilot programs to test AVs and V2X technology.[155] Expanding beyond the issues of AVs, Massachusetts' governor followed up with a second executive order establishing the Commission on the Future of Transportation in the Commonwealth to advise on Massachusetts' future transportation needs and challenges.[156]
  - **Connecticut**'s Office of Policy and Management convened a working group in the summer and fall of 2016, prior to the 2017 state legislative session, to discuss how best to handle TNCs and the taxi industry. This working group was made up of state agencies, legislators and representatives from the taxi and TNC industries; the meetings were open to the public. Connecticut ultimately passed TNC legislation during the 2017 legislative session that regulated TNCs and provided some relief to the taxi industry.[157]
  - **Michigan** passed legislation in 2016 creating a 27-member Unmanned Aircraft System Task Force to develop statewide policy recommendations on the operation, use and regulation of UASs in Michigan. This task force is made up of gubernatorial appointees from numerous state agencies, municipalities, various private sector fields and drone users.[158] The task force produced its first report in late 2017 and will meet over the next several years to continue evaluating the issues arising from the use of drones in Michigan.[159]
  - **Maryland**'s Electric Vehicle Infrastructure Council was established through legislation in 2011[160] and consists of officials from the Maryland DOT, Department of Planning, Department of the Environment, Department of Commerce, Energy Administration and Public Service Commission as well as state legislators, stakeholder groups, trade associations, academia and utilities.[161] The council is tasked with producing an action plan to facilitate the successful integration of EVs into the state's transportation network and develop recommendations on infrastructure deployment, increasing consumer awareness, EV incentives, charging solutions for multidwelling units, supporting fleet purchases and shifting charging to clean energy resources among other items to promote the use of EVs in the state.[162] In 2015, the council's authorization was extended through 2020.[163]
- ***Pursue executive action to enable technology diffusion through state and regional planning, and harmonize rules, policy and procedures across agencies:***
  - **California**'s governor issued an executive order in January 2018 directing the state to adopt policies that could result in 5 million EVs on the road by 2030. The executive order increased an October 2016 goal of 1.5 million EVs on California's roads by 2025.[164]
  - In October 2017, governors from eight western states (**Arizona, Colorado, Idaho, Montana, Nevada, New Mexico**, **Utah** and **Wyoming**) signed a memorandum of understanding (MOU) that provides the framework for creating an EV charging corridor, enabling EVs to seamlessly traverse the signatory states' major transportation corridors. The states will explore EV incentives and approaches to deploying costly infrastructure from a collective position.[165]
  - In November 2017, **Oregon**'s governor signed two executive orders that, among other things, will triple the number of EVs in the state. The first executive order requires that all parking structures for new homes and commercial buildings be wired for at least one EV charger by October 2022.[166] The second executive order sets a target of at least 50,000 registered EVs in the state by 2020 (16,000 are currently registered) and commits 15 percent of Oregon's Volkswagen mitigation fund to support vehicle electrification.[167]

Ideas to consider...

- **Identify nontraditional stakeholders for inclusion in working groups, such as public and private members of the insurance industry whom the move to more AV and drones will affect.**
- **Catalog existing incentive programs that can be brought together and potentially repurposed under a new, common vision.**
- **How state agencies can help test new technologies such as AVs and EVs to build a use case for others.**

Inclusive Engagement

States should seek to engage a broad spectrum of stakeholders within government, including budget, economic development, energy, environment, insurance, motor vehicles, public health, public safety and transportation agencies. Ideally, States will extend the effort to those outside of government, as well, such as schools, nonprofits, religious and community organizations, housing agencies, environmental advocacy groups, realtors and chambers of commerce.

- **Colorado**'s governor signed an executive order in 2017 that includes greenhouse gas reduction goals for the state and requires Colorado to develop an EV plan to support the goal of building a network of EV fast charging stations on state corridors.[168]

- ***Enable agencies, municipalities and universities to study, test and pilot emerging technologies:***
  - <u>Connected vehicles and AVs:</u>
    - The **Rhode Island** DOT announced a request for proposals as part of the Rhode Island Transportation Innovation Partnership Mobility Challenge, a collaboration of state and local partners, seeking companies to establish a pilot program to test automated, multipassenger vehicles to serve Providence's Woonasquatucket River Corridor, a section of the city that lacks transit connectivity and is geographically disconnected from downtown.[169]
    - Seeking to address reoccurring truck crashes along Interstate 80 resulting from routine adverse weather conditions, USDOT selected the **Wyoming** DOT (WYDOT) as one of three locations in which to test and deploy advanced DSRC technology to improve safety and mobility. In the Connected Vehicle Pilot, WYDOT will use V2X connectivity to improve monitoring and reporting of road conditions to vehicles on I80.[170]
    - To test AVs and V2X technology, the **Pennsylvania** DOT (PennDOT) partnered with Carnegie Mellon University, the city of Pittsburgh, Cranberry Township and Ross Township to create AV and connected vehicle test beds in the Pittsburgh area by installing nearly 50 roadside safety units (RSUs) on traffic signals, with another 45 planned. PennDOT also plans to install 160 RSUs in the Philadelphia region.[171]
    - **Ohio**'s governor issued an executive order to establish the state's first office for connected and autonomous vehicles, known as DriveOhio, which will serve as the single point of contact for smart mobility initiatives and advancements. DriveOhio will be guided by an advisory board of transportation experts representing the technology, automotive, academic, telecommunications and insurance industries and include the director of Ohio's DOT (ODOT). The Ohio Turnpike and Infrastructure Commission is working through DriveOhio to support the installation of RSUs along a 60-mile stretch of the Ohio Turnpike, which already has fiber-optic cable installed along its entire 241-mile length, and ODOT is working on the U.S. Highway 33 Smart Mobility Corridor, a 35-mile stretch of U.S. Highway 33 that will see the installation of fiber-optic cable and roadside sensors.[172] The state is supporting the Transportation Research Center Inc.'s SMART Center, a 540-acre testing facility that received $45 million from state government and the Ohio State University in early 2017.
    - **Hawaii**'s governor signed an executive order to establish a connected autonomous vehicles (CAV) contact in the Office of the Governor to support companies seeking to test self-driving vehicles and to direct the Hawaii DOT, Department of Public Safety and Department of Business, Economic Development & Tourism to work with companies to test self-driving vehicles and develop this business in the state.[173]

Open Data

Proactively make publicly available the results and lessons learned of any pilot projects, and require data sharing within and outside of government. Data in a silo are not useful.

    - **Minnesota**'s DOT (MnDOT) tested an autonomous shuttle in winter 2018 to better understand winter weather testing, identify infrastructure needed to support these technologies, identify how third-party automated transit vehicles work on MnDOT's system, engage new partners and enable the public to experience AV transportation. In the Minneapolis region, population is expected to grow by more than 30 percent by 2040,[174] and autonomous shuttles offer the opportunity to improve safety while reducing congestion and emissions. In addition, testing the shuttle in Minnesota provided a unique testbed for AV technology in cold-weather conditions, including snow and ice.[175] Minnesota sought to address these unique challenges by partnering with 3M to deploy next-generation traffic-control devices optimized for the safe operation of CAVs.[176]
  - <u>EVs:</u>
    - In 2018, **Washington**'s governor issued an executive order mandating that all agencies prioritize battery EVs (BEVs) when leasing or purchasing new vehicles. The order also requires the Washington DOT to begin transitioning the state ferry system to a zero-carbon-emission fleet.[177]
    - **New Mexico**'s Alternative Fuel Acquisition Act authorized up to $5 million in a revolving loan fund for alternative fuel vehicle (AFV) acquisitions and required that at least 75 percent of new government and educational institution vehicles, with some exceptions, be hybrid electric vehicles (HEVs), EVs or AFVs.[178]

- **South Carolina**'s Energy Office offers low-interest loans to state and local governments, educational institutions and nonprofit organizations (NPOs) converting fleets to AFVs with improved fuel economy.[179]
- The **Guam** Power Authority (GPA) is undertaking an effort to switch all light-duty vehicles to EVs. GPA purchased two Nissan Leaf vehicles in 2017 and installed a charging station at its headquarters in Fadian as part of a pilot program under its Energy Sense Program. It has plans to purchase additional vehicles and install additional charging stations at other customer service centers. GPA is conducting surveys on the use of the EVs and monitoring the mileage and trips being taken to inform its future purchases and decisions on where to install additional charging stations.[180]

▸ <u>Drones</u>:

- **New York**'s State Police announced plans to deploy 18 drones statewide and put state troopers through training to receive their FAA remote pilot certificate. Drones were recently used to check rising water and ice jams on rivers in the Albany region and to assist in a search and rescue operations.[181] One common use of the drones is for aerial accident reconstruction, pairing the drone with geographic information system technology and software that will quickly make measurements, enabling troopers to clear the accident, open the roads and allow traffic to flow much sooner.[182]
- **Idaho**'s State Police have used drones in numerous situations to protect the lives of troopers and first responders, such as flying the drone through the door of a residence to get a view of a suspect or conducting a search for an individual who wandered away from a nursing home. The troopers also plan to use the drones for accident reconstruction to reduce road closure times.[183]
- Flirtey, a commercial drone delivery company, has partnered with the University of Nevada, Reno (UNR) on design, manufacturing and research and is using UNR's indoor UAV flight-testing facilities. In exchange, Flirtey is providing UNR with equity in and allows graduate students to work with the company.[184] Flirtey has also partnered with REMSA, the emergency medical service provider in northern **Nevada**, to test drone delivery of automated external defibrillators in incidents of cardiac arrest.[185]

- ***Direct state agencies to assess the possibility of partnering with the private sector to fully capitalize on private sector expertise and capacity while saving taxpayer dollars.***

▸ **Colorado**'s DOT (CDOT) has been a leader in the installation of DSRC technology. To supplement the planned deployment of RSUs along I-70, CDOT has entered into a PPP with Panasonic to develop a connected vehicle ecosystem that allows CDOT and anyone else that wants to buy a license from Panasonic to install RSUs and connect them to a network and use the equipment. Installation will begin in the second quarter of 2018 and will be operational in 2021.[r]

▸ In **Kentucky**, KentuckyWired is a statewide, open-access fiber-optic network initiative that aims to deliver internet to communities across the state through high-speed broadband technology. Created with a $324 million budget financed by the issuance of bonds,

[r] January Safety Spectrum Letter to Chao, Pai and Mulvaney.

Institutional Capacity for PPPs

Several states have recognized the importance of enhancing agency capacity to evaluate and enter into public-private partnerships (PPPs) and have established PPP offices within state government. Colorado, Virginia and Puerto Rico all have active PPP offices that help state agencies evaluate and execute PPP agreements.

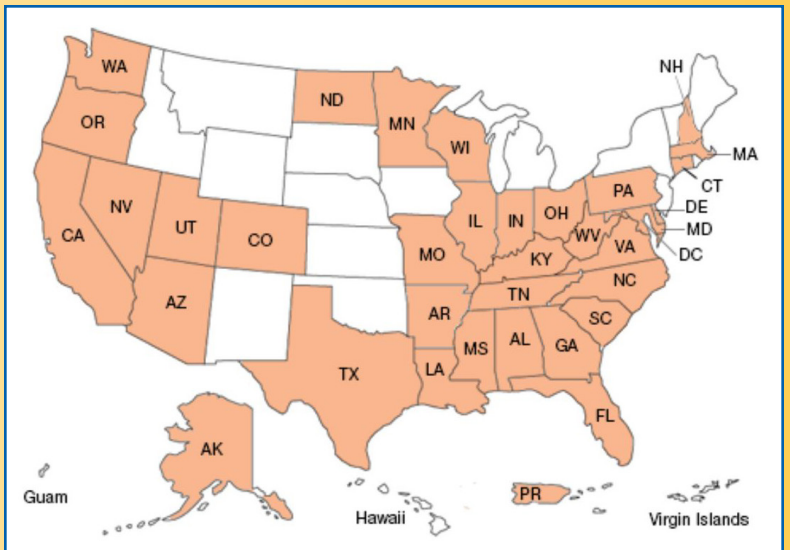


FIGURE 16: 35 U.S. States, DC, and Guam have enacted legislation enabling the use of PPPs for transportation infrastructure.

Source: U.S. Department of Transportation, Federal Highway Administration. State P3 Legislation. Retrieved from: https://www.fhwa.dot.gov/ipd/p3/legislation/

KentuckyWired's goal is to connect all 120 of Kentucky's counties with broadband. Recognizing the expertise of the private sector, the state entered into agreements with Cincinnati Bell Telephone Company and East Kentucky Network LLC to partner on broadband network construction. When complete, KentuckyWired will ultimately consist of 3,000 miles of fiber-optic cable and more than 1,000 sites that will be connectivity points in communities.[186]

- In Charlotte and Halifax counties in southern **Virginia**, about 50 percent of students lack broadband internet access at home. To address this telecommunications gap, the Virginia Mid-Atlantic Broadband Communities Corporation has partnered with Microsoft to launch a Homework Network to provide high-speed internet access to the homes of thousands of rural students in southern Virginia. Broadband will be deployed wirelessly from schools through unused low-band spectrum, generally referred to as "TV white space," at no cost to the recipients.[187]

Private Mapping Partners

Gathering data to create detailed maps of streets can help pave the way for the deployment of Level 4 and Level 5 AVs. Several governments, companies and fleet operators in London, New York City, Dusseldorf and Spain have partnered with Mobileye, An Intel Company, to outfit vehicles with equipment that collects information about streets and infrastructure to create HD crowdsourced maps. Partnerships with states may be valuable given the size of state vehicle fleets.[189] prevents drones from being flown into restricted areas (also known as "geofencing").

- To improve paratransit services, the Regional Transportation Commission (RTC) of southern **Nevada** launched a six-month pilot with Lyft to enable paratransit customers in southern Nevada to schedule rides on demand rather than in advance. The RTC also expects to improve customer experience and reduce costs as the RTC subsidizes every paratransit trip in its service area.[188]
- The government of Washington, D.C., entered into a partnership with Starship Technologies to allow testing of personal delivery devices on District sidewalks. Although such a test has clear benefits for a private company seeking to test its technology in an urban environment before a wider rollout, the District government will also benefit from the partnership by gaining access to the detailed mapping of sidewalks the robots are carrying out. This mapping can help the Department of Public Works assess the condition of sidewalks without manual field inspections and so target resources where they are most needed.[190]

- ***Use innovative solutions to encourage the growth of high-tech industries:***
  - Connecticut Innovations (CI) is **Connecticut**'s state-created and state-funded venture capital arm and leading source of financing and ongoing support for innovative, growing companies. CI is governed by a 17-member board composed of nine members appointed by the governor, four members appointed by the leadership of the general assembly and four ex officio members in state service. CI has multiple tools at its disposal, including equity financing, venture debt, a pre-seed fund, grants and loans. The newest initiative at CI is VentureClash, the state's global venture challenge for early-stage companies disrupting digital health, financial technology, the internet of things and InsureTech. VentureClash winners share in a total of $5 million in investment awards and receive mentoring and other assistance.[191]

State Drone Regulations

In 2014, North Carolina's Department of Transportation (NCDOT) was tasked by a new state statute with implementing a testing and permitting system for the use of drones in the state. A permit is required for commercial and government drone operations in North Carolina, and passing the North Carolina UAS Knowledge Test is a requirement for obtaining a permit. To help aspiring drone pilots obtain a state permit, NCDOT partnered with community colleges to develop curriculum for teaching drone-pilot skills. NCDOT also hosts drone workshops, as well as the North Carolina Drone Summit and Flight Expo.

- The Next Level Fund was established in **Indiana** last year as a successor to the Next Generation Trust Fund, a decade-old pool of money originally funded by the lease of the Indiana Toll Road. The Next Level Fund will invest $250 million over the next decade in high-yield asset classes such as venture capital.[192]
- In 2016, **New York** designated a 50-mile, FAA-approved test site as a drone corridor in central New York and the Mohawk Valley. By cultivating partnerships between the private sector and academia, the state is developing a drone innovation hub, generating economic growth and attracting a new industry. One component of this project is the Great New York State Fair's Drone Film Festival and Competition, which highlights the state's investment in growing the UAS industry and encourages interest in the technology.[193]

Modernize legislation, regulations and incentives

OPPORTUNITIES FOR ACTION

- ✓ **Modernize antiquated state standards and policies through legislative and regulatory changes.**
- ✓ **Establish rate structures for EVs to influence consumer behavior and incentivize charging at the optimal time, such as during off-peak hours or when large amounts of renewable energy are available.**
- ✓ **Offer consumers or businesses incentives to use or purchase EVs or install charging stations.**

Antiquated laws and rules, often established to meet the needs of a different era, may unintentionally restrict new and emerging technologies. Governors can play a key role in identifying such policies and developing strategies to update them while creating incentives that encourage innovation:

- ***Modernize antiquated state standards and policies through legislative and regulatory changes:***
  - Connected and autonomous vehicles:
    - **Nevada** was the first state in the nation to enact AV legislation (2011). That same year, it enacted legislation outlawing the use of cell phones while operating a motor vehicle. Nevada legislators proactively sought to exclude people in an AV from the cell phone ban, deeming them not to be operators – something that other states may need to address in the future.[194] In 2017, Nevada enacted additional AV legislation updating state policies on the technology. The legislation allows for the testing, operation and commercial use of Level 5 or fully autonomous vehicles and authorizes the testing and operation of platooning technologies.[195]
    - **California** first enacted AV legislation in 2012, allowing the Department of Motor Vehicles (DMV) to issue permits for testing AVs on public roads and establish regulations that required a human in the driver seat able to take control of the vehicle being tested. In March 2018, the California DMV issued revised regulations permitting Level 4 and Level 5 AVs to operate without drivers but will require remote operators who could take control if needed to move the vehicle to the side of the road. Cars without steering wheels, accelerators and other manual controls will need waivers from NHTSA before they can operate on California roads.[196]
    - **Arizona**'s governor signed an executive order in 2015 allowing for the testing of AVs on Arizona's roads. In April 2018, a second executive order was signed, updating previous AV policies and rules, stating that "As technology advances, our policies and priorities must adapt to remain competitive in today's economy."[197] The new executive order allows for Level 4 and Level 5 AVs to operate on public roads without a human present in the vehicle but requires that the AVs comply with all state traffic and safety regulations and meet all registration, licensing and insurance requirements.[198]
    - **Virginia** recognized that existing state law prohibiting a motor vehicle operator from being able to view a display screen with moving images was outdated with the testing of AVs on the roads. In 2016, the state enacted legislation allowing vehicles to have visual displays of moving images if the equipment is factory installed and disabled when a human driver performs the driving task.[199]
    - **Arkansas** sought to ensure that advancements in freight technology would not be throttled by existing policies and so in 2017 amended the state's driving regulations by eliminating the requirement that motor vehicles not follow another vehicle more closely than is reasonable so long as they are equipped with driver-assistive truck platooning systems technology.[200] Similar legislative changes were made in Georgia, South Carolina and Tennessee, and North Carolina is currently finalizing new regulations to specifically allow truck platooning.[201]

Ideas to consider...

- **Identify existing legal, regulatory and administrative policies that impede new technologies.**
- **Explore strategic partnerships to encourage technology diffusion.**
- **Catalog policy levers and mechanisms to promote the development and adoption of a desired technology.**
- **Explore changes to state insurance statutes to accommodate AVs without a driver.**

- Ride-hailing and ride-sharing:
  - In 2017, **New York** enacted legislation authorizing ride-hailing operations statewide, except for New York City, where ride-hailing operations were already operating and complying with all city regulations on fingerprint-based background checks and data sharing. The legislation included the establishment of a New York State Transportation Network Company Review Board and a New York State Transportation Network Company Accessibility Task Force. The legislation also gives counties and municipalities with a population over 100,000 the option to prohibit ride-hailing operations.[203]
  - **Nebraska** enacted ride-hailing legislation in 2015 that established statewide standards for the operation of ride-hailing companies, placing the companies under the oversight of the Nebraska Public Service Commission. This legislation also required annual vehicle inspections at a certified mechanic, a provision not found in every state.[204]
  - In 2015, **Texas** enacted legislation setting insurance requirements for ride-hailing but left regulation of the operations to local governments. Following the development of a patchwork of regulations in various municipalities, the Texas Legislature passed supplemental legislation in 2017 establishing uniform statewide regulations for the operation of ride-hailing vehicles, overruling any local regulations that were in effect.[205]
  - Following years of attempts to clarify regulations for ride-hailing services, **Connecticut** enacted legislation in 2017 that established statewide standards for their operation like those found in other states but also used the opportunity to modernize taxi regulations. Connecticut now permits taxis to use modern equipment like phones or tablets to calculate fares and allows them to use tiered pricing and offer discounts. Drivers can now be brought onboard immediately under a temporary permit until the state fingerprint-based background check is complete.[206] Following the legislation being signed into law, the Connecticut General Assembly passed a budget that included a 25-cent fee per ride-hailing trip to help support the state's General Fund.[207]
  - **Oregon**'s government has taken a hands-off approach and is one of only two states that as of March 2018 had not passed statewide legislation pertaining to ride-hailing. Ride-hailing operations are subject to local ordinances, such as those in effect in Portland and Salem.[208]

- ***Establish different rate structures for EVs to influence consumer behavior and incentivize charging at the optimal time, such as during off-peak hours or when large amounts of renewable energy are available:***

Charging Station Inspections

States should consider which state agency is responsible for inspecting EV charging stations and ensuring that they are delivering charges at the proper price, similar to how motor fuel pumps are inspected for consumer protection purposes, and establish guidelines for their inspection.

  - An **Alabama** utility, Alabama Power, offers a business EV time-of-use (TOU) rate for electricity purchased to charge EVs used for fleet purposes. The electricity used for vehicle charging is metered separately from all other electricity use. In addition, Alabama Power offers a residential EV rate for customers who can verify possession of a qualified EV.[209]
  - **Arizona**'s largest utility, Salt River Project, offers an experimental TOU electricity rate for the first 10,000 customers with a qualified EV. The TOU rate is for the super off-peak hours between 11 p.m. and 5 a.m. daily.[210]

- ***Offer consumers or businesses incentives to use or purchase EVs or install charging stations:***
  - Funded by **California**'s Air Resources Board, BlueLA provides EVs for as little as 15 cents a minute, or $9 an hour, to lower income people who qualify. In addition, the city of Sacramento has provided EVs for car-sharing in three public housing complexes.[211] BlueLA is modeled after BlueIndy in Indianapolis, Indiana, an EV car-sharing service that operates throughout the city. Although not expressly for the low-income population, it helps make EVs more accessible.[212]
  - **Colorado** established an annual registration fee of $50 on EVs for a decal that must be displayed. The decal will authorize EV owners to use public EVSE in Colorado. Of the $50 fee, $30 goes to the Highway User Tax Fund and $20 goes to the Electric Vehicle Grant Fund, which provides grants for EVSE.[213]
  - **Connecticut** made a concerted effort to encourage the adoption of EVs by the public and private fleets. Partnering with the statewide automotive retailers' association, the two private electric utilities and an NPO, the state created the Connecticut Hydrogen and Electric Automobile Purchase Rebate (CHEAPR) program, which offers incentives up to $5,000 for Connecticut residents who purchase or lease a new eligible EV, HEV or fuel cell vehicle.[214] To encourage automotive retailers to sell

eligible vehicles, CHEAPR initially awarded retailers $300 per vehicle sold or leased that received a CHEAPR rebate. In 2017, that amount was lowered to $150 per vehicle. Connecticut also offered several rounds of grants to municipalities, state agencies and private businesses to purchase and install EVSE. Connecticut Green Bank also incentivized EVs by offering 0.99 percent loans for their purchase.[215]

HOV Rates

Consider providing discount charging rates for high-occupancy vehicles, such as carpool shuttles or transit buses, to encourage transition to EVs by heavy-duty vehicles.

- **Pennsylvania** has several EV purchase incentive programs administered by the state and utilities. The Alternative Fuels Incentive Grant (AFIG) program provides financial assistance for qualified projects; information about alternative fuels, AFVs, EVs and HEVs; and advanced vehicle technology research, development and demonstration. Projects resulting in product commercialization and the expansion of Pennsylvania companies are favored in the selection process. The AFIG program also offers rebates to assist eligible residents with the incremental purchase cost of new AFVs, including EV, HEV, natural gas vehicles (NGVs) and propane vehicles. The rebate amounts are $1,750 for qualified EVs and $1,000 for qualified EVs, HEVs, NGVs and propane vehicles.[216]
- In **Oklahoma**, for tax years beginning before Jan. 1, 2020, a tax credit is available for up to 75 percent of the cost of installing commercial alternative fueling infrastructure. Eligible alternative fuels include natural gas, propane and electricity. The infrastructure must be new and not previously installed or used to fuel AFVs. The tax credit can be carried forward for up to five years.[217]
- In late 2017, **Oregon**'s governor issued an executive order that, among other things, directed the Oregon Department of Business and Consumer Services Building Codes Division to amend the state building code to require all new residential and commercial buildings to support the installation of at least Level 2 EV charging infrastructure by 2022.[218]

Provide funding and financing mechanisms to drive technology deployment

Nascent technologies often require financial support to accelerate their deployment. Governors can pursue policies and programs that use traditional and innovative financing mechanisms to raise funding and bolster support:

OPPORTUNITIES FOR ACTION

- ✓ **Explore MBUFs.**
- ✓ **Adjust existing taxes for inflation.**
- ✓ **Examine toll revenue.**
- ✓ **Consider ride-hailing fees.**
- ✓ **Examine EV fees.**
- ✓ **Review monetization of assets.**

STORY MAPS

NGA has used the Esri technology platform to create story maps that provide informatics about which states have used which forms of financing for transportation and infrastructure. For more information about state activities, please see our story map at https://arcg.is/1POOjv.

Ideas to consider...

- **Seek partnerships with the private sector to leverage public monies through PPPs or other approaches.**
- **Proactively adjust revenue projections to account for changes in the transportation sector.**
- **Partner with the federal government or neighboring states to test new financing tools, creating a larger pool of participants.**
- **Meet with USDOT to examine whether federal financing and funding tools make sense for your state.**

- ***Mileage-based user fees:*** A handful of states are exploring solutions for declining gas tax revenue resulting from greater fuel efficiencies and electrified transportation by investigating, studying and even piloting the collection of transportation revenue by charging drivers directly for the miles they travel and the resulting wear and tear on the roads – a solution known as "mileage-based user fees." **California, Colorado, Delaware, Hawaii, Minnesota, Missouri, Oregon** and **Washington** received federal funding under the Fixing America's Surface Transportation Act of 2015 to study alternative transportation revenue sources like MBUFs.[219]

Public Awareness

MBUFs are a new concept that may lead to confusion or anger among the public. Therefore, it is important to build a robust public education component into any pilot program.

- **Oregon** has been a leader in the study of MBUFs, convening a Road User Fee Task Force in 2001 to investigate options for sustainable funding of Oregon's transportation system, testing pilot programs in 2006 and 2012 and launching a true revenue-collecting program called "OreGO" in 2015 for up to 5,000 volunteers. Drivers who volunteer for OreGO are charged 1.7 cents per mile, recorded by a secure device added to their car (participants choose from three program administrators), and then credited for state gas taxes they pay at the pump.[220] The Road User Fee Task Force continues to meet and consists of state legislators, transportation officials and municipal and private sector partners.[221]

- ***Adjustment of existing taxes for inflation:*** The federal gas tax has not been adjusted since 1993, but states have taken steps to fill the void, with 26 states adjusting motor fuel taxes between 2013 and 2017. It is difficult for governors and legislatures to secure passage of motor fuel tax increases; realizing that the value will decrease over time as costs increase, some states have tried to counteract inflation. **California, Georgia, Indiana, Maryland, Michigan, North Carolina, Rhode Island** and **Utah** have all made some changes to motor fuel taxes to allow for inflationary adjustments without additional legislative action.[222]

Pilot Design

Make sure that pilot programs include a diverse participant base that is representative of the population in terms of demographics, geography and vehicle type.

- ***Toll revenue:*** Tolls existed in the United States long before creation of the Interstate Highway System, and they continue to be an important source of revenue to support the maintenance and expansion of infrastructure, with 34 states plus **Puerto Rico** having at least one toll facility in operation. Some states are looking at new and innovative tolls, such as new congestion-priced toll lanes along I66 in northern **Virginia**. **Rhode Island** is taking a unique approach, as well, installing commercial truck-only electronic toll gantries along six major highway corridors at 13 locations. Each location is associated with a bridge or group of bridges, and the revenues will be used to repair or replace the associated bridges. All told, Rhode Island plans to use this revenue to repair or replace 35 bridges.[223]

- ***Ride-hailing fees:*** Numerous municipalities, including New York City, the District of Columbia, and Chicago, that locally regulate taxis and ride-hailing operations have imposed fees or surcharges for each ride originating within their jurisdiction. Airports, which typically have imposed a pickup fee for taxis operating at the facility, have now begun to extend these fees to ride-hailing operations to stem monetary losses from taxi and parking revenue declines. Some states view rides that ride-hailing services provide as a potential source of revenue and impose an additional fee or surcharge at the state level, extend existing sales tax to each ride or have passed legislation specifically granting local government the ability to impose surcharges or fees on each ride. **Connecticut, Massachusetts, Nevada, New York, Pennsylvania,** and **South Carolina** all imposed a statewide fee that either the state retains or is distributed to local government entities, although not every state requires that this revenue stream be used for transportation**. Wyoming** and **Rhode Island** extended existing sales tax on taxi services to ride-hailing services.[224]

Alternative Funding

Independent commissions, working groups or task forces established by executive order, legislation or a request from the governor can provide a significant opportunity for states to explore alternative funding solutions to their infrastructure challenges. Over the past decade, many transportation funding commissions that were made up of diverse stakeholders, policymakers and private citizens issued consensus recommendation reports, including in Connecticut, Iowa, Maryland, Minnesota, Missouri, Pennsylvania South Carolina, Vermont, Washington and Wisconsin. In many cases, the reports resulted in legislative activity on the issue of transportation funding. Independent commissions have proven to be helpful in making the case for new transportation revenues and shoring up public trust in transportation decision making.[230]

- ***EV fees:*** In **Washington**, EV owners must pay an annual vehicle registration renewal fee of $150. This fee expires if the legislature imposes a VMT fee or tax. EVs and HEVs with an all-electric range of at least 30 miles are subject to the registration renewal fee. EV registration fees will contribute to the state's Electric Vehicle Infrastructure Bank to deploy charging stations through PPPs.[225]

- ***Monetization of assets:*** States should consider the viability of leasing or selling roadway and railroad-adjacent, state-owned rights of way for renewable energy generation, economic development or public utility. **Massachusetts** successfully leases its rights of way along the Massachusetts Turnpike to developers for the installation and operation of solar panels. Such arrangements can decrease routine maintenance costs by shifting those costs to the developer of such facilities through a power purchase agreement and increase the value of such rights of way by turning them into energy producers.

Governments could generate additional revenue from right-of-way fees and permits for 5G small cells.[226, 227] The city of San Jose, California negotiated an agreement with AT&T for right-of-way access at a rate of $1,500 per year per 5G small-cell site and is expected to generate approximately $5 million in lease revenue over the next 15 years.[228] The proceeds will go toward the city's digital inclusion efforts.[229]

INNOVATIVE FUNDING

Other potential sources of funding for infrastructure that have not been adopted yet in the United States include a carbon tax, congestion pricing on local roads and charging ride-hailing and delivery vehicles for street curb access.

Prepare the workforce

OPPORTUNITIES FOR ACTION

- ✓ **Partner with the private sector to identify skills gaps and workforce availability. Work with educational institutions to ensure that training programs are available to fill skills gaps in the short and long terms.**
- ✓ **Engage with students to get them excited about technology and thinking about the future of transportation.**

The advent of new technologies can lead to structural changes in the labor market as workforce needs shift, jobs become obsolete and employees follow wages. Governors need to be aware of employment shifts and be prepared to meet retraining needs. States are working to develop curriculum and certification programs, provide training and support workforce development in collaboration with companies as part of their overall effort to remain economically competitive. Partnerships among multiple stakeholders are critical to the development and rollout of effective workforce programs because they enable states to use and align existing workforce training efforts and help identify future needs. Each state will have a different mix of players, depending on the industries and organizations active in the state and the population it is targeting.

- ***Partner with the private sector to identify skills gaps and workforce availability. Work with educational institutions to ensure that training programs are available to fill skills gaps in the short and long terms:***
  - **Delaware**, with corporate partners and local foundations, provided start-up funding for Zip Code Wilmington, a 12-week coding boot camp that provides training in advanced computer programming and aims to place graduates in the workforce. Students pay one-quarter of the $12,000 cost, and scholarships are available.[231]
  - Four **South Dakota** organizations, including the Department of Labor and Regulation, created the South Dakota Partnership for Student Success to provide a new technology workforce development program that offers paid internships or apprenticeships while using online and classroom-based courses to provide participants with bachelor's degrees, associate degrees or academic certificates in fields like cybersecurity, software development and network and security administration.[232]
  - In 2017, the governor of **North Dakota** established the state Workforce Development Council through executive order. The council advises the governor on workforce development in the context of economic development needs and identifies opportunities to avoid duplication of effort. The council also serves as the state's workforce investment board under the federal Workforce Innovation and Opportunity Act.[233]

Ideas to consider...

- **Coordinate across state agencies to take advantage of existing economic development and workforce programs that can be expanded to include advanced transportation elements or inform development of new programs.**
- **Identify dual-use programs that can be used for advanced transportation skills development without the risk of creating stranded assets or skill sets.**
- **Conduct outreach and awareness to encourage employment interest in the transportation sector.**

- **Indiana** recently created the Office of Apprenticeship & Work-Based Learning within the Department of Workforce Development to expand apprenticeship opportunities throughout the state, especially in emerging industries, by working closely with the U.S. Department of Labor. The office also partners with businesses and educational institutions to pursue workforce development solutions. An online portal is expected to connect students and employers to apprenticeships and work-based learning opportunities.[234]
- Central Piedmont Community College in **North Carolina** partnered with the automotive and clean energy company Tesla to be the first community college to launch an automotive training program, called "Tesla START,"235 a 12-week automotive technician training program for future service technicians. Students train in a space on campus designed to simulate a service location.
- To address the state's growing cyber-related educational and workforce demands, **South Carolina** launched SC Cyber, the state's first initiative and liaison among industry, academia and government for cybersecurity workforce development. SC Cyber creates and offers education and training programs in advanced technology development and commercialization as well as in critical infrastructure protection.[236]
- **Louisiana** enacted legislation in 2014 that established higher education funding for certain high-demand degree programs and required a statewide workforce gap analysis. The legislation also created the Workforce & Innovation for a Stronger Economy Fund Strategic Planning Council as an independent subcommittee of the state Board of Regents to carry out the workforce gap analysis.[237]
- To address talent shortages in the IT sector and other industries, **Montana** has invested in expanding apprenticeship programs to new industries and occupations. Supported by a new employer tax incentive and technical assistance from statewide industry experts, Montana has grown the number of such training programs by 30 percent in less than five years. Montana is also aligning education to the needs of its economy by creating a joint liaison between the state's labor agency, which oversees many workforce training programs, and the state's university system.[238]

- ***Engage with students to get them excited about technology and thinking about the future of transportation:***
  - In **Pennsylvania**, PennDOT established the PennDOT Innovations Challenge, a statewide competition for high school students to solve real-world transportation problems. This year's challenge asked high schoolers, aside from using traditional paid advertising, marketing and social media channels, which technologies or innovative methods can be developed in the next five to 10 years to curb unsafe teen driving practices.[239]

Update communications networks and data systems

OPPORTUNITIES FOR ACTION

- ✓ **Ensure that agencies are investing in technology alongside infrastructure, ensure that investments are compatible with industry, and anticipate future needs.**
- ✓ **Designate a point person or agency for broadband deployment in the state, and set goals for expansion.**
- ✓ **Engage stakeholders, and identify state property for the development of communications.**
- ✓ **Enter into data-sharing agreements with the private sector.**
- ✓ **Promote the importance of data in government through structures such as a chief data officer, and ensure that state agencies are sharing and using data across silos.**

The growing ubiquity of high-speed communications networks has led to an unprecedented degree of interconnectedness and accumulation of information, giving rise to new industries and ushering innovation. However, a significant portion of the population lacks access to high-speed networks and therefore, on the opportunities and benefits they offer. Moreover, the expansion and improvement of service hold the key to transforming whole industries and by extension, our society. Governors can play a critical role in promoting the deployment of communications networks to help build a more inclusive state and lay the foundation for future growth:

- ***Ensure that agencies are investing in technology alongside infrastructure, ensure that investments are compatible with industry, and anticipate future needs:***
  - In 2016, **Colorado** committed $20 million toward RoadX, a program operated by CDOT, to benefit from and encourage innovative technology integration into transportation infrastructure.[240] One initiative RoadX is undertaking is a partnership with a private sector mapping and real-time data analytics company to process congestion and accident data connected vehicles transmit to a cloud platform. When the data have been validated and analyzed, CDOT will share them with traffic management centers to address incidents and emerging traffic patterns in real time.[241]
  - **Michigan**'s DOT (MDOT) is in the process of deploying 400 DSRC RSUs by 2020, installing DSRC technology at every traffic signal location in the state and installing DSRC-communicating on-board units in some MDOT vehicles. This technology will enable vehicles to communicate with their surroundings and with other connected vehicles to alert drivers to potential perils, improving traffic safety.[s]
  - **Georgia**'s DOT, through a Public Notice of Advertisement for the Georgia Interstate Broadband Deployment Project, is seeking a statewide expansion of Georgia DOT's NaviGAtor traffic management system. The expansion includes delivering high-speed internet to rural areas by contracting with the private sector and using rights of way along interstates to deploy broadband. Georgia DOT anticipates no additional costs to taxpayers and no additional government debt.[242]

Ideas to consider...

- **Articulate a specific, quantifiable broadband goal and designate a single entity to coordinate the state's broadband deployment objectives.**
- **Designate a chief data officer to facilitate data sharing and governance across the public sector.**
- **Use other infrastructure development – for instance, with roads and water systems – to support communications network deployment through "dig-once" provisions and other procedures.**
- **Support private sector deployment of new, advanced communications networks.**

TECHNOLOGY 101

With communications technology advancing rapidly, "Technology 101" courses should be provided to state DOT and other government agency employees to explain the different technologies, their capabilities and the benefits of investing in the technology today.

- ***Designate a point person or agency for broadband deployment in the state, and set goals for expansion:***
  - **Wisconsin**'s Broadband Office is part of the state's Public Service Commission and serves as a one-stop-shop for broadband information in Wisconsin. The Broadband Office collects and maps broadband coverage information to improve state planning and assists in the administration of the state's Broadband Expansion Grants.[243]
  - In 2015, **New York** established the $500 million New NY Broadband Program to provide state grants for projects delivering high-speed internet access to unserved and underserved areas of the state. The program is one of the largest and most ambitious state investments in broadband, with a goal of achieving statewide broadband access by the end of 2018.[244]
- ***Engage stakeholders, and identify state property for the development of communications technology:***
  - **Montana**'s vast mountainous terrain and dispersed population are a challenge to deploying broadband infrastructure. Connecting consumers in areas with low population density is often perceived as unattractive because the initial capital investment is high, profit margins are slim and payback periods are long.[245] For example, in Montana, the average cost of fiber construction per rural customer is $10,000, whereas in Seattle, the average cost per customer is $18.[246] However, rural cooperatives in Montana and other states with low population density have found success in connecting remote populations because these cooperatives tend to be owned and operated by the communities they serve. As a result, more than three-quarters of Montana's schools meet the federally mandated bandwidth standard of 100 kilobits per second per student.[247] USDA has assisted the state by providing more than $165 million in low-interest loans to improve rural broadband service through the Rural Utilities Service programs.[248] This model reflects the success of the Rural Electrification Act of 1936, which stimulated rural electricity development by offering low-interest loans and grants to nonprofit, member-owned cooperatives.[249]

[s] Jan. 23, 2018, letter from the Coalition for Safety Sooner to Chao, Pai and Mulvaney.

- In 2012, **Pennsylvania** enacted the Public-Private Transportation Partnerships Act, permitting public entities to enter into private sector agreements to participate in the delivery, maintenance and financing of transportation-related projects. The act also created a Public-Private Partnership Board comprising legislative and executive branch appointees to, among other things, solicit and oversee transportation projects.[250] In 2016, the Public-Private Partnership Board approved a PPP proposal from the Pennsylvania Turnpike Commission granting a private entity access to its right of way to install a fiber-optic network.[251] In exchange for building the network, the private developer will operate the system for 35 years. The network is expected to cost between $250 million and $300 million, but costs will be recouped from the sale of unused fiber.[252]

- ***Enter into data-sharing agreements with the private sector:***
  - State DOTs, including those in **Delaware, Massachusetts, Pennsylvania, Virginia,** and **Wisconsin**, are partnering with private sector smartphone navigation developers to receive real-time transportation condition data in return for providing the developers with real-time information about construction, crashes and road closures. This exchange helps reduce costs for state DOTs and provides real-time congestion and road condition data that otherwise may not be available.[253]
  - Like other states, **California** has allowed the testing of AVs on public roadways, both with and without a driver. In both cases, the DMV requires manufacturers (those testing the vehicles) to report within 10 business days on any collision involving an AV and provide an annual report summarizing the disengagements of the AV technology during testing. These disengagement reports are made public and include the total number of miles traveled per month per vehicle.[254]

- ***Promote the importance of data in government through structures such as a chief data officer, and ensure that state agencies are sharing and using data across silos:***
  - In 2014, **Connecticut**'s governor signed Executive Order No. 39, which established the CT Open Data Portal with the goal of providing open access to state data before state agencies have aggregated and analyzed those data. The executive order also created the position of chief data officer at the state's Office of Policy and Management, tasking the officer with managing the portal and working with state agencies to provide data sets. In addition, each state agency must designate an agency data officer and make data that do not contain sensitive information openly available to the public.[255] In 2018, the governor proposed and secured passage of legislation codifying the data governance and access structure and policies into state statute.

Data Collection

Do not just encourage agencies to collect data: Make sure that they are collecting useful data, in standard formats, that can be applied to the challenges facing the state today and in the future.

- **Indiana**'s Management and Performance Hub (MPH) was established by executive order in 2014 and codified into statute in 2017. An independent office led by the state's chief data officer and based at the Office of Management and Budget, MPH not only publishes data from across the government in the Indiana Data Hub but also provides data analytics and visualization capabilities to inform state agency decisions and publishes state agency performance metrics. Recent collaborative projects include collecting data from 16 agencies to create a visualization tool to fight opioid addiction and developing a predictive mapping tool for the Indiana State Police to forecast crashes based on historical data, weather, traffic, road conditions, time of day and census data.[256] MPH also works with external partners to learn which data sets would be most impactful to their work, and then provides those data on the Indiana Data hub in an accessible and useful format.

Address cyberthreats

In our increasingly digitized and interconnected world, safeguarding against cyberthreats is critical to protecting the public and economic growth. As sensors and connectivity functions are embedded into infrastructure, it will be imperative to safeguard and ensure that data collected are accurate and safe from compromised. Governors have an important role to play in confronting these challenges and enhancing the cybersecurity posture of their state.

- ***Build cyber planning into all levels of governance in coordination with law enforcement and DHS. Continuously evaluate and upgrade skills, systems and planning in response***

to emerging threats. Start with a focus on cyber hygiene, and consider requiring the following technologies to reduce the impact of breaches: (1) multifactor authentication, (2) encryption, (3) micro-segmentation, (4) persistent and automatic software patching and (5) education.

- Every state employee in **Idaho** must complete rigorous cybersecurity training, helping standardize and optimize cyber capabilities across the state.[257] In addition, the state invested in and partnered with the Idaho National Laboratory's Cybercore Integration Center, which provides training, educational outreach and enhanced cyber capabilities.[258]

Ideas to consider...

- **Create a state cyber advisory board, task force or working group with both public and private sector participants.**
- **Enlist the assistance of the National Guard, including through the creation of a cyber unit.**
- **Promote training and exercising on cyberthreats with state agencies and the transportation sector.**

- **Georgia** is currently constructing the Hull McKnight Georgia Cyber Center for Innovation and Training to train cyber professionals. The center is being developed in partnership with academia, law enforcement, the Army and the private sector and will meet a growing workforce need while strengthening the state's cyber defenses.[259]
- Recognizing the heightened vulnerability risk, the **Nevada** Office of Cyber Defense Coordination was established in 2017 to serve as a single platform to integrate the state's cyber security initiatives, manage strategic policy and planning, and streamline cyber security governance structures.[260]
- **Virginia**'s Cyber Security Commission and the Virginia Cyber Security Partnership, a public-private working group established by the governor, coordinate with the Virginia State Police to assess the potential risk of cyberattacks on automobiles – specifically, those used by first responders. Research results are aiding law enforcement and first responders by establishing training protocols and exploring low-cost technologies to help public safety agencies reduce the risk of cyberattacks against their vehicles.[261]
- Through executive order, **Vermont**'s governor created a 10-member Governor's Cybersecurity Advisory Team to provide advice on the state's cybersecurity readiness, strategy and planning, with members from the public and private sectors.[262] The team is charged with developing a strategic plan and enhancing the relationships and lines of communication across federal, state and local governments and the private sector.

Educate consumers about the benefits and risks of technological innovation

OPPORTUNITIES FOR ACTION

- ✓ **Increase awareness of the benefits of new and forthcoming transportation technology.**
- ✓ **Assuage fears of infringing on citizens' privacy by putting in place policies that prevent improper use of technology.**

Communicating with the public about changes to transportation systems they use daily can improve the success of programs designed to advance transportation innovation. For instance, providing consumers with information about the costs and shortcomings of the current systems can help ensure that they understand both how they can be affected and how they can benefit from deployment of innovative transportation technologies. Governors can articulate a broad new transportation vision to state residents, being clear about why the changes are occurring and why they matter, while state offices can serve as trusted sources of information and outreach to those affected by new transportation technologies and the changes they may bring to economic development, infrastructure development, environmental conditions and data privacy.

The flow of information should not be one way: First-hand experience and local knowledge may identify issues related to the deployment of new technologies, which can then be accounted for in advance. Programs that engage the public also help ensure that the public is – and feels that they are – meaningfully included in planning processes. In addition, not all engagement will focus on external messaging; governors must also ensure that robust internal engagement efforts are made to change minds and get buy-in within state agencies regarding advancing innovative transportation technologies.

- ***Increase awareness of the benefits of new and forthcoming transportation technology:***
  - The Insurance Institute for Highway Safety found that automatic braking technology paired with crash warnings can reduce rear-end crashes by almost 40 percent, which equals almost 13 percent of all police-reported crashes in America.[263] Although this technology costs $2,000 or more to add to a vehicle, most drivers do not see any insurance premium discounts despite the added safety benefits. As this and other automated safety technology become increasingly standard in vehicles,[t,264] state agencies should work with manufacturers, insurers and other safety advocates to promote their adoption and use.[u,265]

Ideas to consider...

- **Pursue a messaging campaign that encourages citizen engagement and informs the public about new technologies.**
- **Explain to the public how your policies will protect their privacy.**
- **Assess different outreach approaches for different communities (e.g., those with reduced internet access or those mainly oriented toward online media).**

  - In **Vermont**, three state agencies – DOT, the Agency of Natural Resources and the Department of Public Service – and the NPO Vermont Energy Investment Corporation formed the Drive Electric Vermont coalition in 2012 to increase adoption of EVs in the state, with education, marketing and outreach being the cornerstones of the strategy. Among many other activities, Drive Electric Vermont held ride-and-drive events to expose more people to EVs; used traditional and social media avenues, videos and internet banner advertisements to raise awareness; developed an online information hub; conducted outreach to major Vermont employers about supporting EV infrastructure and employee purchases; and worked with auto dealers to make them aware of the EV options on the market.[266]

Communication Campaign

Benefits of AVs extend beyond the improvements to road safety. Governors should launch educational campaigns, possibly in partnership with external stakeholders, to detail the economic development, mobility and societal benefits of advanced transportation technology.

- ***Assuage fears of infringing on citizens' privacy by putting in place policies that prevent improper use of technology:***
  - Recognizing that drones offer safety benefits to law enforcement officers, some states have passed laws regulating the use of the technology. **Alaska** state statute requires that every law enforcement agency adopt procedures for the use of drones and "maintain a record of each flight, including the time, date, and purpose of the flight, and the identity of the authorizing official."[267] **Vermont** statute requires that officials who use a drone "operate [it] in a manner intended to collect data only on the target of the surveillance and avoid data collection on any other person, home, or area."[268]

[t]The Highway Loss Data Institute predicts that 95 percent of registered vehicles will be equipped with rear cameras in 2039; rear parking sensors in 2041; forward collision warning, blind spot monitoring and lane departure warning in 2043; autobrake in 2045; and adaptive headlights sometime after 2050.

[u]Two insurance companies offer insurance premium discounts for automatic braking technology, with The Hartford reducing the annual premium by up to 3 percent on vehicles with automatic braking and other safety technology in Arkansas, Illinois, Ohio, Oklahoma and Minnesota.

Appendix: State Spotlights

Autonomous vehicles in Michigan

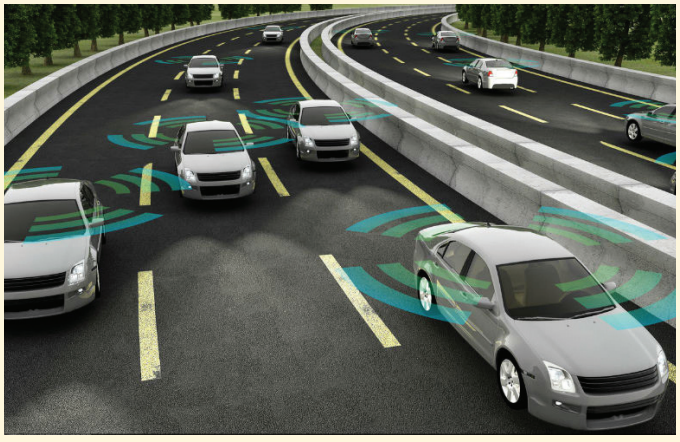
Following the widespread adoption of automobiles, Michigan has been the nation's leading auto manufacturer. With AVs and connected vehicles poised to disrupt the transportation industry, Michigan has made a concerted effort to remain a leading state for mobility and safety research and development. The state has taken a cooperative, inclusive approach toward working with private industry, local and federal government entities and research and academic institutions, creating a welcoming regulatory environment, offering state resources and assistance and establishing state-of-the-art technology proving grounds.

To address the frequent private sector challenge of not knowing whom to talk to at which state agency, Michigan's governor announced in 2016 that the state would be launching Planet M, an initiative of the Michigan Economic Development Corporation (MEDC).[269] With dozens of partners as varied as HNTB Corporation, NAVYA, MDOT and Macomb County to the Michigan Tech Transportation Institute and the Center for Automotive Research, Planet M is a one-stop-shop for companies and investors looking to be connected to Michigan's automotive and mobility industry.[270] Acting as a concierge service for businesses and investors seeking to do business in the state, Planet M provides an ecosystem of support to encourage continued investment in the mobility and safety industry and has successfully connected numerous companies and institutions.

Michigan state government has also worked closely with universities to ensure that students and academics continue to have access to high-quality research opportunities. The University of Michigan, with the financial support of MDOT and private sector partners, opened Mcity in 2015 to provide a controlled environment for testing AV and connected vehicle technology. Mcity is located on 32 acres of the university's campus and hosts one of the world's first AV test facilities, which includes five lane-miles of roads with intersections, traffic signs and signals, sidewalks, simulated buildings, street lights and obstacles such as construction barriers. Mcity provides a venue for academic research as well as cooperation with automakers and suppliers to carry out testing of equipment and technology.

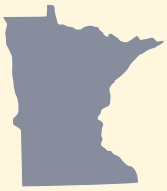
To complement Mcity and create additional capacity, Michigan encouraged the creation of the nonprofit American Center for Mobility (ACM), an AV and connected vehicle premarket testing, development and validation facility located on more than 500 acres of state property in Ypsilanti Township. ACM is a joint initiative founded by the governor of Michigan, MDOT, MEDC, the University of Michigan, Business Leaders for Michigan and Ann Arbor SPARK. With more than $110 million pledged, funding has come from the state, AT&T, Ford, Toyota, Hyundai and Visteon Corporation. ACM can offer testers unique conditions, such as a 2.5-mile highway loop, a 700-foot curved tunnel and two double overpasses.[271] MDOT has tried to capitalize on ACM's location in the southeast of the state by providing direct access to the more than 100 miles of highway on which V2X technology has already been installed, with another 250 miles planned for installation of V2X technology.[272] In addition, USDOT has designated ACM one of 10 Automated Vehicle Proving Grounds pilot sites.[273]

Michigan has also taken steps to form partnerships with regional neighbors, recognizing that vehicles will not stop at the border of the state or the country. In 2016, the governor of Michigan and the premier of Ontario signed an MOU creating a working group to explore opportunities for increased collaboration in the automotive industry. The MOU specifically referenced supporting connected and AV technology as well as the establishment of a demonstration roadway connecting Michigan and Ontario to test innovative technologies.[274] The following year, MDOT and ACM joined Ohio, Pennsylvania and several local universities and research institutions to form the Smart Belt Coalition. The coalition was established to support testing, validating and deploying connected vehicles and AVs across urban and rural roadways during all weather conditions. In addition, it provides a forum for key transportation decision makers and seeks joint funding for large-scale research and implementation projects.[275]



Collaboration across agencies, research institutions and industry as well as the joint efforts to build testing facilities and partnerships with neighbors – all are steps that other states could mimic to improve mobility and safety technology research and deployment.

Drones in Minnesota



Each bridge under the care of a state DOT is required to undergo routine inspections to ensure the safety of the public traveling over and sometimes under the bridge. The inspections provide detailed insights into the conditions of the structure and its concrete, enabling the DOTs to prioritize bridge and road repairs across the state. Because of differences in their type, size and age, each bridge requires a unique inspection plan, but most will require work zones, heavy equipment and potentially detouring of traffic or reducing travel lanes. Large bridges require numerous inspectors and can necessitate standing in buckets at the end of cranes (called "snoopers") that reach below the deck of the bridge or hanging from ropes to inspect beneath the bridge. For a large bridge, this task can take several weeks and is dangerous for the bridge inspectors and the rest of the crew, who may stand within feet of passing vehicles.[276]

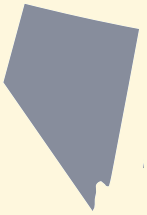
With more than 20,000 bridges that must be inspected at least every 24 months (or every 12 months if the bridge is considered to be in poor condition), Minnesota has been pursuing a safer, more cost-effective and less disruptive option to traditional bridge inspection methods. In 2015, MnDOT initiated a rigorous drone bridge inspection pilot program to examine specific traits of various drone models. The pilot demonstrated explicit benefits of using drones to conduct bridge inspections. The program consisted of three phases: Phase 1 determined the effectiveness of using drone technology for bridge inspections and assessed how well UAVs improved the quality of the inspections and the safety of inspectors. Inspecting four bridges throughout Minnesota, Phase 1 was limited because of its reliance on global positioning system (GPS) technology, which prevented the drones from inspecting some portions of the bridges. Even with the GPS limitations, however, researchers found clear benefits for inspectors and the traveling public.[277]

Phase 2 of the pilot program deployed a new drone specifically designed for the inspections that could operate without GPS. The new drone had a camera that could move up and down as well as protective coverings for the propellers. It had the capability to use the information collected to develop three-dimensional models of the bridges and could use infrared sensors to detect delamination of concrete decks.[278] To determine the benefits of using drones, MnDOT used traditional techniques and drones to inspect four bridges; the agency published effectiveness results and cost comparisons in a detailed research report. One bridge inspected was the John A. Blatnik Bridge in Duluth, which showed an almost 66 percent cost benefit from the use of drones: Traditional inspections would take eight days and four snoopers at a cost of $59,000, while the drone inspection would take five days and cost $20,000.[279]

MnDOT launched Phase 3 of the pilot program in 2017, and it is slated to complete the project in late 2018. This phase includes the inspection of more than five times the number of bridges included in Phase 2 while also testing a new, collision-tolerant drone better suited to the inspection of confined spaces. (Previously, a drone may have experienced damaged propellers.) The final report for Phase 3 will also identify which policies and procedures the state should use to govern the use of drones in bridge inspections and in which situations drones can be most effectively deployed.[280]

As the nation's infrastructure ages, transportation resources continue to be limited and vehicle traffic continues to increase, bridge inspections will continue to be one of the most important responsibilities of state DOTs. MnDOT's experiences and the documented results from testing different drones in different situation will benefit other state DOTs as they look to cut costs and improve inspection techniques while keeping the traveling public safe.

Electric vehicles in Nevada



Nevada has a rich history of encouraging emerging technologies, as evidenced by the annual CES convention hosted in Las Vegas, which highlights the latest innovations in consumer electronics. In early 2018, NGA held a Transportation Innovation Summit in Nevada in conjunction with CES. Among the many transportation policies discussed at the summit, Nevada's numerous efforts to facilitate EV adoption and develop the requisite infrastructure featured prominently.

In 2015, Nevada's governor announced the launch of the Nevada Electric Highway (NEH), a partnership among the Governor's Office of Energy, Nevada DOT, multiple electric utilities and private commercial host sites to strategically expand public EV charging infrastructure throughout the state.[281] The objective of the NEH is to provide an electric highway system that serves the entire state, helping eliminate a key impediment to EV adoption – range anxiety – while drawing awareness to the technology.[282] The NEH will also help Nevada drivers access lower cost fueling options, avoid fluctuating gas prices and promote

environmental sustainability.[283] Phase 1 of the NEH was recently completed, with construction of three charging stations along U.S. Route 95. Each station contains one DC fast charger (which substantially charges an EV in under an hour) and two Level 2 chargers (which require several hours for a full charge)[284] and was partially funded by TNC licensing fees operating in Nevada.[285]

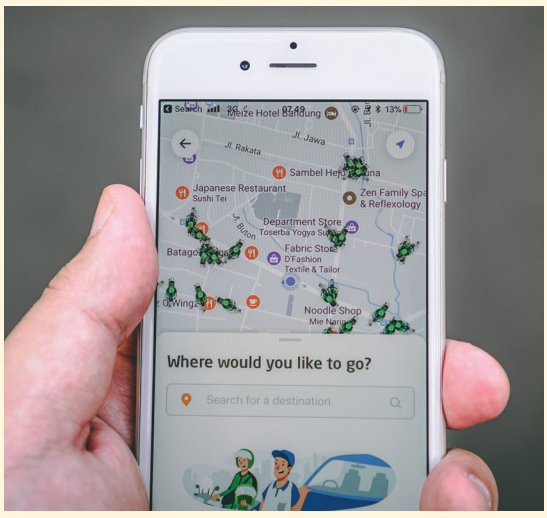
With Phase 2 construction underway along U.S. Route 93, Nevada has also sought out-of-state partnerships. In October 2017, Nevada signed on to the Regional Electric Vehicle Plan for the West, an MOU among eight western states to coordinate development of a regional EV charging networks on key western interstates and highways.[286] Collectively, these initiatives are helping the state achieve its 2020 strategic planning objectives of completing an electric highway system to reduce dependence on imported fossil fuels and carbon emission.[287] By using in-state and regional partnerships and employing unique financing mechanism, Nevada has established itself as a leader in incentivizing cost-effective and strategic EV infrastructure deployment.

Ride-hailing in Massachusetts

The ADA requires public transit agencies that provide fixed-route service to provide paratransit services to individuals with disabilities who are not able to use the fixed-route bus or rail service because of a disability. ADA regulations require that paratransit service be provided within three-fourths of a mile of a bus or rail station, at the same hours and days and for no more than twice the regular fixed route fare to individuals who cannot board or ride a bus without assistance, who require an accessible vehicle or who have a specific condition that prevents them from traveling to or from the bus stop or rail station.[288]

The intent of paratransit service is to provide adequate mobility options for all individuals in an existing transit service area, but the historic unreliability and unpopularity of paratransit services and high costs to government and transit agencies have led many providers to seek alternative methods of providing mobility solutions for paratransit customers. The Massachusetts Bay Transportation Authority (MBTA) sought an alternative to its paratransit service – The RIDE – to reduce costs for both passengers and the transit agency and to improve the quality, reliability and convenience of the trips provided to passengers. In 2016, governor of Massachusetts and the MBTA announced the launch of a pilot program for up to 400 The RIDE customers to use the ride-hailing companies Uber or Lyft for on-demand paratransit service instead of traditional The RIDE services.[289]

For traditional The RIDE trips, passengers pay $3.15 per trip, with the MBTA subsidizing approximately $31, but the rides must be scheduled by phone at least 24 hours in advance, and the service requires a 30-minute pickup window. Under the pilot program, passengers do not need to schedule on-demand The RIDE trips accessed through Uber and Lyft in advance. When the pilot first launched, the initial cost to each passenger was $2, with the MBTA subsidizing the next $13.00 of each trip; customers paid the additional costs. To address equity concerns, Uber is testing a plan to provide smartphones to those customers who do not already have one, and Lyft allows program participants to request rides by telephone if they do not have access to a smartphone.[290]



After less than six months and more than 10,000 rides, the pilot program was opened to all eligible The RIDE users because of the pilot's demonstrated success. According to the MBTA, the initial pilot showed a difference of 71 percent between traditional The RIDE and on-demand trip costs ($9 for on-demand versus $31 using traditional The RIDE), and customers saved an average of 34 minutes on every pilot trip taken. The overall cost to the MBTA of providing paratransit services decreased by 6 percent during this period. Not only did costs decline, but The RIDE trips went down by 18 percent while total trips the paratransit users (The RIDE and on-demand pilot combined) took increased by 28 percent, demonstrating that improving access and reliability can improve use of paratransit services.[291] A year later, the popularity had only grown, with participants taking 43 percent more paratransit trips overall, while their trips through The RIDE declined by 27 percent.[292]

Further changes have been made to the program, which is still in its pilot phase. In late 2017, the maximum MBTA subsidy was increased to $40 per trip to encourage longer trips with the on-demand pilot and fewer longer trips with traditional The RIDE services.[293] In addition, ride-sharing option uberPOOL was made available as an option starting at $1 instead of the $2 for other Uber and Lyft trips.[294] As the popularity of the program and the total number of rides have increased, the cost savings the MBTA has seen has decreased, but the program has helped improve mobility for those who were traditionally limited to unreliable and inconvenient paratransit services. As a result, many other jurisdictions are looking at similar forms of on-demand services.[295]

Smarter communities in Virginia

In August 2017, the governor of Virginia signed Executive Order 13, launching a statewide initiative to place Virginia at the forefront of the global movement to develop "smart" communities.[296] Initial findings and recommendations were released in October 2017, and in March 2018, the state was awarded a highly competitive Smart Cities Grant,[297] but work is continuing, and further recommendations are expected.[298]

Executive Order 13 directed the secretary of technology to launch the Virginia Smart Communities Working Group (VASC) to explore seven "Superclusters"[v] set forth in the National Institute of Standards and Technology Global City Team Challenge.[299] Led by the secretary of technology, the executive leadership of the VASC Working Group includes the secretaries of transportation, public safety and homeland security, commerce and trade and health and human resources as well as other private and nonprofit entities.[300] The group is split into six committees, each focusing on topics such as transportation and broadband and tasked with developing best practices, policies, processes and technologies to provide the resources, support and tools necessary to transform Virginia's communities into smart communities.[301]

Adding to ongoing efforts, the Transportation Workgroup's goal is to use innovation to increase efficiencies and quality of life, evaluating new technologies and determining how best to incorporate them into existing infrastructure and systems. By taking a proactive approach, the Transportation Workgroup anticipates and responds to future needs while ensuring that the state is sufficiently prepared to integrate new technologies and innovations.

The Transportation Workgroup began by examining the current state of transportation in Virginia. Initial findings included an analysis of the DOT's long-term objectives, the state's economic outlook and unique characteristics of key regions. Based on this analysis, the workgroup identified three overarching goals to pursue: (1) Improve quality of life, (2) efficiently transport people and (3) support sustainable development and movement of goods. The next phase of analysis, currently underway, is assessing key transportation innovations and trends, including connected vehicles, automation, EVs, the sharing economy and mobility as a service. Under evaluation is the future of transportation infrastructure, including topics such as transportation electrification, connected devices and cybersecurity, hyperloop technologies, ports and airports and adaptation to climate change.

Understanding the importance of a communications network to support new technologies, including those in the transportation sector, the Public Wireless/Broadband Workgroup conducted an analysis of broadband access in Virginia. The workgroup found that some areas still lacked access to high-speed broadband, and large parts of the state were served by a single provider, leading to higher costs and poor service. The Broadband Workgroup is exploring ways to expand high-speed connectivity and, in the process, looking beyond traditional options toward emerging technologies such as satellite or TV white space.

Virginia's approach – convening the relevant cabinet members and stakeholders to develop committees focused on key smart community components – has received wide acclaim. The Smart Cities Grant was awarded to Virginia for uncovering synergies and fostering collaboration among agencies, external stakeholders and nearby regions.[302] The grant provides tailored mentorship and workshops as well as free products and services from the private sector to help Virginia become a "Smart State."[303]

[v] A "Supercluster" is a multicity, multistakeholder collaboration organized based on common project objectives and shared solutions. Committed cities, communities and partners jointly tackle shared issues, such as developing and deploying shared solutions to create economies of scale. Each Supercluster produces a blueprint or playbook for cities and communities around the world to use as the foundation for their own smart city strategies. A "SuperCluster" is an alliance of action clusters in the same sector; they can be joined by individual entities that do not belong to a specific action cluster.

Additional Resources

- Advancing Automated and Connected Vehicles: *Policy and Planning Strategies for State and Local Transportation Agencies:* Released by the National Academies of Science, Engineering and Medicine, this research report assesses policy and planning strategies at the state, regional and local levels that may influence private-sector AV and connected vehicle choices to positively affect societal goals. [National Academies of Sciences, Engineering, and Medicine; Transportation Research Board; National Cooperative Highway Research Program; Zmud, J., Goodin, G., Moran, M., Kalra, N., & Thorn, E. *Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies.* Retrieved from https://www.nap.edu/catalog/24872/advancing-automated-and-connected-vehicles-policy-and-planning-strategies-for-state-and-local-transportation-agencies]
- *Automated Driving Systems 2.0: A Vision for Safety:* The second version of NHTSA's voluntary guidance on automated driving systems includes model state policies and current regulatory guidelines. Version 3.0 is in development by USDOT as of June 2018. [National Highway Traffic Safety Administration. (2017). *Automated driving systems: A vision for safety.* Retrieved from https://www.nhtsa.gov/document/automated-driving-systems-20-voluntary-guidance]
- *EV Infrastructure Projection (EVI-Pro) Lite Tool:* Developed with support from DOE's Vehicle Technologies Office, this online tool can estimate the quantity and type of charging infrastructure necessary to support EV adoption at the state or municipal level. [Electric Vehicle Infrastructure Projection Tool (EVI-Pro) Lite. (2018, March 4). Retrieved from U.S. Department of Energy website: https://www.afdc.energy.gov/evi-pro-lite]
- *The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budget and Finance:* Released by the Urbanism Next Initiative at the University of Oregon, this paper considers the impact of AVs on municipal budgets, with many of the same impacts facing states. [Clark, B. Y., Larco, N., & Mann, R. F. (2017). *The impacts of autonomous vehicles and e-commerce on local government budgeting and finance.* Retrieved from https://urbanismnext.uoregon.edu/files/2017/07/Impacts-of-AV-Ecommerce-on-Local-Govt-Budget-and-Finance-SCI-08-2017-2n8wgfg.pdf]
- *eGallon:* Developed by DOE, this online tool compares the cost, by state, of fueling a vehicle with electricity to a similar vehicle with gasoline. [eGallon. Retrieved from U.S. Department of Energy website: https://www.energy.gov/maps/egallon]
- *Alternative Fuel Toolkit:* Developed through the *Deployment of Alternative Vehicle and Fuel Technologies Initiative,* a joint project of Oregon DOT and FHA, this online tool is to help state and local agencies facilitate the deployment of alternative fuel technologies. [Alternative Fuel Toolkit. Retrieved from the Deployment of Alternative Vehicle and Fuel Technologies Initiative website: http://altfueltoolkit.org/]
- *Jurisdictional Guidelines for the Safe Testing and Deployment of Highly Automated Vehicles:* Released by AAMVA in May 2018, this document contains administrative, vehicle credentialing, driver licensing and law enforcement considerations for jurisdictions that choose to regulate testing and deployment. [American Association of Motor Vehicle Administrators. (2018). *Jurisdictional guidelines for the safe testing and deployment of highly automated vehicles.* Retrieved from https://www.aamva.org/GuidelinesTestingDeploymentHAVs-May2018]
- *Electric Vehicle Charging Station Locations:* Compiled by the DOE's Alternative Fuels Data Center, this online map helps users locate public EV charging stations across the United States. [Electric Vehicle Charging Station Locations. Retrieved from U.S. Department of Energy website: https://www.afdc.energy.gov/fuels/electricity_stations.html]
- Sperling, D. (2018). Three revolutions: *Steering automated, shared, and electric vehicles to a better future.* Washington, DC: Island Press.
- Nordman, E. (2017, March). *Understanding the future of auto insurance in a changing world* (National Association of Insurance Commissioners CIPR Newsletter). Retrieved from http://www.naic.org/cipr_newsletter_archive/vol21_future_auto.pdf

ENDNOTES

1 Bert, J., Collie, B., Gerrits, M., & Xu, G. (2016, February 23). What's ahead for car sharing? Retrieved from https://www.bcg.com/publications/2016/automotive-whats-ahead-car-sharing-new-mobility-its-impact-vehicle-sales.aspx

2 Kerr, D. (2018, January 16). Lyft grows gangbuster in 2017, brining competition to Uber. *CNET.* Retrieved from https://www.cnet.com/news/lyft-sees-massive-growth-brings-uber-competition

3 Huston, C. (2017, May 27). Ride-hailing industry expected to grow eightfold to 285 billion by 2030. *MarketWatch.* Retrieved from https://www.marketwatch.com/story/ride-hailing-industry-expected-to-grow-eightfold-to-285-billion-by-2030-2017-05-24

4 Huston, C. (2017, May 27). Ride-hailing industry expected to grow eightfold to 285 billion by 2030. *MarketWatch.* Retrieved from https://www.marketwatch.com/story/ride-hailing-industry-expected-to-grow-eightfold-to-285-billion-by-2030-2017-05-24

5 Gitlin, J. (2018, January 4). 2017 was the best year ever for electric vehicle sales in the US. *arsTechnica.* Retrieved from https://arstechnica.com/cars/2018/01/2017-was-the-best-year-ever-for-electric-vehicle-sales-in-the-us

6 Loveday, S. (2018, January 3). December 2017 plug-in electric vehicle sales report card. *InsideEVs.* Retrieved from https://insideevs.com/december-2017-plugin-electric-vehicle-sales-report-card

7 Loveday, S. (2018, May 8). April 2018 plug-in electric vehicle sales report card. *InsideEVs.* Retrieved from https://insideevs.com/april-2018-plug-in-electric-vehicle-sales-report-card

8 The Alliance 50X50 Commission on U.S. Transportation Sector Efficiency. (2018). *Halving transportation energy consumption by 2050.* Retrieved from http://www.ase.org/sites/ase.org/files/transportation-white-paper-feb2018.pdf; International Energy Agency. (2017). *Global EV outlook 2017: Two million and counting.* Retrieved from https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

9 International Energy Agency. (2017). *Global EV outlook 2017: Two million and counting.* Retrieved from https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

10 IHS Markit. (2018, January 2). *Autonomous vehicle sales to surpass 33 million annually in 2040, enabling new autonomous mobility in more than 26 percent of new car sales, IHS Markit says* [Press release]. Retrieved from http://news.ihsmarkit.com/press-release/automotive/autonomous-vehicle-sales-surpass-33-million-annually-2040-enabling-new-auto

11 Federal Aviation Administration. (2017). *FAA aerospace forecast: Fiscal years 2017–2037.* Retrieved from https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2017-37_FAA_Aerospace_Forecast.pdf

12 Ibid.

13 Desjardins, J. (2018, February 16). A brief history of technology. Retrieved from https://www.weforum.org/agenda/2018/02/the-rising-speed-of-technological-adoption

14 Desjardins, J. (2018, February 16). A brief history of technology. Retrieved from https://www.weforum.org/agenda/2018/02/the-rising-speed-of-technological-adoption

15 Broekaert, K., & Espinel, V. A. (2018, February 13). How can policy keep pace with the fourth industrial revolution? Retrieved from https://www.weforum.org/agenda/2018/02/can-policy-keep-pace-with-fourth-industrial-revolution

16 Schwab, K. (2016, January 14). The fourth industrial revolution: What it means, how to respond. Retrieved from https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond

17 Collie, B., Rose, J., Choraria, R., & Wegscheider, A. K. (2017, December 18). The reimagined car: Shared, autonomous, and electric. Retrieved from https://www.bcg.com/publications/2017/reimagined-car-shared-autonomous-electric.aspx

18 Rohr, J. (2016, October 19). Strolling with Stroll Guam. *Post Guam.* Retrieved from https://www.postguam.com/business/strolling-with-stroll-guam/article_1ef7cec8-944e-11e6-b520-233a74341018.html

19 Kerr, D. (2018, January 16). Lyft grows gangbusters in 2017, brining competition to Uber. *CNET.* Retrieved from https://www.cnet.com/news/lyft-sees-massive-growth-brings-uber-competition

20 Huston, C. (2017, May 27). Ride-hailing industry expected to grow eightfold to 285 billion by 2030. *MarketWatch.* Retrieved from https://www.marketwatch.com/story/ride-hailing-industry-expected-to-grow-eightfold-to-285-billion-by-2030-2017-05-24

21 Molina, B., & Weise, E. (2018, February 21). Uber rolls out cheaper Express Pool service that rivals transit buses. *USA Today.* Retrieved from https://www.usatoday.com/story/tech/news/2018/02/21/uber-rolls-out-cheaper-express-pool-service-rivals-buses/358069002/ (accessed May 9, 2018)

22 Hawkins, A. (2018, February 21). Uber Express Pool offers the cheapest fares yet in exchange for little walking. *The Verge.* Retrieved from https://www.theverge.com/2018/2/21/17020484/uber-express-pool-launch-cities

23 Calbaugh, J. (2016, August 1). New ride-sharing service in DC charges just $2.15 per ride. *Washington Top News.* Retrieved from https://wtop.com/business-finance/2016/08/new-ride-sharing-service-in-dc-charges-just-2-15-per-ride

24 Bert, J., Collie, B., Gerrits, M., & Xu, G. (2016, February 23). What's ahead for car sharing? Retrieved from https://www.bcg.com/publications/2016/automotive-whats-ahead-car-sharing-new-mobility-its-impact-vehicle-sales.aspx

25 Loveday, S. (2018, January 3). December 2017 plug-in electric vehicle sales report card. *InsideEVs.* Retrieved from https://insideevs.com/december-2017-plugin-electric-vehicle-sales-report-card; Gitlin, J. (2018, January 4). 2017 was the best year ever for electric vehicle sales in the US. *arsTechnica.* Retrieved from https://arstechnica.com/cars/2018/01/2017-was-the-best-year-ever-for-electric-vehicle-sales-in-the-us

26 The Alliance 50X50 Commission on U.S. Transportation Sector Efficiency. (2018). *Halving transportation energy consumption by 2050.* Retrieved from http://www.ase.org/sites/ase.org/files/transportation-white-paper-feb2018.pdf

27 International Energy Agency. (2017). *Global EV outlook 2017: Two million and counting.* Retrieved from https://www.iea.org/publications/freepublications/publication/GlobalEVOutlook2017.pdf

28 Fitzgerald, G., & Nelder, C. (2017). *From gas to grid.* Retrieved from https://www.rmi.org/insights/reports/from_gas_to_grid/

29 Ibid.

30 Ibid.

31 Memorandum of understanding between Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming regional electric vehicle plan for the west. (2017, October 12). Retrieved from https://www.colorado.gov/governor/sites/default/files/rev_west_plan_mou_10_12_17_all_states_final_1.pdf

32 Norsworthy, M., Craft, E., & Wolfe, C. (2015). *Clean air guide for ports & terminals: Technologies and strategies to reduce emissions and save energy.* Retrieved from https://www.edf.org/sites/default/files/content/edf_clean_air_guide_for_ports_terminals_0.pdf

33 Volkswagen Clean Air Act Civil Settlement. (n.d.). Retrieved from https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement

34 Ibid.

35 Gerdes, J. (2018, March 7). Tesla and Uber weigh in on policies to boost EV adoption. Retrieved from https://www.greentechmedia.com/articles/read/tesla-and-uber-weigh-in-on-policies-to-boost-ev-adoption#gs.4Dhjvvs

36 National Association of City Transportation Officials. (2017). Bike share in the U.S.: 2017. Retrieved from https://nacto.org/wp-content/uploads/2018/05/NACTO-Bike-Share-2017.pdf

37 Elliott Bay Design Group. (2018). *Jumbo Mark II class hybrid system integration study* (Ref: 17102-070-0). Retrieved from http://www.wsdot.wa.gov/NR/rdonlyres/6C78A08B-19A1-4919-B6E6-E9EF83E6376D/123052/HybridSystemIntegrationStudy.pdf

38 Hydrogen fuel cell vehicles. (2017, December 5). Retrieved from https://www.epa.gov/greenvehicles/hydrogen-fuel-cell-vehicles

39 Fuel cell electric vehicles. (2017, April 12). Retrieved from https://www.afdc.energy.gov/vehicles/fuel_cell.html

40 Muoio, D. (2017, July 17). Elon Musk predicts the 3 biggest changes hitting the auto industry in 20 years (TSLA). *Business Insider.* Retrieved from http://markets.businessinsider.com/news/stocks/elon-musk-how-the-auto-industry-will-change-in-20-years-2017-7-1002179497

41 IHS Markit. (2018, January 2). *Autonomous vehicle sales to surpass 33 million annually in 2040, enabling new autonomous mobility in more than 26 percent of new car sales, IHS Markit says* [Press release]. Retrieved from http://news.ihsmarkit.com/press-release/automotive/autonomous-vehicle-sales-surpass-33-million-annually-2040-enabling-new-auto

42 Automated vehicles for safety. (n.d.). Retrieved from https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

43 Beres, D. (2016, August 17). Autonomous cars may one day be data hogs. *Mashable.* Retrieved from https://mashable.com/2016/08/17/intel-autonomous-car-data/

44 Federal Aviation Administration. (2017). *FAA aerospace forecast: Fiscal years 2017–2037.* Retrieved from https://www.faa.gov/data_research/aviation/aerospace_forecasts/media/FY2017-37_FAA_Aerospace_Forecast.pdf

45 Cohn, P., Green, A., Langstaff, M., & Roller, M. (2017). Commercial drones are here: The future of unmanned aerial systems. Retrieved from https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/commercial-drones-are-here-the-future-of-unmanned-aerial-systems

46 Mazur, M., Wisniewski, A., & McMillan, J. (2016). *Clarity from above: PwC report on the commercial applications of drone technology.* Retrieved from https://www.pwc.pl/en/publikacje/2016/clarity-from-above.html

47 Spectrum Business. (2015). *Fiber or coaxial: Which one is best for your property?* Retrieved from https://sb.spectrum.com/mediacontent/pdfs/sb-wp-fiber-or-coax.pdf

48 Communications Act of 1934, 41 U.S.C. § 57 (1934). Retrieved from https://transition.fcc.gov/Reports/1934new.pdf

49 Federal Communications Commission. (2018, February 2). *2018 Broadband deployment report* (GN Docket No. 17-199). Retrieved from https://apps.fcc.gov/edocs_public/attachmatch/FCC-18-10A1.pdf

50 IHS Markit. (2017, June). *The urban unconnected.* Retrieved from http://worldwifiday.com/wp-content/uploads/2017/06/The-Urban-Unconnected_White-Paper_FINAL-1.pdf

51 Deloitte. (2017). *Wireless connectivity fuels industry growth and innovation in energy, health, public safety, and transportation.* Retrieved from https://api.ctia.org/docs/default-source/default-document-library/deloitte_2017011987f8479664c467a6bc70ff0000ed09a9.pdf

52 Fixed broadband deployment data from FCC Form 477. (2016, December). Retrieved from https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477

53 Federal Communications Commission. (2018, January 2). *Ex parte comments of the National Telecommunications and Information Administration* (WC Docket No. 11–10). Retrieved from https://www.ntia.doc.gov/files/ntia/publications/ntia_comments_on_modernizing_the_fcc_form_477_data_program.pdf

54 U.S. Census Bureau. (2012, July 25). *Nearly 1 in 5 people have a disability in the U.S.* [Press release]. Retrieved from https://www.census.gov/newsroom/releases/archives/miscellaneous/cb12-134.html; U.S. Department of Transportation, Bureau of Transportation Statistics. (2003, April). *Transportation difficulties keep over half a million disabled at home* (Issue Brief). Retrieved from https://www.bts.gov/sites/bts.dot.gov/files/legacy/publications/special_reports_and_issue_briefs/issue_briefs/number_03/pdf/entire.pdf

55 Ortman, J. M. (2012, December 14). A look at the U.S. population in 2060. Retrieved from https://www.census.gov/newsroom/cspan/pop_proj/20121214_cspan_popproj.pdf

56 Etherington, D. (2018, March 1). Uber launches Uber Health, a B2B ride-hailing platform for healthcare. *TechCrunch.* Retrieved from https://techcrunch.com/2018/03/01/uber-launches-uber-health-a-b2b-ride-hailing-platform-for-healthcare; Musulin, K. (2018, March 5). Lyft, Allscripts partner for healthcare platform. Retrieved from https://www.smartcitiesdive.com/news/lyft-allscripts-partner-healthcare-platform/518370

57 Parker, K., Horowitz, J. M., & Rohal, M. (2015). *Raising kids and running a household: How working parents share the load.* Retrieved from http://www.pewsocialtrends.org/2015/11/04/raising-kids-and-running-a-household-how-working-parents-share-the-load

58 U.S. Department of Labor, Bureau of Labor Statistics. (2017, August 29). *Consumer expenditures–2016* [Press release]. Retrieved from https://www.bls.gov/news.release/cesan.nr0.htm

59 Barter, P. (2013, February 22). "Cars are parked 95% of the time". Let's check! Retrieved from https://www.reinventingparking.org/2013/02/cars-are-parked-95-of-time-lets-check.html

60 Rodriguez, J. F. (2018, February 27). Group files class-action law suit against Uber for "discrimination," lack of wheelchair access. *The San Francisco Examiner.* Retrieved from http://www.sfexaminer.com/group-files-class-action-suit-uber-discrimination-lack-wheelchair-access

61 U.S. Department of Transportation, Federal Highway Administration. (2017, February 21). *3.2 Trillion miles driven on U.S. roads in 2016* [Press release]. Retrieved from https://www.fhwa.dot.gov/pressroom/fhwa1704.cfm

62 Bliss, L. (2017, December 24). Ride-hailing apps are clogging New York's streets. *The Atlantic.* Retrieved from https://www.theatlantic.com/business/archive/2017/12/ride-hailing-new-york-traffic/549131

63 Clewlow, R. R. (n.d.). New research on how ride-hailing impact travel behavior. Retrieved from https://steps.ucdavis.edu/new-research-ride-hailing-impacts-travel-behavior; Fare choices: A survey of ride-hailing passengers in metro Boston report #1. (2018, February). Retrieved from Metropolitan Area Planning Council website: https://www.mapc.org/farechoices

64 Clewlow, R. R. (n.d.). New research on how ride-hailing impact travel behavior. Retrieved from https://steps.ucdavis.edu/new-research-ride-hailing-impacts-travel-behavior

65 Fare choices: A survey of ride-hailing passengers in metro Boston report #1. (2018, February). Retrieved from https://www.mapc.org/farechoices

66 Ibid.

67 National Automobile Dealers Association. (n.d.). Driving the United States' economy: Annual contribution of United States' new-car dealers. Retrieved from https://www.nada.org/WorkArea/DownloadAsset.aspx?id=21474837318

68 Wall, M. (2016). *Automotive industry outlook: Navigating the waters in a post-recovery environment.* Retrieved from https://www.spratings.com/documents/20184/908551/US_CO_Event_Auto2016_Article3.pdf

69 Highway statistic series: Highway statistics 2013. (2016, January). Retrieved from https://www.fhwa.dot.gov/policyinformation/statistics/2013/mv2.cfm

70 Special report: How autonomous vehicles could constrain city budgets. (n.d.). *Governing the States and Localities.* Retrieved from http://www.governing.com/gov-data/gov-how-autonomous-vehicles-could-effect-city-budgets.html#data

71 Zipkin, A. (2017, December 11). Airports are losing money as ride-hailing services grow. *The New York Times.* Retrieved from https://www.nytimes.com/2017/12/11/business/airports-ride-hailing-services.html

72 National Academies of Sciences, Engineering, and Medicine; Transportation Research Board; Airport Cooperative Research Program; & Mandle, P., & Box, S. (2017). *Transportation network companies: Challenges and opportunities for airport operators.* Retrieved from The National Academies of Sciences, Engineering, and Medicine website: https://www.nap.edu/catalog/24867/transportation-network-companies-challenges-and-opportunities-for-airport-operators

73 Flamm, M., & Geiger, D. (2018, February 21). Uber and Lyft crushed taxis—is the commercial parking industry next? *Crain's New York Business.* Retrieved from http://www.crainsnewyork.com/article/20180221/FEATURES/180219923

74 Oristagilo, K. (2017, June 19). New regulations for transportation network companies go into effect July 1. *TC Palm.* Retrieved from https://www.tcpalm.com/story/specialty-publications/progress-and-innovation/2017/06/19/new-regulations-transportation-network-companies-go-into-effect-july-1/366898001

75 Transportation network company (TNC) legislation. (n.d.). Retrieved from https://policy.tti.tamu.edu/technology/tnc-legislation/

76 Let's find smarter ways forward. (2018). Retrieved from https://movement.uber.com

77 Marshall, A. (2018, April 16). Uber makes peace with cities by spilling its secrets. *Wired.* Retrieved from https://www.wired.com/story/uber-nacto-data-sharing

78 Power sector carbon dioxide emissions fall below transportation sector emissions. (2017, January 19). Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=29612

79 Health Effects Institute Panel on the Health Effects of Traffic-Related Air Pollution. (2010). *Traffic-related air pollution: A critical review of the literature on emissions, exposure, and health effects.* Retrieved from the Health Effects Institute website: https://www.healtheffects.org/publication/traffic-related-air-pollution-critical-review-literature-emissions-exposure-and-health

80 Health care satellite account. (n.d.). Retrieved from https://www.bea.gov/national/health_care_satellite_account.htm

81 WHO: Global Urban Ambient Air Pollution Database (update 2016). Retrieved from http://www.who.int/phe/health_topics/outdoorair/databases/cities/en

82 Khan, S., & Vaidyanathan, S. (2018, February 13). *Strategies for integrating electric vehicles into the grid.* Retrieved from American Council for an Energy-Efficient Economy website: http://aceee.org/research-report/t1801

83 Dennis, K., Colburn, K., & Lazar, J. (2016). Environmentally beneficial electrification: The dawn of "emissions efficiency." *The Electricity Journal, 29*(6), 52–58. doi:10.1016/j.tej.2016.07.007

84 Norsworthy, M., Craft, E., & Wolfe, C. (2015). *Clean air guide for ports & terminals: Technologies and strategies to reduce emissions and save energy.* Retrieved from https://www.edf.org/sites/default/files/content/edf_clean_air_guide_for_ports_terminals_0.pdf

85 *San Pedro Bay Ports clean air action plan 2017: Final clean air action plan update.* (2017). Retrieved from http://www.cleanairactionplan.org/documents/final-2017-clean-air-action-plan-update.pdf

86 The Port of Virginia. (2014, December 9). *NIT's automated gate system preps to "go-live"* [Press release]. Retrieved from http://www.portofvirginia.com/nits-automated-gate-system-preps-go-live/

87 *San Pedro Bay Ports clean air action plan 2017: Final clean air action plan update.* (2017). Retrieved from http://www.cleanairactionplan.org/documents/final-2017-clean-air-action-plan-update.pdf

88 *Total cost of ownership for current plug-in electric vehicles: Update to model 2013 and 2014 model year vehicles.* (2014). Retrieved from Electric Power Research Institute website: https://www.epri.com/#/pages/product/000000003002004054

89 Fitzgerald, G., & Nelder, C. (2017). *From gas to grid.* Retrieved from https://www.rmi.org/insights/reports/from_gas_to_grid/

90 Khan, S., & Vaidyanathan, S. (2018, February 13). *Strategies for integrating electric vehicles into the grid.* Retrieved from American Council for an Energy-Efficient Economy website: http://aceee.org/research-report/t1801

91 Baumhefner, M., & Hwang, R. (2016, June 16). *Driving out pollution: How utilities can accelerate the market for electric vehicles.* Retrieved from Natural Resources Defense Council website: https://www.nrdc.org/resources/driving-out-pollution-how-utilities-can-accelerate-market-electric-vehicles

92 Energy Security Leadership Council. (2016). *A national strategy for energy security: The innovation revolution.* Retrieved from http://secureenergy.org/wp-content/uploads/2016/06/SAFE-National-Strategy-for-Energy-Security-2016.pdf

93 M.J. Bradley & Associates. (2017). *Electric vehicle cost-Benefit analysis.* Retrieved from https://www.nrdc.org/sites/default/files/mi-pev-cb-analysis.pdf

94 Knupfer, S. M., Hensley, R., Hertzke, P., Schaufuss, P., Laverty, N., & Kramer, N. (2017). *Electrifying insights: How automakers can drive electrified vehicle sales and profitability.* Retrieved from https://www.mckinsey.com/~/media/mckinsey/industries/automotive%20and%20assembly/our%20insights/electrifying%20insights%20how%20automakers%20can%20drive%20electrified%20vehicle%20sales%20and%20profitability/how%20automakers%20can%20drive%20electrified%20vehicle%20sales%20and%20profitabilitymck.ashx

95 Margin call: Refining capacity in a 2°C world. (2017, November 2). Retrieved from https://www.carbontracker.org/reports/margin-call-refining-capacity-2-degree-world

96 Bousso, R., & Zhdannikov, D. (2017, November 6). Shell looks beyond road fuels to secure future of refining. Retrieved from https://www.reuters.com/article/shell-refining/shell-looks-beyond-road-fuels-to-secure-future-of-refining-idUSL8N1N06AG

97 Hartman, K., & Dowd, E. (2017, September 26). State Efforts to Promote Hybrid and Electric Vehicles. Retrieved from http://www.ncsl.org/research/energy/state-electric-vehicle-incentives-state-chart.aspx

98 *Metals & Mining–Global: Metal supply shortfall likely to slow battery electric vehicles near term.* (n.d.). Retrieved from Moody's website: https://www.moodys.com/researchdocumentcontentpage.aspx?docid=PBC_1114731

99 Olivett, E. A., Ceder, G., Gustard, G., & Fu, X. (2017). Lithium-ion battery supply chain considerations: Analysis of potential bottlenecks in critical metals. *Joule, 1*(2), 229–243. Retrieved from https://doi.org/10.1016/j.joule.2017.08.019

100 Khan, S., & Vaidyanathan, S. (2018, February 13). *Strategies for integrating electric vehicles into the grid.* Retrieved from American Council for an Energy-Efficient Economy website: http://aceee.org/research-report/t1801

101 National Renewable Energy Laboratory. (2018, January 22). *NREL research determines integration of plug-in electric vehicles should play big role in future electric system planning* [Press release]. Retrieved from https://www.nrel.gov/news/press/2018/nrel_research_determines_integration_of_electric_vehicles.html

102 Wood, E., Rames, C., Muratori, M., Raghavan, S., & Melaina, M. (2017). *National plug-in electric vehicle infrastructure analysis.* Retrieved from https://www.nrel.gov/docs/fy17osti/69031.pd

103 Baumhefner, M., & Hwang, R. (2016, June 16). *Driving out pollution: How utilities can accelerate the market for electric vehicles.* Retrieved from Natural Resources Defense Council website: https://www.nrdc.org/resources/driving-out-pollution-how-utilities-can-accelerate-market-electric-vehicles

104 Khan, S., & Vaidyanathan, S. (2018, February 13). *Strategies for integrating electric vehicles into the grid.* Retrieved from American Council for an Energy-Efficient Economy website: http://aceee.org/research-report/t1801

105 Norsworthy, M., Craft, E., & Wolfe, C. (2015). *Clean air guide for ports & terminals: Technologies and strategies to reduce emissions and save energy.* Retrieved from https://www.edf.org/sites/default/files/content/edf_clean_air_guide_for_ports_terminals_0.pdf

106 Baumhefner, M., & Hwang, R. (2016, June 16). *Driving out pollution: How utilities can accelerate the market for electric vehicles.* Retrieved from Natural Resources Defense Council website: https://www.nrdc.org/resources/driving-out-pollution-how-utilities-can-accelerate-market-electric-vehicles

107 National Highway Traffic Safety Administration. (2017, October 6). *USDOT releases 2016 fatal traffic crash data* [Press release]. Retrieved from https://www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data

108 Ingraham, C. (2018, March 7). After decades of improvement, roads are becoming more dangerous for pedestrians again. *The Washington Post.* Retrieved from https://www.washingtonpost.com/news/wonk/wp/2018/03/07/after-decades-of-improvement-roads-are-becoming-more-dangerous-for-pedestrians-again/?utm_term=.8f90038d9084

109 National Highway Traffic Safety Administration. (2017, October 6). *USDOT releases 2016 fatal traffic crash data* [Press release]. Retrieved from https://www.nhtsa.gov/press-releases/usdot-releases-2016-fatal-traffic-crash-data

110 Statistical facts about blindness in the United States. (2018, June). Retrieved from https://nfb.org/blindness-statistics

111 *Autonomous vehicles for the Postal Service* (RARC Report No. RARC-WP-18-001). (2017). Retrieved from https://www.uspsoig.gov/sites/default/files/document-library-files/2017/RARC-WP-18-001.pdf

112 Muratori, M., Holden, J., Lammert, M., Duran, A., Young, S., & Gonder, J. (2017). *Potentials for platooning in U.S. highway freight transport* (Conference Paper No. NREL/CP-5400-67618). Retrieved from https://www.nrel.gov/docs/fy17osti/67618.pdf

113 Walker, A. (2017, April 26). Parking garages are getting a second life as places for people. *Curbed.* Retrieved from https://www.curbed.com/2017/4/26/15421594/parking-garages-driverless-cars-gensler

114 Calthorpe, P., & Walters, J. (2017, March 1). Autonomous vehicles: Hype and potential. *UrbanLand.* Retrieved from https://urbanland.uli.org/industry-sectors/infrastructure-transit/autonomous-vehicles-hype-potential/

115 May 2017 national occupational employment and wage estimates United States. (2018, March 30). Retrieved from https://www.bls.gov/oes/current/oes_nat.htm#53-0000 (accessed May 9, 2018)

116 Centers for Disease Control and Prevention. (2014, October 7). *CDC report shows motor vehicles crash injuries are frequent and costly* [Press release]. Retrieved from https://www.cdc.gov/media/releases/2014/p1007-crash-injuries.html

117 Highway statistics 2013. (2016, January). Retrieved from https://www.fhwa.dot.gov/policyinformation/statistics/2013/mv2.cfm

118 Brandt, E. (2017, October 10). Autonomous cars are getting into accidents because they drive too well. *The Drive.* Retrieved from http://www.thedrive.com/sheetmetal/15023/autonomous-cars-are-getting-into-accidents-because-they-drive-too-well

119 Kaplan, J., Glon, R., Edelstein, S., & Chang, L. (2018, May 8). Video of deadly Uber autonomous car crash raises more questions than it answers. *Digital Trends.* Retrieved from https://www.digitaltrends.com/cars/self-driving-uber-crash-arizona

120 Greenberg, A. (2015, July 21). Hackers remotely kill a Jeep on the highway–with me in it. *Wired.* Retrieved from https://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway

121 Autonomous Vehicle Best Practices Working Group. (n.d.). Retrieved from American Association of Motor Vehicle Administrators website: https://www.aamva.org/Autonomous-Vehicle-Best-Practices-Working-Group

122 Blain, G. (2016, May 30). N.Y. pols want to fix 1971 steering wheel law to allow for self-driving cars. *New York Daily News.* Retrieved from http://www.nydailynews.com/news/politics/n-y-self-driving-cars-fix-1971-law-article-1.2654122

123 Digest of motor laws: Video screens. (2018). Retrieved from https://drivinglaws.aaa.com/tag/video-screens

124 Following too closely, Penn. Gen. Ann. § 3310 (1991). Retrieved from http://www.legis.state.pa.us/cfdocs/legis/LI/consCheck.cfm?txtType=HTM&ttl=75&div=0&chpt=33&sctn=10&subsctn=0

125 Crash avoidance (Part 571, Federal Motor Vehicle Standards). (1999, March). Retrieved from https://icsw.nhtsa.gov/cars/rules/import/FMVSS/

126 Average age of automobiles and trucks in operation in the United States. (n.d.). Retrieved from https://www.bts.gov/content/average-age-automobiles-and-trucks-operation-united-states

127 Occupational employment projections. (2018, March 6). Retrieved from https://www.bls.gov/emp/ep_data_occupational_data.htm

128 Reinhart, R. J. (2018, February 21). Americans hit the brakes on self-driving cars. Retrieved from http://news.gallup.com/poll/228032/americans-hit-brakes-self-driving-cars.aspx

129 Mazur, M. (2016, July 20). Six ways drones are revolutionizing agriculture. *MIT Technology Review.* Retrieved from https://www.technologyreview.com/s/601935/six-ways-drones-are-revolutionizing-agriculture; Meola, A. (2017, August 1). Exploring agriculture drones: The future of farming is precision agriculture, mapping, and spraying. *Business Insider.* Retrieved from http://www.businessinsider.com/farming-drones-precision-agriculture-mapping-spraying-2017-8; Margaritoff, M. (2018, February 13). Drones in agriculture: How UAVs make farming more efficient. *The Drive.* Retrieved from http://www.thedrive.com/tech/18456/drones-in-agriculture-how-uavs-make-farming-more-efficient

130 Global Market Insights. (2017). *Agricultural drones market size by product (hardware [fixed wing, multi rotor, nano, hybrid], software [data management, imaging, data analytics]), by application (field mapping, variable rate application, crop scouting), industry analysis report, regional outlook (U.S., Canada, Germany, UK, France, Italy, China, Japan, Australia, South Korea, India, Brazil, Mexico), application potential, price trends, competitive market share & forecast, 2017–2024* (Report ID GMI253). Retrieved from https://www.gminsights.com/industry-analysis/agricultural-drones-market

131 Adams, E. (2018, March 3). Drones help bring back electricity in Puerto Rico. *Wired.* Retrieved from https://www.wired.com/story/drones-electricity-puerto-rico

132 Amazon Prime Air. (2018). Retrieved from https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011

133 Landhuis, E. (2018, March 10). Medical cargo could be the gateway for routine drone deliveries. *National Public Radio.* Retrieved from https://www.npr.org/sections/health-shots/2018/03/10/592059175/medical-cargo-could-be-the-gateway-for-routine-drone-deliveries

134 Stolaroff, J. K., Samaras, C., O'Neill, E. R., Lubers, A., Mitchell, A. S. & Ceperley, D. (2018, March 8). Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery. *Nature Communications.* Retrieved from https://www.nature.com/articles/s41467-017-02411-5

135 American Association of State Highway and Transportation Officials. (2018, March 27). *35 State DOTs are developing drones to save lives, time and money* [Press release]. Retrieved from https://news.transportation.org/Pages/NewsReleaseDetail.aspx?NewsReleaseID=1504

136 Shea, D., Essex, A., & Husch, B. (2016, September 12). Drones and critical infrastructure. Retrieved from http://www.ncsl.org/research/energy/drones-and-critical-infrastructure.aspx

137 Guanajuato, S. (2017, October 20). "Dron bomba" listo para detonar a distancia. *AM.* Retrieved from https://www.am.com.mx/2017/10/20/sucesos/dron-bomba-listo-para-detonar-a-distancia-385808

138 Rassler, D., Al-'Ubaydi, M., & Mironova, V. (2017, January 31). The Islamic State's drone documents: Management, acquisitions, and DIY tradecraft. Retrieved from https://ctc.usma.edu/ctc-perspectives-the-islamic-states-drone-documents-management-acquisitions-and-diy-tradecraft

139 Peters, J. (2015, September 11). Buzz Off? Drones can be awful at sporting events. But they could also be awesome. *Slate.* Retrieved from http://www.slate.com/articles/technology/future_tense/2015/09/drones_in_sports_they_can_help_coaches_and_athletes_but_also_create_major.html

140 Abbasi, W. (2017, June 15). Inmates fly mobile phones, drugs, and porn into jail–via drone. *USA Today.* Retrieved from https://www.usatoday.com/story/news/2017/06/15/inmates-increasingly-look-drones-smuggle-contraband-into-their-cells/102864854

141 Travis, R. (2017, July 19). Threat from the sky: 35 drones already spotted at GA prison this year. *Fox News.* Retrieved from http://www.fox5atlanta.com/news/i-team/threat-from-the-sky-35-drones-already-spotted-at-ga-prisons-this-year

142 Fiegel, B. (n.d.). Narco-drones: A new way to transport drugs. *Small Wars Journal.* Retrieved from http://smallwarsjournal.com/jrnl/art/narco-drones-a-new-way-to-transport-drugs

143 *National Transportation Safety Board aviation incident final report* (No. DCA17IA202A). (2017, September 21). Retrieved from https://app.ntsb.gov/pdfgenerator/ReportGeneratorFile.ashx?EventID=20170922X54600&AKey=1&RType=HTML&IType=IA

144 Grass, M. (2018, March 12). A new way drone hobbyists are endangering first responders. *Route Fifty.* Retrieved from http://www.routefifty.com/public-safety/2018/03/drone-wildfire-arizona/146580

145 Mazur, M., Wisniewski, A., & McMillan, J. (2016). *Clarity from above: PwC report on the commercial applications of drone technology.* Retrieved from https://www.pwc.pl/en/publikacje/2016/clarity-from-above.html

146 U.S. Department of Transportation, Federal Aviation Administration. (2016, July 21). *Operation and certification of small unmanned aircraft systems: Final rule* (Docket FAA-2015-0150). Retrieved from https://www.faa.gov/uas/media/RIN_2120-AJ60_Clean_Signed.pdf; U.S. Department of Transportation, Federal Aviation Administration. (2016, June 21). *Fact sheet–Small unmanned aircraft regulation* (Part 107). Retrieved from https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20516

147 UAS integration pilot program. (2018, May 7). Retrieved from https://www.faa.gov/uas/programs_partnerships/uas_integration_pilot_program

148 Elwell, D. (2017, November 8). Speech–Drone integration. Retrieved from https://www.faa.gov/news/speeches/news_story.cfm?newsId=22294

149 McNeal, G. (2014). *Drones and aerial surveillance: Considerations for legislatures.* Retrieved from https://www.brookings.edu/research/drones-and-aerial-surveillance-considerations-for-legislatures

150 Calabrese, C. (2014, January 15). *The future of unmanned aviation in the U.S. economy: Safety and privacy considerations before the United States Senate Committee on Commerce, Science, and Transportation.* Retrieved from https://www.aclu.org/sites/default/files/assets/domestic_drones_statement_senate_commerce_committee.pdf

151 Hampton, M. (2016). *FAA lacks a risk-based oversight process for civil unmanned aircraft systems.* Retrieved from https://www.insurancejournal.com/app/uploads/2016/12/FAA-Oversight-of-UAS-Final-Report.pdf

152 Desjardins, J. (2018, February 16). A brief history of technology. *The World Economic Forum.* Retrieved from https://www.weforum.org/agenda/2018/02/the-rising-speed-of-technological-adoption

153 Desjardins, J. (2018, February 16). A brief history of technology. Retrieved from https://www.weforum.org/agenda/2018/02/the-rising-speed-of-technological-adoption

154 Broekaert, K., & Espinel, V. A. (2018, February 13). How can policy keep pace with the fourth industrial revolution? Retrieved from https://www.weforum.org/agenda/2018/02/can-policy-keep-pace-with-fourth-industrial-revolution

155 Office of the Governor, Commonwealth of Massachusetts. (2016, October 20). Executive Order No. 572, To promote the testing and deployment of highly automated driving technologies. Retrieved from http://www.mass.gov/courts/docs/lawlib/eo500-599/eo572.pdf; Executive Department, State of Minnesota. (2018, March). Executive Order 18-04, Establishing the Governor's Advisory Council on Connected and Automated Vehicles. Retrieved from https://mn.gov/governor/assets/E.O.%2018-04_tcm1055-328490.pdf

156 Office of the Governor, Commonwealth of Massachusetts. (2018, January 23). Executive Order 579, Establishing the Commission on the Future of Transportation in the Commonwealth. Retrieved from https://www.mass.gov/executive-orders/no-579-establishing-the-commission-on-the-future-of-transportation-in-the

157 Connecticut House Republicans. (2016, August 16). *O'Dea appointed to State Transportation Working Group* [Press release]. Retrieved from http://www.cthousegop.com/odea/2016/08/16/odea-appointed-state-transportation-working-group

158 Office of Governor Rick Snyder. (2017, July 10). *Gov. Rick Snyder makes initial appointments to the Unmanned Aircraft Systems Task Force* [Press release]. Retrieved from http://www.michigan.gov/snyder/0,4668,7-277--425958--,00.html

159 State of Michigan Department of Transportation, Unmanned Aircraft Systems Task Force. (2017). *Unmanned Aircraft Systems Task Force final report.* Retrieved from http://www.michigan.gov/documents/aero/UASTF_Final_Report_v2_Full_606520_7.pdf

160 Maryland Electric Vehicle Infrastructure Council. (2018). Retrieved from http://msa.maryland.gov/msa/mdmanual/26excom/html/13electricv.html

161 Maryland hosts workplace charging workshops. (2018). Retrieved from http://www.mdot.maryland.gov/newMDOT/Planning/Electric_Vehicle/About_the_Council.html

162 S.B. 176, Maryland Legis. (2011). Retrieved from http://mgaleg.maryland.gov/2011rs/chapters_noln/ch_400_sb0176e.pdf

163 S.B. 714, Maryland Legis. (2015). Retrieved from http://mgaleg.maryland.gov/2015RS/chapters_noln/Ch_378_sb0714T.pdf

164 Office of Governor Edmund G. Brown Jr. (2018, January 26). *Governor Brown takes action to increase zero-emission vehicles to fund new climate investments* [Press release]. Retrieved from https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments

165 Memorandum of understanding between Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming regional electric vehicle plan for the west. (2017, October 12). Retrieved from https://www.colorado.gov/governor/sites/default/files/rev_west_plan_mou_10_12_17_all_states_final_1.pdf

166 State of Oregon, Office of the Governor. (2017, November 6). Executive Order 17-20, Accelerating efficiency in Oregon's built environment to reduce greenhouse gas emissions and address climate change. Retrieved from http://www.oregon.gov/gov/Documents/executive_orders/eo_17-20.pdf

167 Ibid.

168 State of Colorado, Office of the Governor. (2017, July 11). Executive Order D 2017-015, Supporting Colorado's clean energy transition. Retrieved from https://www.colorado.gov/governor/sites/default/files/executive_orders/climate_eo.pdf

169 Government of Rhode Island. (2018, April 30). *RIDOT accepting proposals for mobility challenges to bring autonomous transit service to Rhode Island* [Press release]. Retrieved from http://www.ri.gov/press/view/33096

170 Wyoming DOT connected vehicle pilot: Improving safety and travel reliability on I-80 in Wyoming. (2017). Retrieved from https://wydotcvp.wyoroad.info

171 Row, G. C. (2017, June 26). *Pennsylvania DOT SPaT deployments.* Retrieved from https://cote.transportation.org/wp-content/uploads/sites/26/2017/07/SPaT-Deployment-in-PA-Rowe.pdf; *Connected autonomous vehicles.* (2015). Retrieved from http://www.itspennsylvania.com/wp-content/uploads/2015/05/ITSA-App-Connected-Automated-Section.pdf (accessed May 10, 2018)

172 Office of the Governor, State of Ohio. (2018, January 18). Executive Order 2018-01K, Establishing DriveOhio as statewide center for smart mobility. Retrieved from http://www.governor.ohio.gov/Portals/0/%21EX%202018-01K%20%28Drive%20Ohio%29%20SIGNED%20_1.pdf

173 Office of the Governor of Hawaii, State of Hawaii. (2017, November 22). Executive Order 017-07, Autonomous vehicle testing. Retrieved from https://governor.hawaii.gov/wp-content/uploads/2017/11/EO-17-07.pdf

174 Metropolitan Council. (2017, June). *The Twin Cities regional forecast to 2040: Steady growth and big changes ahead.* Retrieved from https://metrocouncil.org/Data-and-Maps/Publications-And-Resources/MetroStats/Land-Use-and-Development/The-Twin-Cities-Regional-Forecast-to-2040-Stea-(1).aspx

175 Shueh, J. (2017, December 13). Minnesota will test its autonomous shuttle on icy roads. *State Scoop.* Retrieved from https://statescoop.com//minnesota-will-test-its-autonomous-shuttle-on-icy-roads

176 Ibid.

177 Office of the Governor, State of Washington. (2018, January 16). Executive Order 18-01, State efficiency and environmental performance. Retrieved from https://www.governor.wa.gov/sites/default/files/exe_order/18-01%20SEEP%20Executive%20Order%20%28tmp%29.pdf

178 P.L. 13-1B through P.L. 12-1B-7, New Mexico Stat. (2018). Retrieved from http://public.nmcompcomm.us/nmnxtadmin/NMPublic.aspx

179 Loans, grants & tax incentives. (2018). Retrieved from http://www.energy.sc.gov/incentives/conserfund

180 Losinio, L. (2017, August 13). GPA to phase out fuel-powered vehicles. *Guam Daily Post.* Retrieved from https://www.postguam.com/news/local/gpa-to-phase-out-fuel-powered-vehicles/article_7838e2b8-7be5-11e7-93c9-4709b00d5e30.html

181 Wilkin, J. (2018, January 24). Eye in the sky: State police launch drone program. *The Daily Gazette.* Retrieved from https://dailygazette.com/article/2018/01/24/eye-in-the-sky-state-police-launch-drone-program

182 Huges, S. (2018, January 25). State police unveil new drone fleet. *Times Union.* Retrieved from https://www.timesunion.com/news/article/State-Police-unveil-new-drone-fleet-12521595.php

183 Walker, B. (2017, May 24). Aerial officers. *Coeur d'Alene/Post Falls.* Retrieved from http://www.cdapress.com/article/20170524/ARTICLE/170529896

184 Lim, J. (2014, September 8). Drones startup Flirtey partners with the University of Nevada, Reno to push UAV delivery forward. *Forbes.* Retrieved from https://www.forbes.com/sites/jlim/2014/09/08/drone-startup-flirtey-partners-with-the-university-of-nevada-reno-to-push-uav-delivery-forward/#676ca9de69d8; Livingston, M. (2018, July 26). Flirtey continues to lead drone delivery industry. *PR Newswire.* Retrieved from https://www.prnewswire.com/news-releases/flirtey-continues-to-lead-drone-delivery-industry-300494221.html

185 Flirtey partners with pioneering ambulance service to launch first emergency delivery program in the United States. (2017, October 10). *PR Newswire.* Retrieved from https://www.prnewswire.com/news-releases/flirtey-partners-with-pioneering-ambulance-service-to-launch-first-emergency-drone-delivery-program-in-united-states-300534046.html

186 Kentucky statewide broadband network moves forward with build-out. (2016, September 20). *Government Technology.* Retrieved from http://www.govtech.com/network/Kentucky-Statewide-Broadband-Network-Moves-Forward-Buildout.html

187 Mid-Atlantic broadband communities and Microsoft launch new Homework Network to bring thousands of students online in rural Virginia. (2017, May 23). Retrieved from https://news.microsoft.com/2017/05/23/mid-atlantic-broadband-communities-and-microsoft-launch-new-homework-network-to-bring-thousands-of-students-online-in-rural-virginia

188 Regional Transportation Commission of Southern Nevada. (2018, February 8). *RTC to launch innovative "ride on demand" paratransit service* [Press release]. Retrieved from https://www.rtcsnv.com/press-archive/rtc-to-launch-innovative-ride-on-demand-paratransit-service

189 Intel News Byte. (2018, January 10). *2018 CES: Ride share fleets map cities around the world through Mobileeye 8 connect* [Press release]. Retrieved from https://newsroom.intel.com/news/ride-share-fleets-map-cities-around-world-through-mobileye-8-connect

190 Wood, C. (2018, March 1). Sidewalk robot test program extended in Washington, D.C., with strong government support. *State Scoop.* Retrieved from https://statescoop.com/sidewalk-robots-dc-starship-technologies-extended

191 Ventureclash. (2017). Retrieved from http://ctinnovations.com/obtain-funding/venture-solutions/ventureclash

192 Council, J. (2017, August 4). Holcomb preparing to put $250M into startups. *Indiana Business Journal.* Retrieved from https://www.ibj.com/articles/64877-holcomb-preparing-to-put-250m-into-startups

193 Office of the Governor, State of New York. (2018, January 28). *Governor Cuomo announces state fair's film festival competition returns for second year* [Press release]. Retrieved from https://www.governor.ny.gov/news/governor-cuomo-announces-state-fairs-drone-film-festival-and-competition-returns-second-year

194 S.B. 140, 76th Nevada Senate Comm. Retrieved from https://www.leg.state.nv.us/Session/76th2011/Bills/SB/SB140_EN.pdf

195 Ackers, M. (2017, June 20). Autonomous vehicles in Nevada roll forward with new legislation. *Las Vegas Sun.* Retrieved from https://lasvegassun.com/news/2017/jun/20/autonomous-vehicles-in-nevada-roll-forward-with-ne

196 Driverless testing of autonomous vehicles. (2018). Retrieved from https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/auto

197 Office of the Governor, State of Arizona. (2018, March 1). *Governor Ducey updates autonomous vehicle executive order* [Press release]. Retrieved from https://azgovernor.gov/governor/news/2018/03/governor-ducey-updates-autonomous-vehicle-executive-order

198 Office of the Governor, State of Arizona. (2018, March 1). Executive Order 2018-04, Advanced autonomous vehicle testing and operating; prioritizing public safety. Retrieved from https://azgovernor.gov/sites/default/files/related-docs/eo2018-04_1.pdf

199 Virginia Tech Transportation Institute part of new state legislation enacted for the testing and use of automated-vehicle technologies, (2016, June 11). Retrieved from https://vtnews.vt.edu/articles/2016/06/vtti-legislation.html

200 H.B. 1754, 91st Arkansas Ass. (2017). Retrieved from http://www.arkleg.state.ar.us/assembly/2017/2017R/Acts/Act797.pdf

201 Globe, K. (2017, August 31). Seven states authorize truck platoon testing. *Land Line Magazine.* Retrieved from http://www.landlinemag.com/story.aspx?storyid=70741#.Wql9QejwaUl

202 Title 14 § 14-293b-1, Connecticut Department of Motor Vehicles (20145). Retrieved from https://eregulations.ct.gov/eRegsPortal/Browse/RCSA?id=Title%2014|14-293b|14-293b-1|14-293b-1

203 FAQ for TNC passengers. (n.d.). Retrieved from https://dmv.ny.gov/more-info/faq-tnc-passengers

204 L.B. 629, Nebraska Legis. (2015). Retrieved from https://nebraskalegislature.gov/FloorDocs/104/PDF/Slip/LB629.pdf

205 Samuels, A. (2017, May 29). Uber, Lyft return to Austin as Texas Gov. Abbott signs ride-hailing measure into law. *The Texas Tribune.* Retrieved from https://www.texastribune.org/2017/05/29/texas-gov-greg-abbott-signs-measure-creating-statewide-regulations-rid

206 Substitute H.B. 7126, P.A. 17-140, Conn. Legis. (2017). Retrieved from https://www.cga.ct.gov/2017/act/pa/2017PA-00140-R00HB-07126-PA.htm

207 S.B. 01502, Conn. Legis. (2017). Retrieved from https://www.cga.ct.gov/2017/BA/2017SB-01502-R00SS1-BA.htm

208 Monahan, R. (2017, April 17). Bill to legalize Uber across Oregon die in legislative committee. *Willamette Week.* Retrieved from http://www.wweek.com/news/state/2017/04/17/bill-to-legalize-uber-across-oregon-dies-in-legislative-committee

209 Alabama laws and incentives for electricity. (2017, April 21). Retrieved from https://www.afdc.energy.gov/fuels/laws/ELEC/AL

210 Electric vehicle price plan. (n.d.). Retrieved from SRP website: http://www.srpnet.com/prices/home/electricvehicle.aspx

211 Tulp, S. (2017, June 20). Programs bring electric cars to low-income people. *USA Today.* Retrieved from https://www.usatoday.com/story/money/cars/2017/06/20/programs-bring-electric-cars-low-income-people/102790350

212 BlueIndy. (2018). Retrieved from https://www.blue-indy.com

213 S.B. 13-1110, 2013 Colorado General Assembly. (2013). Retrieved from https://www.leg.state.co.us/clics/clics2013a/csl.nsf/fsbillcont3/0602C7EBF986A79387257AEE00574BCD?open&file=1110_enr.pdf

214 EV Connecticut CHEAPR. (2018). Retrieved from http://www.ct.gov/deep/cwp/view.asp?a=2684&q=561422&deepNav_GID=2183

215 Introducing Smart-E for EV. (2017). Retrieved from https://ctgreenbank.com/smart-ev

216 Alternative fuels incentive Grants. (2018). Retrieved from http://www.dep.pa.gov/Citizens/GrantsLoansRebates/Alternative-Fuels-Incentive-Grant/Pages/default.aspx#.Vl9OeHarSUk

217 Oklahoma laws and incentives for electricity. (2017, April 21). Retrieved from https://www.afdc.energy.gov/fuels/laws/ELEC/OK

218 State of Oregon, Office of the Governor. (2017, November 6). Executive Order 17-20, Accelerating efficiency in Oregon's built environment to reduce greenhouse gas emissions and address climate change. Retrieved from http://www.oregon.gov/gov/Documents/executive_orders/eo_17-20.pdf

219 U.S. Department of Transportation. (2016, August 30). *Federal Highway Administration announces more than $14 million in grants to test new ways of funding highways* [Press release]. Retrieved from https://www.fhwa.dot.gov/pressroom/fhwa1648.cfm; U.S. Department of Transportation. (2017, October 6). *FHWA awards more than $15 million to six states for exploring new ways to pay for highways* [Press release]. Retrieved from https://www.fhwa.dot.gov/pressroom/fhwa1718.cfm.

220 Getting to OReGO. (n.d.). Retrieved from http://www.myorego.org/about

221 Road User Fee Task Force. (n.d.). Retrieved from http://www.oregon.gov/ODOT/Programs/Pages/Road-User-Fee-Task-Force.aspx

222 Recent legislative actions likely to change gas taxes. (2018, February 20). Retrieved from http://www.ncsl.org/research/transportation/2013-and-2014-legislative-actions-likely-to-change-gas-taxes.aspx

223 The RhodeWorks tolling program. (2018). Retrieved from http://www.dot.ri.gov/tolling/index.php

224 Brainberd, J. (2017, May 25). Evolving responses to state taxation of transportation network companies. *Bloomberg.* Retrieved from https://www.bna.com/evolving-responses-state-n73014451555

225 RCW 46.17.323, Wash. Legis. (2012). Retrieved from http://app.leg.wa.gov/RCW/default.aspx?cite=46.17.323

226 Al Amine, M., Mathias, K., & Dyer, T. (2017). *Smart cities: How 5G can help municipalities become vibrant smart cities.* Retrieved from https://newsroom.accenture.com/content/1101/files/Accenture_5G-Municipalities-Become-Smart-Cities.pdf

227 S.B. 649, 2017–2018 Cal. Legis. (2017). Retrieved from https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB649

228 Harkness, K., Walesh, K., & McCahan, M. (2018, April 19). Approval of actions related to an amendment and a funding and reimbursement agreement by and between the city of San Jose and AT&T DBA New Cingular Wireless PCS, LLC. related to the permitting of small cells on city owned assets in the public right of way [Memorandum]. Retrieved from https://cdn.govexec.com/media/gbc/docs/pdfs_edit/memorandum.pdf

229 Mayor's Office, City of San Jose. (2018, April 23). *City of San Jose reaches agreement with AT&T to deploy small cell technology on city lightpoles* [Press release]. Retrieved from http://www.sanjoseca.gov/DocumentCenter/View/76522

230 Slone, S. (2013, July 9). *Transportation funding commissions II.* Retrieved from http://knowledgecenter.csg.org/kc/content/transportation-funding-commissions-ii; Frisman, R. (2016). *Transportation Finance Panel recommendations.* Retrieved from https://www.cga.ct.gov/2016/rpt/2016-R-0047.htm

231 Fayze, R. (2016, August 16). Zip Code Wilmington receives national recognition. *Technical.ly Delaware.* Retrieved from https://technical.ly/delaware/2016/08/16/zip-code-equip-program-wilmu; Office of the Governor, State of Delaware. (2015, December 7). *Zip Code Wilmington announces all members of initial graduating class obtained employment opportunities* [Press release]. Retrieved from https://news.delaware.gov/2015/12/07/zip-code-wilmington-announces-all-members-of-initial-graduating-class-obtained-employment-opportunities

232 Dakota State University. (2018, February 26). *DSU's new Workforce Development Alliance a "win" for everybody* [Press release]. Retrieved from https://dsu.edu/news/dsus-new-workforce-development-alliance-a-win-for-everybody

233 Office of the Governor, State of North Dakota. (2017, July 21). Executive Order 2017–10. Retrieved from http://www.jobsnd.com/sites/default/files/Executive-Order-201710-Workforce-Development-Council.pdf

234 Office of the Governor, State of Indiana. (2018, March 1). Executive Order 18-04, Creation of the Office of Apprenticeship &Work-Based Learning. Retrieved from http://in.gov/gov/files/20180301112440245.pdf

235 Central Piedmont Community College. (2018, April 2). *Tesla establishes START training program at CPCC* [Press release]. Retrieved from https://www.cpcc.edu/news/tesla-establishes-start-training-program-at-cpcc; Tesla START: Student automotive technician program. (2018). Retrieved from https://www.tesla.com/careers/tesla-start?redirect=no

236 South Carolina Cyber. (2018, March 8). *We're growing– Announcement of North Augusta office opening* [Press release]. Retrieved from https://www.sccyber.org/news/news.asp?id=390170

237 H.B. 1033, 2014 Louis. Legis. (2014). Retrieved from http://www.legis.la.gov/Legis/ViewDocument.aspx?d=915596

238 Wogan, J. B. (2018, March). Can apprenticeships train the workforce of the future? States hope so. *Governing the States and Localities.* Retrieved from http://www.governing.com/topics/mgmt/gov-work-study-student-debt-apprenticeships.html

239 PennDOT, "PennDOT Announces statewide innovations challenge Winner" Press Release May 3, 2018 Retreviwed from http://www.penndot.gov/pages/all-news-details.aspx?newsid=490

240 Why RoadX? (n.d.). Retrieved from https://www.codot.gov/programs/roadx/programs/roadx/why-roadx

241 Ibid.

242 Georgia Department of Transportation. (2018, February 20). *GDOT broadband deployment project moves ahead* [Press release]. Retrieved from https://us13.campaign-archive.com/?u=80dbe14272ec0b5e1a1bf5b4e&id=fdd3edb6eb

243 Wisconsin Broadband Office. (n.d.). Retrieved from https://psc.wi.gov/Pages/Programs/WBO.aspx

244 New York Broadband Program Office. (n.d.). Retrieved from https://nysbroadband.ny.gov

245 Shesh, J. (2017, November 29). Broadband cooperatives could be the overlooked solution to rural America's internet woes. *State Scoop.* Retrieved from https://statescoop.com/broadband-cooperatives-could-be-the-overlooked-solution-to-rural-americas-internet-woes

246 Montana Telecommunications Association. (2016). *Conquering Montana's divide: A report on the state of rural broadband.* Retrieved from http://www.broadbandmt.com/wp-content/uploads/2016/10/MTA_Broadband_Report_2016.pdf

247 Ibid.

248 Lutey, T. (2015, July 21). USDA funds 30 million for broadband in rural Montana. *Government Technology.* Retrieved from http://www.govtech.com/network/USDA-Funds-30-Million-for-Broadband-in-Rural-Montana.html

249 Electric programs. (n.d.). Retrieved from https://www.rd.usda.gov/programs-services/all-programs/electric-programs

250 P.L. 853, No. 88, 74 PA C.S., 2012 Penn. Legis. (2012). Retrieved from http://www.legis.state.pa.us/cfdocs/legis/li/uconsCheck.cfm?yr=2012&sessInd=0&act=88

251 Broadband public-private partnership (P3). (2018). Retrieved from https://www.paturnpike.com/business/Broadband_P3.aspx

252 Crawczeniuk, B. (2018, April 30). Turnpike plan to expand internet access in area. *The Times-Tribune.* Retrieved from http://thetimes-tribune.com/news/turnpike-plan-to-expand-internet-access-in-area-1.2331616

253 Enwemeca, Z. (2016, June 16). MassDOT partners with Waze in hope of easing transit in Mass. *Bontonmix;* Healey, M. (2015, December 15). Gov. *Wolf announces partnership with Waze to improve traveler information* [Press release]. Retrieved from https://www.governor.pa.gov/round-up-gov-wolf-announces-partnership-with-waze-connected-citizens-program-to-improve-traveler-information; Virginia Department of Transportation. (2016, December 12). *VDOT partners with Waze Connected Citizens program to improve travel on Virginia's roadways* [Press release]. Retrieved from http://www.virginiadot.org/newsroom/statewide/2016/vdot_partners_with_waze109749.asp; Cash, T. (2017, January 10). Wisconsin DOT joins Waze Connected Citizens program. *WTMJ News.* Retrieved from https://www.tmj4.com/news/local-news/wisconsin-dot-joins-waze-connected-citizens-program; AASHTO. (2017, April 28). *DelDOT provides real time crowd source traffic management through new data exchange partnership* [Press release]. Retrieved from http://news.transportation.org/Pages/StateDotNewsDetail.aspx?MessageId=50340

254 Autonomous vehicles in California. (2018). Retrieved from https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/bkgd

255 Office of the Governor, State of Connecticut. (2014, February 20). Executive Order 39. Retrieved from http://www.ct.gov/opm/lib/opm/secretary/open_data/eo_39_open_data.pdf

256 Eidam, E. (2017, July 28). Legislation makes data-driven decision-making part of Indiana's cultural governance fabric. *Government Technology.* Retrieved from http://www.govtech.com/data/Legislation-Makes-Data-Driven-Decision-Making-Part-of-Indianas-Cultural-Governance-Fabric.html; About MPH. (2018). Retrieved from http://www.in.gov/mph/932.htm

257 State of Idaho cybersecurity awareness. (n.d.). Retrieved from https://cybersecurity.idaho.gov

258 The impact leaders for cyber-physical control. (n.d.). Retrieved from https://www.inl.gov/cybercore-integration-center

259 Georgia Cyber Center. (n.d.). Retrieved from https://cybercenter.georgia.gov

260 *Nevada Office of Cyber Defense Coordination: Strategic Plan 2018 - 2020.* (2017). Retrieved from http://dps.nv.gov/uploadedFiles/dpsnvgov/content/divisions/OCDC/home/Nevada-Office-of-Cyber-Defense-Coordination_Strategic-Plan_2018%202020.pdf

261 Office of Governor, Commonwealth of Virginia. (2015, September 30). *Virginia cyber security research leading the way in safeguarding nation's first responders* [Press release]. Retrieved from https://www.vita.virginia.gov/about/news-events/news-archive/2015-news--events/virginia-cyber-security-research-leading-the-way-in-safeguarding-nations-first-responders.html

262 Executive Department, State of Vermont. (2017, October 10). Executive Order 18-17, Governor's Cybersecurity Advisory Team. Retrieved from http://governor.vermont.gov/sites/scott/files/documents/EO%2018-17%20-%20Governor%27s%20Cybersecurity%20Advisory%20Team.pdf

263 Insurance Institute for Highway Safety Highway Loss Data Institute. (2016). Crashes avoided: Front crash prevention slashes police-reported rear-end crashes. *Status Report, 51*(1). Retrieved from http://www.iihs.org/iihs/news/desktopnews/crashes-avoided-front-crash-prevention-slashes-police-reported-rear-end-crashes

264 Insurance Institute for Highway Safety Highway Loss Data Institute. (2017). New estimates of safety features in vehicle fleet. *Status Report, 52*(10). Retrieved from http://www.iihs.org/iihs/sr/statusreport/article/52/10/2

265 Krisher, T. (2016, June 8). Car buyers paying extra for safety devices are unlikely to get insurance discounts. Yet. *Chicago Tribune.* Retrieved from http://www.chicagotribune.com/classified/automotive/sc-car-insurance-adas-discounts-autocover-0616-20160608-story.html

266 Wagner, F., Roberts, D., Francfort, J., & White, S. (2016). *Drive Electric Vermont case study.* Retrieved from https://www.energy.gov/sites/prod/files/2016/06/f32/Vermont%20Case%20Study.pdf

267 A.S. 18.66.010, 30th Alaska Legis. § 18.65.901 (2017). Retrieved from http://www.legis.state.ak.us/basis/statutes.asp#18.66

268 20 V.S.A. § 4622. Vermont legis (2016). Retrieved from https://legislature.vermont.gov/statutes/section/20/205/04622

269 Gallagher, J. (2016, June 2). Gov. Rick Snyder unveils Michigan branding campaign called Planet M. *Detroit Free Press.* Retrieved from https://www.freep.com/story/money/business/michigan/2016/06/01/detroit-chamber-mackinac-snyder-transportation-mobility-peters/85242712

270 Michigan's partnership network for mobility. (2018). Retrieved from https://planetm.michiganbusiness.org/what-is-planet-m/partners

271 acmwillowrun.org "Toyota Research Institute Joins Study of Workforce Impact from Automated Vehicles" American Center for Mobility (June 27, 2018) Retrieved from http://www.acmwillowrun.org/the-project/

272 Burden, M. (2017, June 20). GM testing smart road tech with MDOT, Macomb Co. *The Detroit News.* Retrieved from https://www.detroitnews.com/story/business/autos/mobility/2017/06/20/gm-smart-road-mdot-macomb/103055834

273 U.S. Department of Transportation. (2017, January 19). *U.S. Department of Transportation designates 10 automated vehicle proving grounds to encourage testing of new technologies* [Press release]. Retrieved from https://www.transportation.gov/briefing-room/dot1717

274 Memorandum of understanding regarding the automotive industry of Michigan and Ontario. (2016, August 3). Retrieved from https://www.michigan.gov/documents/snyder/MOU_Wynne_8.3.16_531251_7.pdf

275 Michigan Department of Transportation. (2017, January 18). *MDOT forms "Smart Belt Coalition" to collaborate on connected/automated vehicle initiatives* [Press release]. Retrieved from http://www.michigan.gov/mdot/0,4616,7-151--402603--,00.html

276 Traditional inspection techniques: The foundation of structural health monitoring (2007). Retrieved from http://iti.northwestern.edu/news/2008/04-08_inspection_techniques.html

277 Lovelace, B. (2015). *Unmanned aerial vehicle bridge inspection demonstration project* (Final Report 2015-40). Retrieved from http://www.dot.state.mn.us/research/TS/2015/201540.pdf

278 Crossroads. (2017, August 24). New project: Phase 3 of drone bridge inspection research focuses on confined spaces [Web log post]. Retrieved from Crossroads website: https://mntransportationresearch.org/2017/08/24/new-project-phase-3-of-drone-bridge-inspection-research-focuses-on-confined-spaces

279 Lovelace, B. (2015). *Unmanned aerial vehicle bridge inspection demonstration project* (Final Report 2015-40). Retrieved from http://www.dot.state.mn.us/research/TS/2015/201540.pdf

280 Crossroads. (2017, August 24). New project: Phase 3 of drone bridge inspection research focuses on confined spaces [Web log post]. Retrieved from Crossroads website: https://mntransportationresearch.org/2017/08/24/new-project-phase-3-of-drone-bridge-inspection-research-focuses-on-confined-spaces

281 Nevada Governor's Office of Energy. (2015, June 16). *Governor Sandoval and NV Energy announce the Nevada electric highway* [Press release]. Retrieved from http://energy.nv.gov/Media/Press_Releases/2015/Governor_Sandoval_and_NV_Energy_Announce_the_Nevada_Electric_Highway

282 energy.nv.gov, "Nevada Electric Highway" Nevada Governor's Office of Energy. Revived from http://energy.nv.gov/Programs/Nevada_Electric_Highway/

283 Nevada Governor's Office of Energy. (2018). *Nevada electric highway phase I to link northern and southern Nevada with electric vehicle charging stations along U.S. Route 95* [Fact Sheet]. Retrieved from http://energy.nv.gov/uploadedFiles/energynvgov/content/Programs/Nevada%20Electric%20Highway%20Fact%20Sheet%20Feb%202018.pdf

284 Ibid.

285 Nevada Department of Transportation. (2018, March 8). *Nevada further expands electric vehicle infrastructure* [Press release]. Retrieved from https://www.nevadadot.com/Home/Components/News/News/3506/395

286 Memorandum of understanding between Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming regional electric vehicle plan for the west. (2017, October 12). Retrieved from https://www.colorado.gov/governor/sites/default/files/rev_west_plan_mou_10_12_17_all_states_final_1.pdf

287 Office of Nevada Governor. (2016). *"Generations to come": Nevada's strategic planning framework, 2016–2020.* Retrieved from http://gov.nv.gov/uploadedFiles/govnvgov/Content/StrategicPlan/GovernorsPlanningFrameworkFinal.pdf

288 *Topic guides on ADA transportation. Topic guide 3: Eligibility.* (n.d.). Retrieved from https://dredf.org/ADAtg/elig.shtml

289 Office of Massachusetts Governor. (2016, September 16). *Governor Baker, MBTA launch RIDE pilot program with Uber, Lyft* [Press release]. Retrieved from http://www.mass.gov/governor/press-office/press-releases/fy2017/governor-t-launch-ride-pilot-program-with-uber-lyft.html

290 Powell, E. (2016, September 17). MBTA, Uber and Lyft join forces: Is this the future of paratransit? *The Christian Science Monitor.* Retrieved from https://www.csmonitor.com/USA/2016/0917/MBTA-Uber-and-Lyft-join-forces-Is-this-the-future-of-paratransit

291 Massachusetts Bay Transportation Authority. (2017, February 28). *Governor Baker, MBTA celebrate expansion of The RIDE's on-demand paratransit service* [Press release]. Retrieved from https://mbta.com/news/2017-02-28/governor-baker-mbta-celebrate-expansion-the-rides-demand-paratransit-service

292 Metzger, A. (2018, February 28). MBTA's disabled customers switch to Uber, Lyft. *Boston Globe.* Retrieved from https://www.bostonglobe.com/metro/2018/02/27/mbta-disabled-customers-switch-uber-lyft/CO8S5Cohy0gjorj6rQk1XO/story.html

293 Draft memorandum for the record: Access Advisory Committee to the Massachusetts Bay Transportation Authority (AACT) membership minutes. (2017, November 15). Retrieved from http://www.bostonmpo.org/data/calendar/htmls/2017/AACT_1220_Draft_Minutes_1115.htm

294 mbta.com, "On-Demand Paratransit Pilot Program" Massachusetts Bay Transportation Authority, https://www.mbta.com/accessibility/the-ride/on-demand-pilot

295 Roman, A. (2017, May 3). How transit agencies are alleviating demand for paratransit services. *Metro Magazine.* Retrieved from http://www.metro-magazine.com/accessibility/article/722158/how-transit-agencies-are-alleviating-demand-for-paratransit-services

296 Establishing an Executive Work Group to Advance Smart Communities in Virginia, Virginia Executive Directive 13 (August 2, 2017). Retrieved from https://wayback.archive-it.org/4186/20180111033122/http://technology.virginia.gov/media/9395/ed-13-establishing-an-executive-work-group-to-advance-smart-communities-in-virginia.pdf

297 Virginia Smart Communities (VASC) Working Group. (2017). *Virginia Smart Communities Working Group Report: Initial findings and recommendations.* Retrieved from https://wayback.archive-it.org/4186/20180111033123/http://technology.virginia.gov/media/9713/vasc-interim-report_final.pdf; Office of the Governor, Commonwealth of Virginia. (2018, March 12). *Governor Northam announces Virginia as recipient of Smart Cities Grant* [Press release]. Retrieved from https://governor.virginia.gov/newsroom/newsarticle?articleId=25723

298 Wood, C. (2018, January 11). Virginia's smart communities work expected to continue under new governor. *State Scoop.* Retrieved from https://statescoop.com/virginias-smart-communities-work-expected-to-continue-under-new-governor

299 Nist.gov, "Superculsters" National Institute of Standards and Technology. Retrieved from https://pages.nist.gov/GCTC/

300 Office of the Governor, Commonwealth of Virginia. (2017, November 20). *Governor McAuliffe announces initial findings and recommendations report of the Virginia Smart Communities Working Group* [Press release]. Retrieved from https://wayback.archive-it.org/4186/20180111032202/https://technology.virginia.gov/news/newsarticle?articleId=21810

301 Virginia Smart Communities (VASC) Working Group. (2017). *Virginia Smart Communities Working Group Report: Initial findings and recommendations.* Retrieved from https://wayback.archive-it.org/4186/20180111033123/http://technology.virginia.gov/media/9713/vasc-interim-report_final.pdf

302 Smart Cities Council announces 2018 Readiness Challenge Grant winners. (2018, March 8). Retrieved from https://na.smartcitiescouncil.com/article/smart-cities-council-announces-2018-readiness-challenge-grant-winners

303 White House commitment: Smart Cities Council challenge grants. (2016, September 26). Retrieved from https://smartcitiescouncil.com/article/white-house-commitment-smart-cities-council-challenge-grants

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