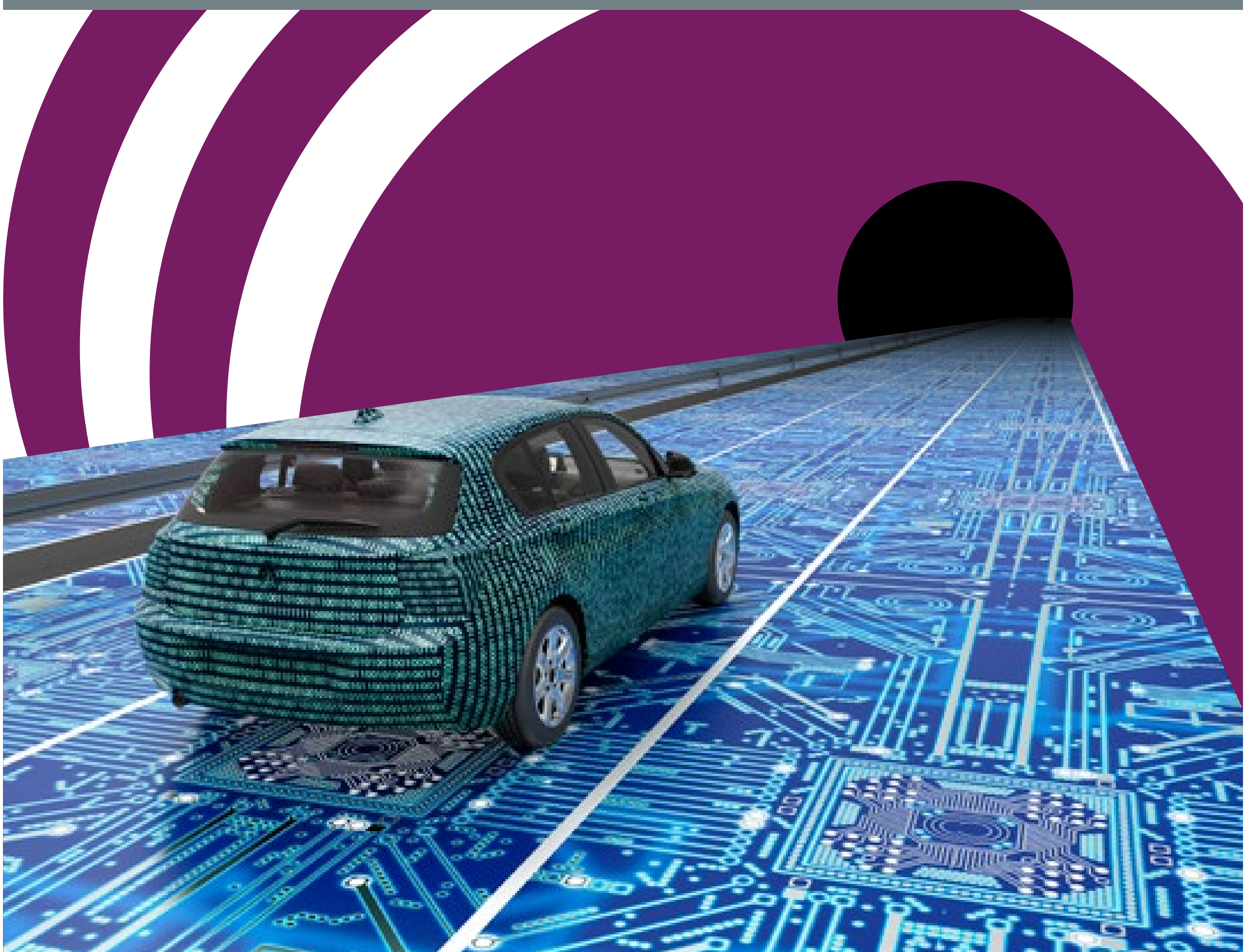
American Planning Association

Making Great Communities Happen

PREPARING COMMUNITIES FOR AUTONOMOUS VEHICLES

Jennifer Henaghan, AICP, Editor



An American Planning Association Report

Abstract

This paper summarizes the findings of a symposium and research on the implications of autonomous vehicles for cities and regions. It is intended for planners and local government officials involved in land-use planning, urban design, and transportation. Readers will learn about the need to plan for the potential benefits and negative impacts of autonomous vehicles and what steps they can take now to prepare their communities.

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Navya

Shuttle services, such as the Navya shuttle shown in testing at Mcity, can connect residents in low-density areas to employment hubs.

I. Introduction

Author: Jennifer Henaghan, AICP

On October 6, 2017, 85 thought leaders in planning, transportation, and related fields gathered at the National League of Cities (NLC) headquarters in Washington, D.C., to discuss how to plan for the impacts of autonomous vehicles (AVs) on cities and regions. This event was convened by the American Planning Association (APA), NLC, Mobility e3, George Mason University, Mobility Lab, the Eno Center for Transportation, and the Brookings Institution. Its purpose was to identify planning, policy, and research directions and needs to prepare cities and regions for a revolutionary new technology that will transform the way we think about transportation, transit, and land use.

Planners need to be thinking about AVs because of the significant impacts they will have on our communities. There are potential positive benefits as well as potential negative impacts, but none of these are assured. The secondary impacts are even more of an unknown. Working with other professionals, planners have an important role to play in helping communities maximize the benefits and minimize the negative impacts of the technology.

www.pedbikeimages.org – Nicole Schneider

Crosswalks and sidewalks could become less common if AVs supplant walking as an easy, low-cost way of getting around.

Potential Bene ts of Autonomous Vehicles	Potential Negative Impacts of Autonomous Vehicles
• Fewer traffic deaths and injuries • More efficient vehicle movement • First/last mile connectivity • Increased mobility for people with disabilities, seniors, and children • Less land area needed for parking	• Negative health impacts • Increased congestion • Job losses • Privacy and security concerns • Effects on other transportation modes

AVs have the potential to save lives by preventing accidents caused by driver error (including distracted driving), which claimed nearly 40,000 lives on American roads in 2016, according to the National Highway Traffic Safety Administration, and they could allow for more efficient vehicle movement gained by closer vehicle spacing. They could provide "first and last mile" and "last 50 feet" connectivity to transit increasing mobility options for people with disabilities, seniors, and children. And they are expected to free up vast amounts of land currently used for parking.

However, AVs are not guaranteed to produce uniformly positive interactions between humans and the built environment. They may end up increasing congestion if people shift from transit to personal autonomous vehicles. If people rely on AVs for door-to-door transportation, they may walk less. This may initiate a cycle of reduced local requirements for sidewalks and crosswalks that further discourages the choice to walk, creating negative health and social impacts. There will certainly be impacts on workers in the transportation field, as people who drive buses, trucks, and cars for a living stand to lose their jobs. And there are bigger-picture concerns with regard to privacy, data security, and personal safety if technology companies drive AV-related policies.

Autonomous vehicles are going to change our cities and regions, and those changes will come sooner rather than later. Most prognosticators agree that it will be decades before AVs are the dominant form of transportation, but pilot programs and commercial applications are rolling out faster than expected. Although their adoption time lines vary as to when their vehicles will be on the highways or in urban conditions, 11 of the largest automakers plan to have fully autonomous vehicles on the road between now (in the case of Tesla) and 2021.

2018	2019	2020	2021
• Tesla • GM		• Honda • Toyota • Renault-Nissan • Hyundai	• Ford • Volvo • Daimler • Fiat-Chrysler • BMW

Source: venturebeat.com/2017/06/04/self-driving-car-timeline-for-11-top-automakers

The ongoing (and rapidly increasing) adoption of autonomous vehicle technology will have a profound impact on the way our communities look and feel. It's clear that a change is coming, but what's less clear is what, precisely, that change will mean. At this point, there are many more questions than there are answers.

Shared Use versus Private Ownership

Many of the potential benefits and costs of AVs hinge on whether the predominant model is shared use (resulting in fewer cars and less congestion) or private ownership of single-occupancy and "zero-occupancy" vehicles (resulting in more cars, more congestion, and diminution of other transportation modes). Vehicle miles traveled (VMT) may increase under any scenario, meaning that electrification of the AV fleet will be imperative to reduce greenhouse gas emissions. **How can markets move from privately owned automobiles powered by fossil fuels to a predominantly shared use, electric vehicle model?**

Land-Use Patterns

There is a great deal of concern that AVs may encourage sprawl, but they also provide potential opportunities for "sprawl repair." New urban/suburban districts may be more efficient for transit, energy production/distribution, and stormwater management. Forward-thinking cities and regions could create mobility hubs to aggregate and provide seamless transfer across a growing number of options and partnership models. **As mobility shifts, how will we determine value capture (similar to transit-oriented development (TOD))?**

Right-of-Way Size and Usage

Autonomous vehicles require less road space than a manually driven vehicle, as their ability to communicate with the transportation network as well as each other allow them to operate with a smaller following distance and in narrower lanes. As a result, future roads will require less pavement width and existing roads may be adapted. **Will the "extra" space gained by this transition be used for transportation enhancements (such as bike lanes, pedestrian paths, transit ways, on-street parking) or park space, or will it be transferred to the adjacent property owners?**

Traf c Management

Traffic signals, signs, and street markings will likely need to change to accommodate autonomous vehicles, especially where they can help reduce potential conflicts between vehicular traffic and nonmotorized road users, such as cyclists and pedestrians. These will also be important during the transitional phase where AVs and non-AVs share the roadway. Optimizing a roadway for AVs will also require the installation of various types of sensors and communications technology to allow vehicles to travel more efficiently. **Who will pay for the installation of AV-friendly traf c management systems?**

Related Infrastructure

Large numbers of autonomous vehicles on city streets will generate additional types of infrastructure needs. Communications networks based on available wifi will be crucial not just to vehicles, but also to the occupants who will be free to teleconference, access the internet, and enjoy other activities instead of needing to watch the road. **Who will install infrastructure and provide service on these wi etworks?**

Similarly, assuming that future AVs will largely (if not entirely) be electric vehicles, where and when will they charge, and how will this impact the power grid?

Liability

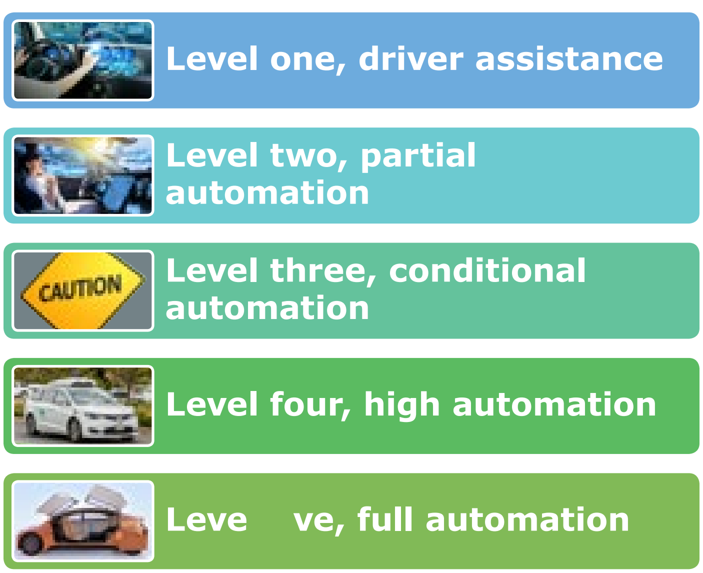
Smart transportation systems will rely on a complex interaction between mechanical vehicles, the software within those vehicles, the software and available technology within the roadways, and people. **Who will be liable when an accident occurs, and how will this affect insurance requirements?**

Economy

Millions of truck drivers, delivery people, taxi drivers, rail workers, and transit workers will likely see their current jobs change significantly, or outright disappear, as AVs remove the need for a person to physically move goods and people from place to place. **What further impact will this have on the transportation industry?**

Equity

Semiskilled labor and blue-collar jobs will likely see the highest impact from a shift to AVs. Public transportation could be supplanted by private alternatives (such as ride sharing), which could leave residents of low-income neighborhoods stranded. While AVs could increase mobility for persons with disabilities and seniors, such gains are not assured. Most discussion of AVs has focused on urban environments and it is unclear how low-density and rural areas will be affected. **How can AV policies reduce inequities or, at the very least, not increase them?**



We discuss the above questions in this report, plus many more related to issues such as municipal operations and finances, parking and revenue, environmental impact, and land use and urban design. We offer a framework for use by planners and their colleagues in local government as they seek to answer these questions and prepare communities and regions for the onset of AVs.

The paper contains three main chapters following this introduction. Chapter 2 provides an overview of the current state of AV technology and the federal and state policy context. Chapter 3 summarizes the discussions from the symposium, focusing on three primary themes: equity and access, the transportation network, and land use and development. Chapter 4 provides guidance on how planners and local and regional government agencies can begin planning for the impacts of AV, using APA's strategic points of intervention (community visioning and goal setting; plan making; regulations, standards, and incentives; site design and development; and public investment) as a framework. The report concludes with an identification of future research needs (Chapter 5), followed by a comprehensive list of references and resources.

II. Autonomous Vehicles: an Overview

Author: Jennifer Henaghan, AICP, and Jason Jordan

Levels of autonomy

Autonomous vehicles, as defined by the International Society of Automotive Engineers, range from a baseline of no automation, up to five levels of increasing autonomy:

- **Level zero, no automation.** Level zero, or conventional, vehicles require the driver to be actively in control of the vehicle at all times.

- **Level one, driver assistance.** This includes now commonly available technologies such as adaptive cruise control and parking assist that allow a vehicle to perform certain acceleration/deceleration or steering tasks, but not both.

- **Level two, partial automation.** This includes Tesla's autopilot, where the car can take over both the pedals and the wheel at the same time, but the driver maintains ultimate control.

Glossary of Terms

Adaptive technology: Features that allow a car to adjust its behavior based on the surrounding conditions (as in adaptive cruise control).

Autonomous vehicle: A vehicle that is capable of driving itself without human intervention. Also referred to as a driverless car or self-driving car.

Autopilot: A system that allows a vehicle to stay on its course without human intervention.

Connected vehicle: A vehicle that communicates with other vehicles, infrastructure, and occupants via wireless technology.

Driver assistance systems: Driver alerts that use sensors to detect potentially hazardous surrounding conditions, such as lane departure or blind spot warnings.

Drone: An unmanned aerial or ground-based vehicle (or "robot") that may operate autonomously or via remote human control.

Electric vehicle: A vehicle that is powered by electricity (as opposed to an internal combustion engine).

Levels of driving automation: The six levels of driving automation as defined by SAE International (see page ##).

Mobility: The movement of people and goods via any mode of transportation.

Platooning: The coordinated operation of multiple vehicles to increase efficiency (as in a convoy).

V2V: The communication between a vehicle and other cars (vehicle-to-vehicle).

V2X: The communication between a vehicle and sensors within the road network and surrounding infrastructure (also known as V2I).

- **Level three, conditional automation.** Level three vehicles require human drivers to serve as the backup for an autonomous system that operates under certain conditions.

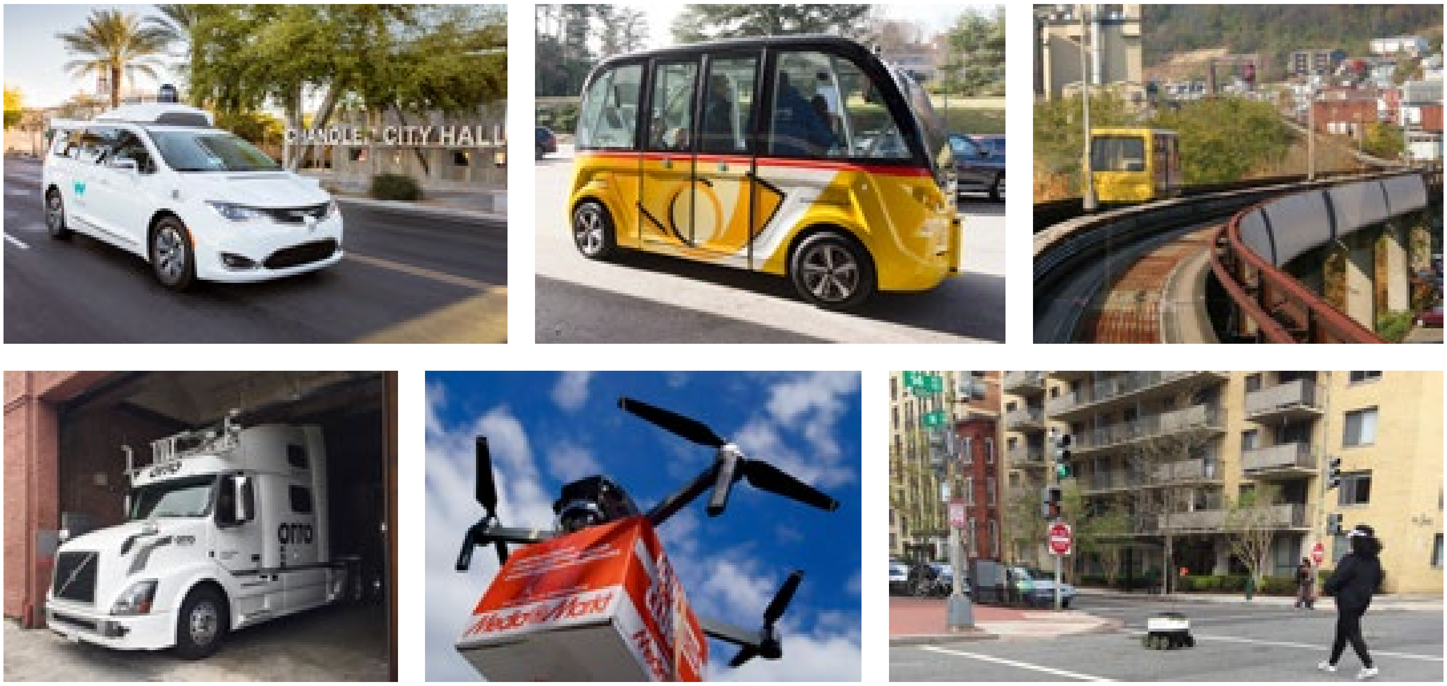
- **Level four, high automation.** This grouping includes vehicles such as the Google/Waymo test cars that can be driven by a human, but never need to be. Unlike level three, a level four vehicle can safely park itself in the event of an emergency situation or other condition the vehicle is unable to navigate on its own.

- **Leve ve, full automation.** Level five vehicles require no human driver input under any driving conditions, such that there is no need for a steering wheel in the vehicle.

Types of autonomous vehicles

AV technology can be incorporated into any vehicle type or size. The technology showcased by auto manufacturers is often in the form of private passenger vehicles designed to carry a small number of people from place to place. However, AVs are expected to initially be deployed at scale in the form of shuttles and buses that supplement (and perhaps gradually replace) existing public transit service. Light-rail services may also become autonomous, such as those in Miami and Jacksonville, Florida; Morgantown, West Virginia; Las Vegas, and numerous U.S. airports.

Although much of the discussion on AVs centers around moving people, the movement of goods and services will also be disrupted by AVs. Autonomous semitrucks that "platoon" to maximize efficiency (such as reducing drag) are currently being tested on highways. Smaller-scale AVs can provide door-to-door delivery of goods through the use of drones. Amazon has promoted its Prime Air service, which is being developed to use unmanned aerial vehicles to deliver packages to customers within 30 minutes of an order being placed. AVs can also be found on city sidewalks, for example ground-based drones delivering takeout in Washington, D.C.



Clockwise from upper left: Waymo, World Health Organization, flickr users 70428838@N00, flickr user jurvetson, Media Markt, and flickr user Joe Warminsky (all flickr photos CC BY-NC-SA 2.0)

Autonomous vehicle types include private passenger vehicles, buses/shuttle buses, light rail, semi-trucks, aerial drones, and sidewalk drones.

Federal and state policy on autonomous vehicles

While this report focuses on local policy and planning for AVs, planners and allied professionals need to be aware of developments in federal and state policy as well. In September 2016, The U.S. Department of Transportation (U.S. DOT) issued Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety. This document was intended as a comprehensive policy guide (as opposed to rules or regulations) at the national level, focusing primarily on safety. It has been replaced by newer guidance issued in September 2017 (see below).

Federal policy making for autonomous vehicles accelerated in 2017. For the first time, AV legislation was passed by the House of Representatives and approved by a Senate committee. It appears likely that 2018 will see additional legislative and regulatory action on AVs. On Capitol Hill, AV legislation has enjoyed bipartisan support, and Senate leaders appear optimistic that the bill will move to the floor.

The pace of legislative progress on AVs reflects a general bipartisan consensus that federal action is important for smoothing the way for AV implementation and avoiding a patchwork of differing state standards. The House passed the SELF Drive Act (H.R. 3388) on a voice vote in September 2017. The Senate Commerce Committee sent the AV START Act (S. 1885) to the floor in November 2017, also on a voice vote. These two bills are similar, but not identical, and those differences will need to be resolved before the legislation can be enacted. The measures take slightly different approaches to rule making and the safety standard exemption process. In addition to resolving those differences, there are several policy areas where legislators have voiced concerns. Issues surrounding trucking, cybersecurity, local authority, and some vehicle standards will likely have to be addressed.

Both of the current bills prohibit state and local governments from regulating the design, construction, or performance of AVs. States can continue to regulate sales and repairs. The House version specifies other areas where states can regulate activity provided it does not constitute an "unreasonable restriction." The Senate approach does not specify other changes to state powers but does require that licensing cannot discriminate against disabled operators. Neither bill makes explicit changes

Ford

The University of Michigan's Mcity facility allows vehicle manufacturers to safely test their AVs in a simulated urban environment. Vehicles, such as the pictured Ford Argo, navigate scenarios such as traf c in intersections, pedestrians in crosswalks, different traf c signals, and bicyclists.

to existing authorities over infrastructure design and performance, which is an area of tremendous interest to planners and local officials.

Both bills would require a new federal rule-making process. The House approach requires U.S. DOT to submit a priority list within one year and begin formal rule making within 18 months of enactment. The Senate version tasks the Volpe Center to identify needed changes and establishes a technical committee to suggest new standards. U.S. DOT would conduct a rule-making process within one year of receiving these recommendations. One of the most immediate impacts of the legislation would be the provision of exemptions from existing vehicle standards to allow for AV testing and pilot program implementation. The House bill would give 25,000 vehicle exemptions in the first year, 50,000 in the second, and 100,000 in the third and fourth years. The Senate numbers are slightly lower, with 15,000 in year one, 40,000 in year two, and 80,000 in year three with a petition process for exemptions after four years. The House bill requires that exempt vehicles be listed in a public database with mandatory crash notification.

On cybersecurity and data, manufacturers are required to develop policies, but no data-sharing provision is included. Many local government and regional planners are pushing for future standards that would facilitate, if not require, the sharing of certain travel and performance data to improve planning and design related to AVs. Consumer advocates have voiced worries over privacy and data security.

Both bills would set up new advisory and research bodies. The Senate language creates committees on consumer education and data access. In addition, an amendment added during the committee debate would require a study on congestion, mobility, environment, and energy impacts. These efforts would be aimed at informing both future federal legislative and regulatory activity and state and local implementation and planning efforts.

Neither bill addresses trucking issues and no new exemptions are included for commercial trucking. Industry officials have pressed for the inclusion of freight and trucking language, but the opposition from labor groups concerned about job impacts has kept those provisions out of the current versions. This debate is far from over and will likely continue as the federal policy framework for AVs continues to evolve.

In addition to the AV legislation, Congress may also have opportunities to address some related issues that could have an impact on implementation. President Donald Trump's administration continues to plan for a legislative push on infrastructure. Any such package could include eligibilities for AV-supportive infrastructure upgrades. Separate legislation, the Smart Cities and Communities Act (H.R. 3895 / S. 1904) would create a new demonstration grant and technical assistance program for new tools, including connected infrastructure, vehicle-to-vehicle communication, and other smart transportation technologies.

On the policy front, U.S. DOT published new guidance in September 2017. "Automated Driving Systems: A Vision for Safety 2.0" replaced the 2016 "Federal Automated Vehicles Policy Guide." Although nonbinding, the policies do set specific directions and assistance aimed at speeding implementation. The guidance clarifies that the testing and deployment can proceed and addresses appropriate state and local roles. The document also tries to better align federal policies with new standards and developments in the industry. One of U.S. DOT's stated goals with the update was to provide additional flexibility for early stage implementation. U.S. Secretary of Transportation Elaine Chao has announced that the department plans to release a "3.0" version of AV guidance in 2018. In anticipation of this release, U.S. DOT published several automated vehicle notices for public comment in January 2018. Despite the flurry of activity and interest in Washington, it seems clear that the new legislation and guidance are likely only the first steps in establishing a federal role in the development and deployment of AVs. As implementation advances, further steps toward modernizing regulatory frameworks and supporting local infrastructure, technology, and planning will be necessary.

State governments have also shown a proactive interest in AVs, with 41 states and the District of Columbia having considered AV-related legislation since 2012. As of January 2018, 21 states have passed legislation and governors in an additional five states have issued executive orders related to AVs.

In January 2018, APA adopted Policy Principles and Recommendations for Autonomous Vehicles to inform discussions at the local, state, and national levels. The principles address the need for planners and the public sector to take the lead in the following areas: mobility, connectivity and access; energy and sustainability; research and development; safety and security; data and decision making; and economics and fiscal planning.

III. Notes from the Symposium

Authors: Kelley Coyner and Jennifer Henaghan, AICP

This chapter contains a summary of the discussion from the October 6, 2017, symposium. David Rouse, FAICP, APA's managing director of research and advisory services, kicked off the event with a summary of how the conversation has moved from the first phase of exploring the possible implications of AVs to the next one of beginning to develop solutions. Kenneth Petty, the Federal Highway Administration's director of planning, then spoke about the need to change how we think about transit and technology in order to improve safety, mobility, and efficiency.

In his keynote address, Jeff Tumlin, principal and director of strategy with Nelson\Nygaard, shared the pros and cons of the future revenue model for AVs and the need for cities to consider congestion pricing to counteract urban sprawl. He recommended that cities and metropolitan planning organizations (MPOs) work together to foster mobility as a service in a way that achieves the public good, which includes frank discussions with labor unions on the jobs that will be displaced or transformed by AV technology. Tumlin stated that cities will need to define their goals regarding equity and ensure that their budgets reflect those goals. He emphasized that, despite the numerous challenges that AVs will bring, cities should embrace a spirit of opportunity to use this technology as a way to further their planning ideals.

Discussion panels throughout the morning tackled three questions:

1. How can autonomous vehicle technology expand access to health care, employment, education, and recreation for users of all ages, abilities, and incomes?
2. How will autonomous vehicles impact the transportation ecosystem?
3. What are the potential benefits and costs of widespread deployment of autonomous vehicles for cities and metropolitan regions?

Equity and access

Brooks Rainwater of the National League of Cities, Laurie Schintler of George Mason University, Jana Lynott, AICP, of AARP, and Darnell Grisby of the American Public Transit Association kicked off the panel sessions with a discussion on issues related to access, accessibility, and equity. While these terms cover a variety of concepts, the panelists framed access as meaning both access to mobility services and access to opportunity. Accessibility refers to the ability of those with physical and cognitive limitation to take advantage of AV mobility services. Equity refers to both the ability of all to take advantage of the benefits of AVs and the secondary impacts of automation on transportation workers and those who rely on public transportation systems.

Access to transportation is closely linked to opportunities for employment, education, health care, and recreation. If autonomous vehicles are thoughtfully implemented with access and equity in mind, AV technology can expand access to these resources for users of all ages, abilities,

Reasons given by 18- to 39-year old U.S. residents for not possessing a driver's license

- Too busy/not enough time to get a license
- Owning/maintaining a vehicle is too expensive
- Able to get transportation from others
- Prefer to bike or walk
- Prefer to use public transportation
- Concerned about how driving impacts the environment
- Able to communicate and/or conduct business online instead
- Disability/medical/vision problem

Source: The Reasons for the Recent Decline in Young Driver Licensing in the U.S.

and incomes. That promise will not automatically appear, but will require cultivation, innovation, incentivization, and perhaps regulation as well.

There is much reason to herald the promise of expanded mobility through AV, especially for the millions of adults in the United States who either do not or cannot drive or live in mobility deserts (which are areas where there is no or very limited access to transit). AVs offer blind, mobility impaired, and older people and those with cognitive and behavioral disorders the potential for a degree of personal autonomy that is presently unavailable to them. However, cities must take an active role to ensure that AV does not reinforce existing disparities in access.

Alongside these considerations, policy makers and planners should be mindful both about equitable access to new forms of mobility services and to the disproportionate negative impact on transportation workers. AVs will displace them from their current roles as drivers and, to a lesser extent, as mechanics (if AVs and electrification proceed in tandem).

> 'More than one in five elderly Americans has retired from driving.'
>
> *—Jana Lynott, 2017*

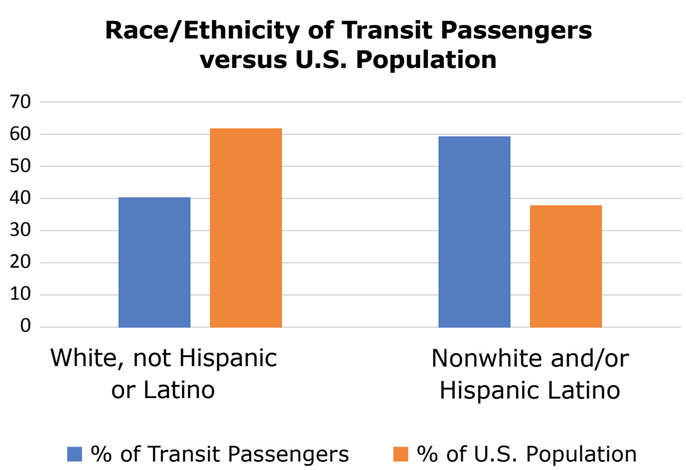
Racial equity

Disruptive impacts on public transportation should be considered an equity issue due to the disproportionate impact on the transit-dependent population.

Some current inequities such as uneven digital access and discriminatory practices such as transportation redlining require action to ensure that all neighborhoods and communities have access to mobility services. Other new potential equity issues may arise with changing development patterns, land uses, and land valuation.

Access for the disabled

AVs could be especially transformative for one group of people in particular: those who are physically unable to drive. As noted by the Shared Use Mobility Center, nearly one in every five people in the United States, or more than 57 million, has a disability. Of those, some six million currently have difficulty getting the transportation they need. That includes deaf people, blind people, and those with physical mobility issues that require the use of a wheelchair or other assistive device. Additionally, more than one in five elderly Americans has, as Lynott noted, "retired from driving."



This graph shows the racial and ethnic makeup of public transit passengers as compared to the U.S. population as a whole.

Source: Data from American Public Transportation Association and U.S. Census Bureau

The trucking industry is expected to see some of th rst large-scale deployments of AV in long-hau eets using vehicles such as the Otto truck (now owned by Uber).

Meanwhile, the population of U.S. residents over the age of 65 is expected to increase from 40 million to 88 million by 2050.

Simply having access to mobility service via AVs is an important but not in itself sufficient condition for millions of disabled people to have meaningful access and the related personal autonomy it affords. Design, human service support, and accessible transportation planning will be essential to achieve these aims. A combination of universal design and integrated transportation and human service planning is required to make sure that AVs are accessible. Some considerations are vehicle-centric, while others focus on whether attendants are available onboard, if there is curbside management, and if wayfinding is provided. How can vehicles be designed to accommodate mobility devices such as wheelchairs? How should the Americans with Disabilities Act be applied to AVs? How can user interfaces be designed to accommodate visually and cognitively limited people? How will riders navigate the "last 50 feet" to AVs, especially if there is no paratransit driver? Some questions also apply to current conditions including ride hailing services and transit. For example, how do the cognitive and visually impaired find their way to a vehicle? How can ride-hailing apps be made accessible?

Workforce displacement and future workforce needs

As the transportation industry, particularly the freight sector, transitions to fleets of autonomous vehicles, there will be economic implications in terms of job loss and dislocation. Policy makers and job-training organizations will need to be cognizant of the impact on access to stable, well-paying jobs, as well as the skills required by those jobs.

As in the case of automation in manufacturing, automation at levels of full autonomy will disproportionately impact truck, bus, tax, and delivery truck drivers (especially, Schintler noted, for black and Hispanic men). Mechanics will be impacted as well because electric vehicles, which will likely account for all autonomous vehicles, have fewer moving parts and fluids than those powered by internal combustion engines. As a result, they generally require much less maintenance. Schintler estimates that, at higher end of AV deployment, transportation automation will eliminate more than four million jobs. Reduction of driving jobs will occur over time, and those positions will likely be replaced by either concierge and inventory control positions with lower wage rates and few benefits, or jobs requiring additional technology-related knowledge and skills. Planners and policy makers should analyze both the shift in type of jobs and timing for job displacements to develop training and placement activities that align with this displacement, ensuring that those who are displaced can access the resources necessary to obtain comparable employment. The time is now to develop skills and workforce capacity requirement for safety operators and technicians implementing early systems.

> 'What we do know, is that AVs will transform everything they touch.'
>
> *—Stephen Buckley, 2017*

Transportation network

Paul Mackie of Mobility Lab, Kevin Vincent of Faraday Future, Stephen Buckley of WSP, and Paul Lewis of the Eno Center for Transportation considered how AVs will impact the transportation ecosystem. As the arrival of

Pedestrians walk in the street in Bennington, Vermont, because there is no sidewalk. Safety features in AVs can potentially save lives by reducing con icts between road users.

highly automated vehicles moves beyond speculation to reality, the effect on the transportation system is a great unknown. "What we do know," said Buckley, is that "AVs will transform everything they touch" across all types of transport. Full deployment offers tremendous safety benefits, as more than 80 percent of all traffic fatalities are attributable to human error. As such, even level one AV technology, such as automated braking systems and automated driver assist systems, could save lives and reduce conflicts between vehicles and road users (such as pedestrians and bicyclists).

While automated vehicles will almost certainly be highly disruptive, they also offer tremendous opportunities. For cities and regions, AV deployment and the related emergence of new service and business models raise questions about the implications for longstanding issues surrounding congestion and capacity management, transit service, and integration of freight and passenger modes as well as active and motorized transportation. The emergence of transportation network companies like Lyft and Uber provide a window of what AV deployment may mean to communities of all sizes. Increased mobility and decreased costs of trips have come with uncontrolled, disruptive pickup and drop-off at curbsides, problems with access for people with disabilities, and a net increase in vehicle miles traveled. And cities and regions have had little meaningful access to data from those ride-sharing services that could inform the management of the network and make the user experience better.

At the same time, shared ownership, shared use, and app-driven, mobility-on-demand approaches provide business and service models that could determine whether the benefits of AVs can be achieved without inefficiencies and devastating externalities (such as high levels of induced demand that drive further dispersal of housing and centers of economic activity). In addition to congestion, with its corollary increase in travel times, sprawl resulting from the willingness of people to travel further without needing to fully account for the time costs of driving could worsen greenhouse gas emissions if AVs are primarily powered by internal combustion engines. However, AVs could accelerate the shift to electric vehicles. The question for cities and regions is how to encourage that shift, and what investments in electric charging infrastructure are needed to make that conversion a reality.

Electrical charging stations are only a small portion of the challenges of infrastructure management, maintenance, and investment that will ensue as AVs are deployed on public roadways. In the short term, most AV applications depend on smart vehicles with limited connectivity needs or, especially in the case of higher-speed uses, rely on vehicle-to-vehicle communications. Even these more constrained applications will demand increasing bandwidth on existing wifi networks and are constrained by the absence of sensor and communication technology embedded in infrastructure. In the medium term, the introduction of AVs raises questions of adapting and (re)designing infrastructure such as intersections, lanes, and mobility hubs. Redesign or adaptation should allow for mixed traffic, not just of AVs and conventional vehicles, but also of pedestrians and cyclists. This will need to be combined with careful attention to the rules of the road so that steps to facilitate AV traffic encourages rather than impedes walking and biking. Also, more efficient use of existing capacity may allow cities to repurpose streets for bikers and pedestrians. In the short term, localities may be called on to heighten their attention to basic maintenance such as striping, or retrofitting existing paths to allow for the coexistence of electric vehicles, AVs, bicyclists, and walkers.

AV deployment will touch all other modes of surface transportation; transit represents a special set of challenges for communities of all sizes. (In discussions across the three topic areas—equity and access, transportation, and land use and the built environment—the implication for existing transit systems, especially fixed route bus and rail service, was repeatedly referenced.) The rise of transportation network companies (TNCs) has contributed to declines in transit ridership nationally. AVs could exacerbate this decline, especially if transit systems are unable to innovate by adopting AV and other forms of smart technology, including mobility on demand.

AVs—especially urban or "low speed" service—could complement and support traditional transit if used for first and last mile connectivity, to bridge service during nonpeak hours, to function as a micro or on demand circulator, or to serve mobility deserts. Implications of lost ridership include further undercutting underfunded pension systems, displacing workers, and canceling services for the transit-dependent population that may not be replaced.

Charging for Geometric Ef ciency

- Time of day
- Actual roadway congestion levels
- Number of occupants or empty seats
- Amount of empty cargo space

Cities and regions, sometimes in tandem with states and sometime independently, build, maintain, and operate transportation systems for their communities. Testing on public streets has already begun and will continue to rapidly expand over the coming years, meaning that cities need to understand what their roles and responsibilities are regarding safety. As long-range plans are updated, localities and regions now need approaches that allow them to plan for a future that is uncertain. Across modes, communities need to begin planning now for what is likely to be a long transition from the original horseless carriage to the driverless car, and beyond.

AVs may either complement or compete with transit services, depending on how well transit agencies are able to adopt and adapt to new technology (Pictured: a bus stop in Seattle).

Land use and the built environment

David Rouse, FAICP, of APA, Nico Larco of the University of Oregon, Lisa Nisenson of Alta Planning + Design and GreaterPlaces, and David Dixon of Stantec discussed the potential benefits and costs of widespread deployment of AV for cities and metropolitan regions. A key message was that the public and private sectors will need to change the way they approach planning, design, and development at scales ranging from the site to street, district, city, and region.

Sensors will allow autonomous vehicles to travel closer together than human-controlled vehicles, reducing the necessary pavement width and freeing up space for wider sidewalks, bike lanes, and other amenities. Local zoning codes will need to address requirements for passenger loading and unloading, and parking needs will change drastically if a shared use model is employed. As cities transition away from ordinances that now require large amounts of land to be used for parking and circulation, they will need to determine how best to make use of that land through new approaches to land use and zoning.

> 'Rarely does any effort get funded or off the ground unless it's in the comprehensive plan.'
>
> *—Lisa Nisenson, 2017*

Brian Hoeft

Las Vegas launched a year-long AV pilot program on November 8, 2017. The service shuttles passengers along a 0.6-mile route in downtown Las Vegas.

Comprehensive plans and related plans

As the backbone of community decision making, comprehensive plans should be less prescriptive and more goal oriented to help cities cope with and adapt to rapid changes. In addition to the typical sections on land use, transportation, housing, parks and open space, and community facilities, they might include a chapter on "The Future," with language that allows flexibility, experimentation, and innovation. Plans should encourage small-scale municipal demonstration projects and pilots, with a way to share and learn from best practices in other communities and regions.

Comprehensive plans should set strategic direction to address the shifting land use patterns anticipated as a result of AVs (e.g., reduced demand for parking). This could include strategies for land banking and land trusts, as well as flexible policies and model code language to allow uses to be adapted over time as market conditions change. The need to coordinate the installation of AV-friendly sensor networks will make communication between departments and agencies particularly important at the planning and policy stage. Also, the speed of change will likely require shorter update cycles for planning or more agile use of "out-of-cycle" plan updates.

Smaller-scale plans, such as corridor, neighborhood, and "specialty" plans (e.g., Vision Zero, Transportation Technology, New Mobility Roadmaps) can also help meet the needs of technology-based land-use transformations.

Although strong visuals are always important in planning documents, it is particularly necessary to use storytelling and new visualization techniques to help both city officials and the public understand the potential implications of future development patterns. Newer techniques such as scenario planning can be used to assess the possible impacts of different AV scenarios (see Chapter IV). Scenario planning can be particularly useful to project the impacts of major land uses such as educational institutions, medical campuses, and office parks.

Land-use patterns

The shift to AV technology will change the physical layout of urban and suburban areas, as retail space needs will shrink to smaller showroom/pickup spaces in conjunction with greater demand for warehousing and e-commerce logistical square footage. In some cases, AVs in the form of mobile tiny houses and office pods may even replace traditional office and hotel uses. Electric vehicles require less maintenance than

Curitiba, Brazil's Linha Verde bus rapid transit system helped the city win a 2010 Sustainable Transport Award.

conventional vehicles, which will translate to a greatly reduced demand for automobile repair and maintenance uses. This in turn will free up a large amount of (likely environmentally compromised) land for redevelopment.

There is a great deal of concern that AVs may encourage sprawl, but there is also some optimism that they may provide potential opportunities for "sprawl repair." New urban/suburban districts may be more efficient for transit, energy production/distribution and stormwater management. Forward-thinking cities and regions could create mobility hubs to aggregate and provide seamless transfer across growing number of options and ownership models. As mobility shifts, there will need to be new ways to determine value capture (similar to TOD).

Site design

Buildings will need to be located and designed to facilitate both pedestrians and autonomous deliveries (ground and air), which will change the way in which retail and multifamily/mixed use buildings are designed. Instead of first-floor retail or parking, ground floors may be designed to make buildings more flood and disaster proof.

There should be public discussion of desired and necessary land uses and density that communicates the efficiency benefits of compact forms. Density and mixed use standards should be incorporated into comprehensive plans and zoning ordinances, with an emphasis on form-based codes that are less depended on function.

Parking

Existing parking lots and requirements will see the most obvious changes from a shift to AV. There will be no need for municipalities to require a minimum number of parking spaces if the population does not depend on privately owned automobiles for mobility, opening up a realm of possibilities for use of land that is currently occupied by surface parking. (There will still be a need for AV storage/recharging facilities, but these may be located regionally rather than locally.) Parking garages, to the extent that they continue to exist, will likely become highly automated and serve double-duty as recharging stations that require much more intensive electrical infrastructure.

Stocky Bodies

Over the long term, AVs could result in negative health impacts if people choose to forgo walking, cycling, and other human-powered options for door-to-door AV transportation.

However, cities must proactively plan for this transition. Pilot projects dedicated to reducing or reallocating parking can help cities test strategies for location- and congestion-based parking pricing, district-wide parking cap and trade, and design standards and incentives to make parking lots and structures more easily converted to offices and other spaces. Given the expected needs for additional e-commerce space, warehouses may be a good candidate for reuse of urban parking structures.

Scenario planning exercise

Attendees spent the afternoon in a scenario-planning exercise led by Kelley Coyner of Mobility e3 and Lisa Nisenson of Alta Planning + Design and GreaterPlaces. The scenario put attendees in the shoes of a planning director whose council members are anxious about AV and how it will affect the city's transit, infrastructure, built environment, and economic competitiveness.

Participants identified specific subtopics that would need to be addressed in the areas of equity and access, the transportation network, and land use and the built environment. They also identified the best examples of work that is currently being done in cities to address the three main areas of concern (such as Seattle's 14-cent per-ride charge on transportation network company ride—Uber, Lyft, and similar rideshare models, or South America's bus-only streets).

Key policy concerns included:

- Roles and responsibilities at each level of government
- Retrofitting existing infrastructure as AVs are deployed over time
- Strategies for revenue replacement prior to AV deployment at scale
- Freight, deliveries, and logistics
- Congestion management
- Sidewalk/curb demand management

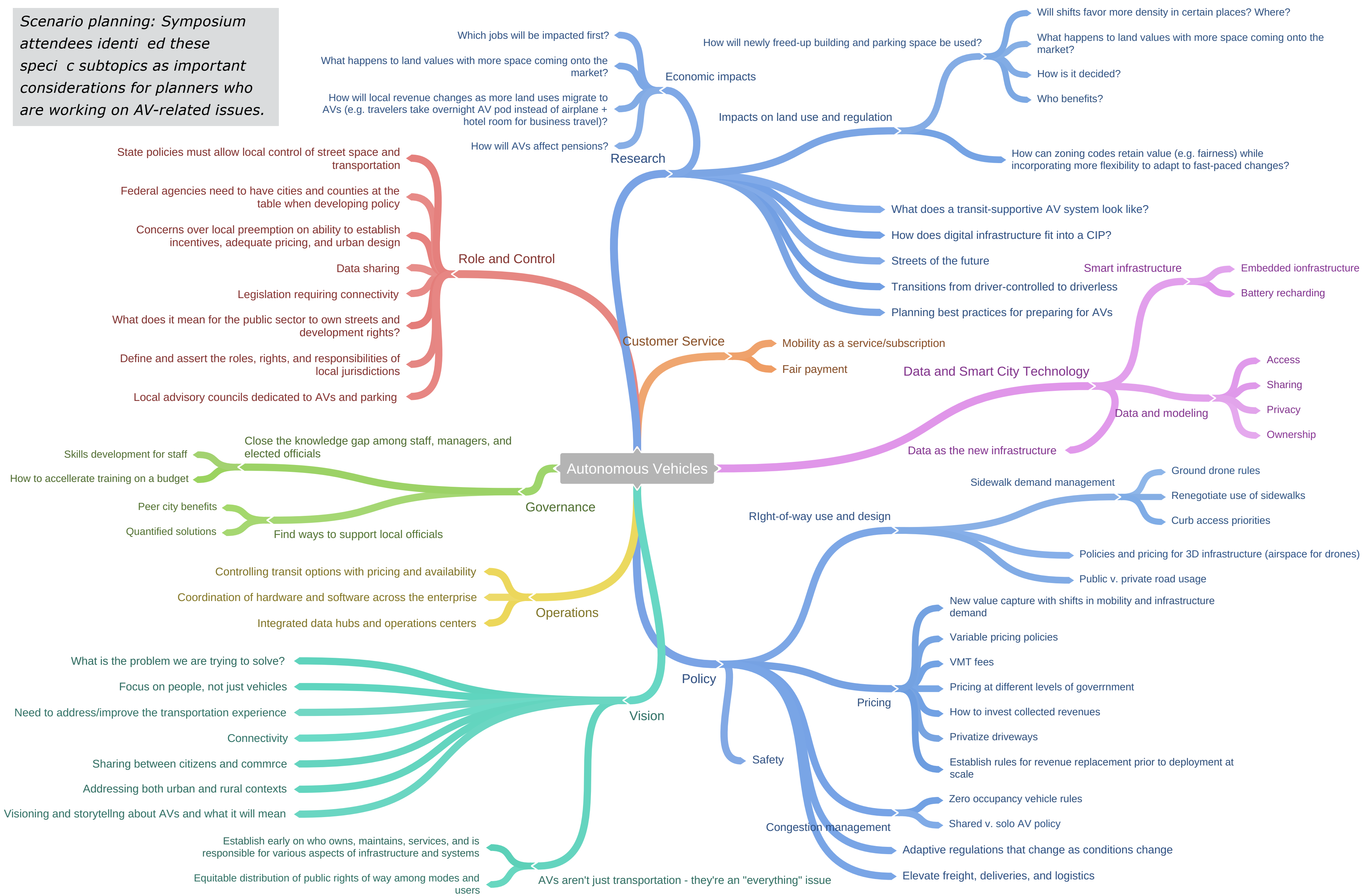
IV. How to Plan for Autonomous Vehicles

Author: David C. Rouse, FAICP

This chapter presents a framework for use by planners and their colleagues in local government as they prepare communities and regions for the onset of AVs. It draws on the symposium discussions described in Chapter 4 and APA's Research Knowledgebase collection. It is important to note that this framework reflects the current state of understanding of the implications of connected and autonomous vehicle technology for planning, which is still in its infancy. As such, it should not be taken as definitive, but as a foundation to build on through additional research, development, and testing of planning practices and tools. Key considerations include:

- **The time to begin planning is now**. The consensus among prognosticators is that there will be a lengthy period of transition to full adoption of automated technology, and that market saturation with fully autonomous vehicles is at least several decades in the future. Irrespective of these projections, local governments should move beyond the "wait and see" attitude that has been prevalent to date and begin to take action. Local governments can start by passing formal resolutions and setting in motion plans to address new mobility, defined as the application of technology for communications, new vehicle design, connecting people to transportation options, and driverless vehicles (Alta Planning + Design 2017). In the short term, policies are needed for

Scenario planning: Symposium attendees identi ed these speci c subtopics as important considerations for planners who are working on AV-related issues.



the pilot applications that will occur with increasing frequency over the next several years. In addition, comprehensive and other long-range planning processes with typical time horizons of 20 to 30 years (a period within which AVs are expected to become widespread) should address the implications of AVs for transportation and other community systems.

- **Good planning principles still hold.** A study by the Florida State University Department of Urban & Regional Planning for the Florida Department of Transportation states that AV technology "has the potential to transform transportation systems and land use patterns to a level not seen since the mass production of the private automobile roughly a century ago" (Chapin et. al. 2016). Local governments should not repeat the mistakes of the post-World War II era, during which convenient automobile travel became the primary transportation focus at the expense of other travel modes (as well as broader community goals), by focusing on planning for AVs. They should consider how AVs can serve the community's vision and goals for the future, which likely include walking, biking, and transit as robust components of an integrated mobility system, and related goals such as community health, cost-effective public infrastructure and services, and resilience. In simple terms, good planning that prioritizes community goals should continue irrespective of when AVs arrive, and will help shape AV deployment in a productive way.

- **Planning must anticipate the disruptive effects of technology.** The planner's 20th century toolbox is not sufficient in a time of accelerating technological change, of which AVs are just one manifestation. Planners need to rethink conventional tools (e.g., Euclidean zoning, roadway classification systems, and street design standards) and develop new tools and practices to meet the challenges ahead. Examples include new approaches to managing use of the public right-of-way, pricing and incentives to promote shared rather than single-occupancy vehicles, and more, all for the purpose of maximizing benefits and minimizing costs/negative impacts of AV technology as measured against community goals. In doing so, planners should take into account the interactions and cumulative impacts of AVs and other technological trends (e.g., the effects of e-commerce on "brick-and-mortar" retail).

- **Planning must account for uncertainty.** There is general agreement that AVs are the next major trend in transportation, but also uncertainty regarding how the technology will be implemented. Examples include how long it will take for the technology to be fully deployed; the mix of conventional, partially automated, and fully automated vehicles over time; private ownership versus shared use; and how AVs will affect urban, suburban, and rural geographies. This level of uncertainty calls for what symposium participants termed "agile, flexible, and adaptable" planning approaches (e.g., monitoring and adjustment of plans and codes based on performance, more frequent update cycles, etc.). Planners should use scenario planning to characterize the range of possible futures and corresponding policy responses that support the community vision and goals.

The framework below is based on APA's five strategic points of intervention, which are key junctures in a community planning process where planners, local officials, and others generate ideas for the future, translate ideas into intentions, and intentions into implementing actions. These points are:

- Community visioning and goal setting
- Plan making
- Regulations, standards, and incentives
- Site design and development
- Public investments

The first two points involve plan preparation and the next three involve plan implementation. All five provide opportunities for communities to prepare for AVs.

Community visioning and goal setting

Community visioning is conducted through a participatory planning process, either for a comprehensive or other long-range plan or as a stand-alone exercise. It engages residents and stakeholders in identifying shared values and aspirations, describing a desired future for the community, and setting goals to follow in order to achieve the vision. A successful community-based visioning and goal-setting process creates the foundation for all other strategic points of intervention.

We are not aware of any community visioning processes to date that have explicitly addressed AVs. As noted, it is most important that participants first describe what they want their community to be in 20 or so years and then consider how AVs can support that vision as part of an integrated transportation system. Planners can use the visioning process to increase basic understanding of AV technology, how long it will likely take for the technology to be fully deployed, and potential impacts on transportation and other community systems. Equipped with this basic understanding, participants can describe the role of AVs in the future vision and address AVs in the accompanying goals.

Given community visioning's long-range time horizon and present uncertainty regarding deployment of AVs over time, scenario planning can be used to productive effect in this early stage of the planning process. Peter Schwartz provides an excellent description of scenarios in *Art of the Long View*:

> *Scenarios are a tool for helping us take a long view in a world of great uncertainty. The name comes from the theatrical term 'scenario'—the script fo lm or play. Scenarios are stories about the way the world might turn out tomorrow, stories that can help us recognize and adapt to changing aspects of our present environment. They form a method for articulating the different pathways that might exist for you tomorrow, and nding your appropriate movements down each of those possible paths. Scenario planning is about making choices today with an understanding of how they might turn out (Schwartz 1991).*

As Creighton Randall of the Shared-Use Mobility Center said in his September 2016 presentation at Smart Cities Week, two predominant stories (i.e., scenarios) about a future AV world have emerged in the past several years. In the first, "utopian" scenario, the AV fleet consists of shared electric vehicles, leading to fewer cars, reduced congestion and carbon emissions, improved air quality, and compact development patterns in which walking, biking, and transit thrive. In the second, "dystopian" story, the AV fleet consists of privately owned vehicles and "zero occupancy" cars roam the streets, resulting in greatly increased traffic, severe reductions in other transportation modes, increased pollution and greenhouse gas emissions, and more sprawl as people choose to live in the hinterlands and have their cars drive them to work.

Wolfgang Gruel and Joseph Stanford of MIT used systems dynamics modelling to develop three scenarios that characterize the potential positive and negative outcomes of widespread adoption of AVs (Gruel and Stanford 2016). Scenario 1 assumes no change in behavior or ownership; AVs are used in the same way as cars are used today and vehicles are privately owned. Expected benefits include safer, cheaper, and more environmentally friendly travel by car, with improved mobility for those with limited access. While traffic volumes will increase, it is assumed that this effect will be offset by increased efficiency of vehicle operations and traffic flow. Scenario 2 assumes major changes in travel behavior (e.g., longer commute trips, zero occupancy cars) and private ownership of cars. Expected outcomes are similar to the dystopian scenario: higher traffic volumes, increased traffic congestion, erosion of public transit, and more sprawl as people choose to have their cars drive them longer distances. Scenario 3 assumes major changes in travel behavior similar to Scenario 2 but that all vehicles in operation will be shared use. The expected outcomes are mixed: decreased numbers of cars in use (freeing up parking for other uses), higher traffic volumes/vehicle miles traveled due to "rebalancing" of trips, and possible positive effects for transit and reduced sprawl due to vehicle-sharing cost structures.

To illustrate how scenario planning might be used in conjunction with community visioning, consider a (hypothetical) city whose comprehensive plan vision describes a compact land-use pattern with mixed use centers connected by a multimodal transportation system. This vision and plan were developed and adopted several years ago through an extensive public participation process that did not take into consideration the potential effects of AVs, which are now seen as likely to become widespread during the plan's 30-year time horizon. To address this situation, the city's planning and transportation departments develop three scenarios with different assumptions regarding factors such as shared use versus private ownership, VMT, impacts on other travel modes, and equity/access for underserved populations. The scenarios are vetted through a public process that evaluates their implications for the adopted vision. Based on this evaluation, a preferred (best-performing) scenario is selected and the comprehensive plan is amended with actions designed to shape the deployment of AVs to support the community's vision.

Plan making

Comprehensive plans, functional plans, and subarea plans translate the overall direction and goals for the future established through a community visioning process into more specific policies and implementing actions. Public officials use these plans to inform decisions that affect the social, economic, and physical development and change of their communities. Each type of plan offers opportunities to address the potential impacts of AVs on the community's future.

Comprehensive plans

The comprehensive plan (referred to as the general plan in California and community master plan in New Jersey) is the leading policy document guiding the long-range development of local jurisdictions in the United States. The vision and goals for a comprehensive plan typically address topics such as land use, transportation, natural resources, and design of the built environment. Contemporary plans consider these topics not as stand-alone elements, but as complex systems whose interactions are key to achieving the desired future (Godschalk and Rouse 2015).

Few comprehensive plans to date have explicitly addressed AVs. The District of Columbia has developed proposed policies for AVs as part of its 2016 Comprehensive Plan amendment process. These policies address topics such as access to information, equity, safety, climate effects, right-of-way design, shared parking use, and funding. Thomas Fisher, director of the Metropolitan Design Center at the University of Minnesota, has developed suggested language on Shared Autonomous Vehicles (SAVs) for incorporation into comprehensive plans by communities in the Minneapolis-Saint Paul area as they undertake mandatory comprehensive plan updates. The language and accompanying graphics address preparing public rights-of-way for the transition from cars with drivers to SAVs, the impacts of shared mobility services on residential districts, and design/reuse of parking ramps and lots.

APA's Comprehensive Plan Standards for Sustaining Places, developed as a guide for incorporating sustainability into local governmental comprehensive plans, is a useful construct for considering how AVs can be addressed in the planning process, plan content, and implementation. The standards include six principles (Livable Built Environment, Harmony with Nature, Resilient Economy, Interwoven Equity, Healthy Community, and Responsible Regionalism); two processes (Authentic Participation and Accountable Implementation); two Attributes (Consistent Content and Coordinated Characteristics); and 85 best practices (Godschalk and Rouse 2015). Developed in 2013 and 2014, the standards do not currently incorporate consideration of AVs (APA is planning to update the standards in 2018). Table 1 illustrates how selected best practices for each principle, process, and attribute can address AVs.

Functional plans

Whereas comprehensive plans cover a wide range of topics of community-wide importance, functional plans address one community system such as transportation, parks and open space, or economic development. Functional plans should be consistent with and provide more detailed guidance on implementation of the goals and policies of the comprehensive plan related to their subject areas. The transportation plan is the core functional plan in which AVs can be addressed as an integrated part of a local government's transportation system. In the past, transportation plans typically identified policies for different transportation modes, street/highway classification systems and level of service standards, and transportation improvement

Table 1. Comprehensive Plan Standards for Sustaining Places and AVs

(Selected Examples)

Principle/Process/ Attribute	Best Practice	AV Considerations
1. Livable Built Environment	1.4 Provide complete streets serving multiple functions.	Develop street design standards integrating AVs into complete streets serving all users, including pedestrians, bicyclists, and transit riders. Prioritize shared over private AVs and address the impacts of curbside pickup and drop-off on other modes.
2. Harmony with Nature	2.4 Enact policies to reduce carbon footprints.	Encourage/incentivize use of shared electric or other energy-efficient AVs. Incorporate convenient electric charging stations into transportation infrastructure, with the long-term goal of providing wireless charging for the AV fleet.
3. Resilient Economy	3.3 Plan for transportation access to employment centers.	Use AVs to improve access to employment centers, particularly for populations that may not have personal vehicles.
4. Interwoven Equity	4.5 Provide accessible, quality public services, facilities, and health care to minority and low-income populations.	Include policies and actions using AVs to expand access and mobility for all ages, abilities, and incomes. Address the digital divide and impacts on transit-dependent populations.
	4.7 Plan for workforce diversity and development.	Identify and provide training in new job opportunities for those impacted by AV technology (e.g., bus, truck, taxi, and delivery drivers).
5. Healthy Community	5.2 Plan for increased public safety through the reduction of crime and injuries.	Ensure that AVs operate safely for all users. Leverage the potential safety benefits of AVs to support Vision Zero goals of no fatalities or serious injuries involving road traffic.
6. Responsible Regionalism	6.5 Promote regional cooperation and sharing of resources.	Working with the regional and other local planning agencies, develop a regional AV strategy coordinating infrastructure changes; regulatory, pricing, and other policy mechanisms; effects on regional land use and employment patterns, etc.
7. Authentic Participation	7.4 Develop alternative scenarios of the future.	Develop scenarios for the future deployment of AVs, and evaluate their impacts on community values and goals.
8. Accountable Implementation	8.6 Establish implementation indicators, benchmarks, and targets.	Incorporate performance metrics for factors such as transit ridership, safety, access for underserved populations, etc., to track the effects of AV deployment.
9. Consistent Content	9.1 Assess strengths, weaknesses, opportunities, and threats.	Address the potential effects of AVs as part of the SWOT analysis, and use to inform community discussions on planning implications and responses.
10. Coordinated Characteristics	10.3 Be innovative in the plan's approach.	Address AVs and other technological change/disruption (e.g., future-oriented language promoting adaptability, innovation, and experimentation).

programs and projects. Today, new forms of transportation plans are emerging in response to changing technologies and recognition of the role of transportation on issues such as community health, resilience, and sustainability. Three examples are:

- *Smart Mobility Roadmap*: Austin's Approach to Shared, Electric, and Autonomous Vehicle Technologies (Austin, Texas)
- *Urban Mobility in a Digital Age* (Los Angeles Department of Transportation)
- *New Mobility Playbook* (Seattle Department of Transportation)

Seattle's *New Mobility Playbook* includes a Preliminary Automated Mobility Policy Framework addressing Equity and Accessibility, Pilots and Partnerships, Infrastructure and Street Design, Mobility Economics, and Land Use and Building Design. Table 2 provides examples of policies for each of these topics.

At the regional level, MPOs are responsible for preparing long-range transportation plans (LRTPs), which serve as the defining vision for transportation systems and services and indicate all of the transportation improvements scheduled for funding over the next 20 years. A survey of the 25 largest MPOs by Erick Guerra of the University of Pennsylvania concluded that none of these organizations had addressed AVs in their most recent LRTP due to uncertainties about the technology and relationship to investment decisions (Guerra 2015). Guerra further noted that interviewees were monitoring developments and actively looking to understand and plan for future impacts. The extent to which MPOs have begun to address

Table 2. Preliminary Automated Mobility Policy Framework, Seattle

Topic	Example Policy
Equity and Accessibility	**EA1:** Ensure the benefits of automated mobility are equitably distributed across all segments of the community and that the negative impacts of automated mobility are not disproportionately borne by traditionally marginalized communities.
Pilots and Partnerships	**PP1:** Develop strategic pilot partnerships to test automated vehicle technology in Seattle's climate, hilly terrain, and urban traffic conditions.
Infrastructure and Street Design	**IS1:** As vehicle ownership decreases and reliance on shared automated vehicle fleets increases: • Capitalize on system efficiencies to implement our transit, bicycle, and pedestrian master plans. • Capitalize on opportunities to invest in placemaking features and expand the pedestrian realm. • Identify and phase in corridors and zones dedicated to transit, walking, and high-occupancy automated vehicles only.
Mobility Economics	**ME1:** Develop a tiered and dynamic per-mile road use pricing mechanism for automated vehicles operating in highly congested areas and corridors of Seattle: • Tier 1 (elevated surcharge): Zero-occupant automated vehicles • Tier 2 (base surcharge): Single-occupant automated vehicles • Tier 3 (reduced surcharge): Automated vehicles using smart lanes with less than three passengers • Tier 4 (no surcharge): Automated vehicles using smart lanes with three or more passengers • Tier 5 (additional surcharge on Tiers 1–3): Peak travel period surcharge for all nonpublic transit vehicles trips with less than three passengers, including freight
Land Use and Building Design	**LB1:** Ensure automated vehicles advance our land-use goals and capture the value of transit-oriented development.

Navya

Shuttle services, such as the Navya shuttle shown in testing at Mcity, can connect residents in low-density areas to employment hubs.

AVs in their LRTPs several years after Guerra's article is uncertain. Regardless, it is clear that MPOs have a major role to play in setting infrastructure investment priorities and providing regional policy guidance on this topic.

AVs have implications for other types of functional plans besides transportation plans. Sustainability plans, for example, can encourage use of shared electric AVs to reduce greenhouse gas emissions from the transportation sector. Economic development plans can promote new job opportunities related to connected and AV technology and promote workforce training for those displaced from traditional jobs. Park, open space, and green infrastructure plans can identify future opportunities to convert parking lots and other lands that may become obsolescent as a result of technological change into uses such as recreational areas and green stormwater infrastructure. (This is reminiscent of the Red Fields to Green Fields research effort that was initiated in the wake of the Great Recession.) Community health improvement plans can address the health implications of AVs; potential positive health effects include, among others, reduced automobile collisions (one of the world's largest preventable causes of disability and death) and increased mobility with resulting health benefits for the elderly. Examples of potential negative impacts on health include: 1) labor market disruptions (employment is an important determinant of mental and physical health) and 2) increased chronic health conditions (obesity, diabetes, etc.) if accessibility to AVs lead to an increase in automobile use at the expense of active transportation modes (Crayton and Meier 2017).

Growth management plans are a hybrid form of plan in that, like a comprehensive plan, they address multiple communitywide systems but focus on the location, type, and timing of new development (a single topic akin to a functional plan). Growth management planning can be used to address the potential for AVs to promote sprawl, including tools such as:

- Urban growth boundaries
- Incentives for infill development
- Agricultural/conservation zoning and purchase of development rights
- Transfer of development rights (TDR)
- Limits on infrastructure (water, sewer, road) extensions

In addition to these established tools, AVs will enable the development of new approaches to meet the needs of rural areas and their residents. Consider, for example, a rural growth strategy that focuses commercial activity and community services in a designated village center. A mobility hub might be incorporated into the center that provides shared AV services for residents of the surrounding area, as well as an AV shuttle link to a regional job center.

Like the new mobility plans referenced above, new forms of functional plans will likely evolve in response to technological and other societal changes. For example, symposium participants identified the need for mobility resilience action plans (possibly as hybrids between new mobility plans, hazard mitigation plans, and climate action/adaptation plans) to address issues such as preparedness for and emergency response during extreme weather events, cyberterrorism, and national security.

Subarea plans

Subarea plans (referred to as specific plans in California) address discrete geographic areas within a jurisdiction, such as a neighborhood, special district, or corridor. They can cover a wide range of topics (similar to a comprehensive plan) or focus on one or several topics of particular importance (e.g., transportation). Because of their limited geographic extent, subarea plans can delve into greater detail

Table 3. District Scale Planning for AVs

Potential Built Environment Impact	**Sample District Scale Planning Intervention**
Smaller and More Ef cient Rights-of-way: AVs' unique navigation capabilities are expected to enable narrower traffic lanes, reduce the number of lanes needed to accommodate traffic demand, and remove the need for medians.	Develop new designs/ cross-sections for district rights-of way that capture space freed up by more efficient AV travel for other uses (pedestrian and bicycle infrastructure, green stormwater infrastructure, etc.). Develop a plan for phasing in improvements over time as the vehicular fleet transitions from conventional vehicles to AVs.
A Drop-off Revolution: AVs are expected to create demand for drop-off areas that are as close as possible to the entrances of destinations. These drop-off areas will impact site-level design and affect access management in the form, location, and design of curb cuts and drop-off/loading areas.	Incorporate pick-off/drop-off areas into the design of the district street network. Address effects on vehicular traffic flow and other travel modes. (Regardless of AVs, this intervention is advisable in many urban districts to manage the effects of TNC vehicles.)
Signage & Signalization: Because traffic information can be transmitted to AVs wirelessly in real time, resulting in far fewer traffic signs and signals and less cluttered urban spaces.	Develop a plan to replace conventional signs and signals with connected, wireless infrastructure combined with navigation/wayfinding systems for pedestrians and bicyclists to support complete streets. Ensure that the municipality has adequate technological capability to manage vehicle-to-infrastructure sensor networks.
Bicycle & Pedestrian Infrastructure: AVs are expected to improve the safety of bicyclists and pedestrians, but they may also make nonmotorized travel more difficult by fragmenting or slowing down bike and pedestrian networks.	Designate connected bike and pedestrian networks throughout the district. Institute AV traffic controls at intersections and other key network points to ensure safe, comfortable travel for bicyclists and pedestrians.
Parking: AVs will bring massive changes to the location, form, and amount of parking, as AVs can park themselves or remain in the transportation network while awaiting their next rider.	Designate parking/staging areas for AVs, ideally around the periphery of the district.
Redevelopment Opportunities: Reducing parking and narrowed rights-of-way will yield substantial redevelopment opportunities in urban areas dominated by surface parking and wide roadways.	Incorporate reuse of surface parking areas and excess roadway space into the district land-use plan, including guidance for mix of uses, density, building form, open space, etc.

(Source: Chapin et. al. 2016)

than communitywide plans on issues such as land use and urban design, including parcel-specific recommendations.

In the short term, subarea planning can be used to address AV pilot projects at the corridor or district scale, for example by determining how AVs will operate within the public-right-of-way in concert with other travel modes. Longer term, subarea planning provides an appropriate scale to develop and test approaches to managing land use, urban design, and other impacts of AV technology. To illustrate this point, Table 3 shows how district scale planning might address six potential impacts on the built environment identified by Chapin et. al.

Because the potential impacts identified in Table 3 are interrelated, district-scale planning interventions should seek to integrate land-use, built form, and public realm improvements with complementary, supporting mobility networks and services. Mobility hubs—defined by Metrolinx (the transportation agency for the Greater Toronto and Hamilton, Canada, area) as "the strong, defining places where an intensity of land uses and destinations interact with high quality, customer-oriented transportation service"—could be designated in concert with smart technology to facilitate seamless transfer across modes.

Given the projected lengthy transition period from a conventional to predominantly AV fleet, the district plan should address how the interventions will be phased in over time.

Complete streets, such as these retrofit projects in New York City, create a safe and welcoming environment for different types of road users including pedestrians, cyclists, cars, and transit vehicles.

In a recent example of subarea planning, ARUP and Perkins + Will developed scenarios and design recommendations for the 4th Street corridor in San Francisco as a case study "to quantify and visualize the ways in which autonomous vehicles could change the street and how we could reclaim the public right-of-way to design streets for people, not just cars" (ARUP and Perkins + Will). The study concluded that AVs will impact urban street design in two major ways. First, increasing curbside (pickup and drop-off) service demand will compete with lagging parking demand while AVs are mixed with "legacy" (conventional) vehicles, eventually yielding to "continual and predictable" demand for curb service, while on-street parking demand "drops to irrelevance" in "more fully autonomous environments." Second, "greater efficiencies with autonomous vehicles will allow for lane reductions and complete street features." The recommendations include passenger loading zones on both sides of the streets, a reduction in travel lanes from four to two, creating space for expanded sidewalks, adding cycle tracks, and green stormwater infrastructure.

Regulations, standards, and incentives

Regulations—zoning and subdivision controls, design and development standards, codes and ordinances, etc.—are the first of three strategic points of intervention that involve plan implementation. They are among the primary tools in the planner's toolbox that can be used to implement goals and policies for AVs set in comprehensive, functional, and subarea plans. Because local governmental policy making on AVs is in its beginning stages, there are no existing examples of regulations enacted specifically to address AVs. The following are examples of how regulatory controls and incentives could be used to manage the impacts of AVs. While presented separately for illustrative purposes, these and other approaches should be developed together to implement community goals (e.g., providing increased density as an incentive for affordable housing). Planners might consider undertaking a comprehensive "audit" or "diagnosis" of the community's regulatory systems to identify opportunities, gaps, and barriers to maximizing the community benefits and minimizing the community costs of smart mobility and technology (including AVs).

Land use

Potential impacts of AVs combined with other technological trends (particularly e-commerce) include freeing up of parking, gas stations, and other auto-oriented land/buildings (including brick-and mortar retail) for conversion to other uses; increased demand for warehousing/distribution and new uses such as AV staging, support services, and electric recharging stations; and increased sprawl if commuters choose to have their cars drive them longer distances. Regulatory approaches to addressing these issues include:

- Amend or replace prescriptive use regulations with more flexible approaches to accommodate demand for conversion of existing properties and emergence of new uses. Form-based codes and performance zoning, which emphasize urban form and outcomes, respectively, over uses, are two approaches to consider.
- Provide for increased density (enabled by the reduction in land needed for parking) to meet affordable housing and other development goals.
- Implement growth management strategies to limit sprawl and reinforce desired development patterns (e.g., urban and rural zoning, TDR).

Parking

Most development codes contain minimum parking standards intended to satisfy peak demand for different land uses. These "one-size-fits-all" standards often bear little relationship to actual parking supply and demand, cause land to be consumed that could be devoted to other uses, and increase development costs, thus impacting housing prices and affordable housing needs. Up to 75 or 80 percent of suburban commercial property area

Parking facilities, such as this garage in Sunnyvale, California, and surface lot in Long Beach, California, are currently a dominant feature of American cities, suburbs, and small towns. Reduced parking needs as a result of AVs will provide opportunities to rethink and redevelop these areas.

consists of "sometimes-occupied parking; in urban areas parking can occupy between 20 and 30 percent of building envelopes" (Elliott 2017). AVs are expected to greatly reduce parking demand over time, rendering large amounts of land devoted to parking and the standards that created them obsolete. In addition, AVs' more efficient use of space will impact dimensional standards for parking lots and garages. Regulatory approaches include:

- Eliminate or significantly reduce minimum parking requirements. Cities across the country are eliminating parking minimums, typically in downtowns or other business districts. In 2017 Buffalo, New York, became the first major U.S. city to eliminate parking minimums citywide.

- Adjust parking dimensional standards (stalls, access lanes) to the reduced area that AVs will require to park. Ultimately, the location and design of AV parking structures will likely not need to take humans into consideration, resulting in much reduced space requirements in underutilized or out-of-the-way locations (Chapin et. al. 2016).

- Implement district-wide rather than site-based parking solutions. Symposium participants suggested a parking "cap-and-trade" system, presumably as a mechanism to balance parking demand and supply over time. Another approach might be to designate sites for parking facilities in a district plan and institute provisions for developers to pay into a fund to construct the facilities rather than providing parking on-site.

Planners should monitor effects on parking demand and supply as the vehicular fleet converts from conventional vehicles to AVs over time, and adjust parking requirements accordingly. It is probable that automated and human-driven vehicles will need separated parking facilities during this transition to ensure AV efficiencies can be realized (Chapin et. al. 2016).

Street standards

The potential built environment impacts identified in Table 3 indicate that local jurisdictions will have the opportunity to reimagine current street standards to promote multimodal travel and reclaim land for other uses as the vehicular fleet converts to AVs. Areas to address include:

- Require complete streets integrating vehicular traffic with safe and comfortable pedestrian, bicycle, and transit facilities. Develop new street typologies and typical cross-sections for different types of streets (narrower lane widths, on-park street parking reduced or eliminated, ample sidewalks and bicycle lanes, etc.).

- Replace vehicular level-of-service standards with standards for all travel modes. Prioritize pedestrian, bicycle, and transit movement over AVs and shared over single-occupancy and zero-occupancy AVs.

- Incorporate guidance for locating and designing on-street drop-off and pickup areas. Vehicular drop-off and pickoff may be prohibited along some street frontages in order to maintain other modes and uses.

- Develop specifications for eliminating conventional traffic signage and signalization, unobtrusively accommodating vehicle-to-infrastructure networks within the public right-of-way, and providing navigation/wayfinding systems and other amenities that demarcate and prioritize pedestrian and bicycle movement.

- Provide street trees and other green infrastructure within public rights-of-way.

- Develop policies, metrics, and milestones to phase in standards over time and repurpose excess capacity for new uses.

Given that the space efficiencies expected from full deployment of AV technology are projected to take several decades to fully realize, it is important to plan ahead for the transition. Seattle's New Mobility Playbook, for example, includes an infrastructure and street design policy to "develop a citywide network of shared residential streets to be operationalized when Level 4/5 automated vehicles consist of a majority of all personal and shared fleet vehicles licensed in Seattle." It is important to note that there could be increased vehicular demand on streets/rights-of-way during the transition period to accommodate separation of conventional and automated vehicles. Planners and designers will need to monitor this situation and develop creative solutions to maintain other modes of travel. This will likely include the use of technology to enable street designs to be flexible and adapt to changing mobility conditions.

Open space

The expected availability of land for other uses enabled by AVs will provide the opportunity to rethink open space and related requirements such as landscaping and stormwater management while maintaining development yields. Minimum percentage requirements that typically relegate open space to "leftover" portions of the development parcel could be replaced by standards for the integration of greenspaces serving multiple, integrated ecosystem functions into new developments (a concept called Eco-Functioning Spaces by Rachel Toker of Urban Ecosystem Restorations). Seattle's Green Factor (a landscape requirement based on a weighted point score) and Philadelphia's Greened Acres (a measure of stormwater management) are examples of regulatory programs based on environmental performance (referenced in case studies in Rouse and Bunster 2013). These examples are not suggested as definitive solutions, but rather to indicate the possibilities for planners and designers to reimagine open space networks and implementing requirements in a world of AVs. Similar to the approach suggested for district parking facilities above, developers might be required to provide a minimum amount of ecologically performing greenspace on site and contribute to development of a district-serving park in a designated location (e.g., former surface parking lot) that becomes available as a result of widespread adoption of AV technology.

Incentives

Development incentives are used to motivate developers to provide a public benefit that they would not otherwise provide, in exchange for increases in development potential, streamlined approval processes, or lower develop¬ment costs. A good example noted above is the provision of affordable housing in exchange for increased density. The reduced space requirements and infrastructure costs for vehicular access and parking resulting from AVs should create other opportunities to meet affordable housing needs. (By all accounts, the development costs created by minimum parking standards can be a significant impediment to affordable housing.)

As characterized by the "utopian" versus "dystopian" scenarios previously described, the extent to which the AV fleet consists of shared-use versus privately owned vehicles is likely the factor that will have the most impact on environmental and other community costs and benefits of AVs. RethinkX predicts that 95 percent of U.S. car miles in 2030 will be in self-driving, electric, shared vehicles, and that this change will largely be driven by market forces (RethinkX 2017). Others expect that current travel behaviors and cultural preferences for driving alone will prevail, meaning that the majority of VMT will continue to be in privately-owned AVs (with or without electrification). RethinkX and others predict that, while the efficiencies of an AV fleet will reduce traffic congestion, VMT will increase even with a predominantly shared-use model.

It may be that the ultimate outcome will be a mixed (shared-use and privately owned) AV fleet, perhaps with shared-use predominating in cities, a combination of both in suburban areas, and private ownership predominating in rural areas with lower population densities. Regardless, incentives (and accompanying disincentives) can be used to encourage use of shared-use electric and shared-use over privately owned vehicles and discourage excess VMT. Seattle's proposed tiered road-pricing mechanism, which incentivizes automated vehicles with three or more vehicles, is an example of a possible approach (see Table 2). Other mechanisms might include:

- Variable congestion pricing
- VMT fees
- Parking policies/pricing that discourage privately owned vehicle parking
- Curbside use (pickup and drop-off) fees
- Incentives for increased vehicular occupancy (e.g., lanes, drop-off and pickup zones, etc. reserved for SAVs; preferential pricing)

- Prioritization of the access needs of mobility-impaired populations (persons with disabilities, elderly, transit-dependent, etc.) in the smart mobility system, including subsidies for transit use supported by pricing structure

Site design and development

Development work—site design and construction—is the second strategic point of intervention that involves plan implementation. AVs are being driven by private-sector innovation, and private investment will play a major role in determining their on-the-ground impacts. A strong planning framework consisting of plans (strategic points of intervention 1 and 2) and implementing regulations (strategic point of intervention 3) will position local jurisdictions to manage deployment of AV technology in ways that meet community goals and minimize adverse impacts. While this section addresses private development, it should be noted that the same principles will come into play in designing public sites and facilities (e.g., integrate drop-off/pickup space, rethink parking garage design). In addition, public-private partnerships that capture and monetize the market value potentially created by AVs have great promise to achieve desired outcomes given the limited financial capacity of local governments. An example might be a public-private partnership to redevelop a public parking lot or garage that becomes available due to reduced parking demand for uses identified in a district plan.

Table 4 presents an initial site development checklist of items to consider in designing for an AV world. They include both direct responses to the impacts of AV technology (primarily under Site Access, Circulation, and Parking) and other measures to promote positive outcomes from new developments (e.g., improved health and wellness).

Architects, planners, and developers are beginning to anticipate the deployment of AVs in development project planning. For example, an April 2017 *Los Angeles Times* article reports that AvalonBay Communities, one of the nation's largest developers of multifamily homes, is incorporating design features such as prominent drop-off points for ride sharing, electric charging stations, and parking garage floors that can be converted to other uses into new developments. A surface parking lot in Brentwood, an existing office park in Nashville, Tennessee, is being redeveloped with smaller footprint underground parking designed for self-parking vehicles and mixed use development above. David Dixon, Stantec's Urban Places Planning and Urban Design Leader, reports that the firm is working on several large projects involving SAV shuttle connections to public transit. One example is being planned to meet current minimum parking standards but is phased to avoid building the parking shown in Phase III (roughly 10 years out) under the assumption that the SAV connection to transit will reduce demand by roughly 50 percent.

Public investment

The fifth and final strategic point of intervention is investment in public infrastructure and facilities. Safe operation of AVs will depend on a predictable driving environment, including roads in a good state of repair (well-marked traffic lanes, uniform pavement, etc.). Meeting this need calls for both substantial capital investment in upgrading existing roadway infrastructure and a higher standard of maintenance than has become the norm in an era of declining governmental budgets. Although the extent of investment that will be required of local governments is uncertain, sensor networks, "Fifth Generation" (5G) broadband, and data storage and processing capacity will be needed to support autonomous and connected vehicle technology. Distributed charging stations and possibly wireless charging capacity built into parking areas and streets will be needed to support electrification of the vehicular fleet. Existing highways, streets, and parking facilities will need to be retrofitted to accommodate AVs, with the changes phased in over time as the vehicular fleet shifts from conventional to autonomous technology. In addition to these direct impacts, public lands (public parking lots and garages, excess right-of-way) will become available for reuse and redevelopment due to widespread deployment of

Table 4. Site Design and Development Checklist for AVs

Questions to Consider	Elements to Consider
Site Location and Context	
Does the site connect with existing development?	• Contiguous with existing development • Infill • Redevelopment of previously developed site
Does the site connect to multimodal transportation networks?	• Bicycle network • Pedestrian network • Bike sharing and car sharing • Transit-oriented development/ proximity to transit stops • Shared autonomous vehicles shuttles to facilitate first mile-last mile connections to transit
Does the site connect to surrounding open space networks?	• Greenway/trail systems • Nearby parks • Green infrastructure (e.g., green streets)
Site Access, Circulation, and Parking	
Is multimodal access and circulation provided on site?	• Safe, comfortable facilities for pedestrians and bicyclists • Mix of autonomous and conventional vehicles, including reduced dimensional requirements potentially enabled by AVs
Does the design accommodate new forms of drop-off and delivery?	• AV passenger drop-off/pickup that does not conflict with other modes • Autonomous deliveries (ground and air)
Is parking limited to what is required for demand, taking into account the expected impacts of AVs?	• Appropriate number of parking spaces • Appropriate parking space dimensions (AVs enable reduced footprints) • Allowance for future reuse of parking areas as parking demand decreases
Building Design and Use	
Is the building designed for the human scale and the health and wellness of occupants?	• Relationship to street/pedestrian realm • Building entrances • Building massing and facade articulation • Universal design • Green/well building certification
Is the density of the development appropriate for the location?	• Compact development • Potential to realize affordable housing and other community goals through increased density enabled by reduced parking demand caused by AVs
Are mixed uses provided on-site or within comfortable walking distances?	• Residential, retail/commercial, office uses • Live-work potential • Access to community facilities and services
Is the building design flexible and conducive to future conversion to other uses as market conditions change?	• Parking garages: design for future conversion when parking demand drops due to AVs (adequate structural capacity, floor-to-floor heights, level parking areas with ramps and spirals that can be removed)

(Table 4 continued)

Table 4. Site Design and Development Checklist for AVs

Questions to Consider	Elements to Consider
Open Space and Vegetation	
Does the site plan incorporate sufficient multifunctional open space?	• Places for people to gather, recreate, have contact with nature • Environmental performance: green infrastructure, biodiversity, etc.
Does the site plan preserve existing vegetation and/ or include new plantings that provide environmental benefits?	• Trees/tree canopy • Habitat value • Species selection (e.g., native/indigenous plants)
Other Considerations	
Does the proposed development address safety and security concerns?	• Pedestrian and bicycle safety • Crime Prevention Through Environmental Design • Cybersecurity

AVs. Moreover, design of new public facilities, including site access, circulation, and parking, should take into account the projected impacts of AVs (Table 4).

The above needs and impacts will have significant implications for governmental budgets as technological change increasingly disrupts traditional revenue sources. Federal and state gasoline taxes have been declining in recent years as VMT levels off and the automobile fleet becomes more fuel-efficient, a trend that could accelerate with the deployment of AVs and electric vehicles. At the local level, various researchers project that fees and fines collected from parking and traffic enforcement will sharply decline (Clark, Larco, and Mann 2017). E-commerce is impacting state and local sales tax revenue, which would be further disrupted by a decline in automobile dealerships and other auto-oriented uses if the market shifts from a privately owned to a predominantly shared-use model.

At the federal level, the Eno Center for Transportation has proposed that Congress establish a per mile/ VMT fee administered by the U.S. Department of Transportation to fund "a new federal grant program . . . targeted to investments that improve the safety and reliability of AVs, including state of good repair programs and connected infrastructure deployment" (Lewis, Rogers, and Turner 2017). At the local level, pricing mechanisms for commuter traffic/congestion, parking, and curbside use could provide new municipal revenue streams while incentivizing shared use over single-occupancy (and zero-occupancy) vehicles. In addition to opportunities for private-sector redevelopment of public lands, public-private partnerships with "mobility-as-a service" companies that use public rights-of-way could create a new source of revenue for capital improvements and maintenance. Data-sharing agreements with such companies are needed to monitor mobility patterns, assess service to all neighborhoods, and inform decision making on investments to create more effective and equitable transportation networks (NLC 2015).

Local, regional, and state capital improvement programming and project planning processes will need to be adapted to the projected impacts of AVs. Anderson and Larco (2017) propose that transportation planning agencies "operationalize a fix-it-first policy" that prioritizes maintenance of existing infrastructure over roadway construction projects to increase traffic congestion. Asset management will need to account for both short-term project requirements and the anticipated long-term need to adapt to the impacts of AV technology within the project's life cycle.

'No one knows, but a reasoned guess to achieve Level 4 automation in all but the most remote areas of the U.S. is:

- $2 trillion initial capital investment over 20 years (1.5 million urban lane miles + 4.5 million of 6.5 million nonurban lane miles x $300k/lane mile with the total rounded—includes capital upgrades and deferred repairs, redesign, and technology installations, but assumes no new roadways), AND
- $100 billion/year for operations and maintenance + $200 billion/year in capital preservation, or $300 billion/year.'

Source: Arthur C. Nelson, FAICP, 2017

V. Future Research Needs

Author: David Rouse, FAICP

Led by the private sector, universities, and the federal government, research on autonomous and connected vehicles has focused to date on issues related to deployment, including safety and the human-machine interface (i.e., human behavior and interaction with the vehicle/technology). Relatively little research has been done on the potential secondary impacts of the technology (e.g., environmental, socioeconomic, land use and built form), except for studies of projected changes in VMT and energy consumption based on factors such as private ownership vs. shared use. Moreover, as this report demonstrates, there is very little guidance available beyond general policies on how local governments can manage those impacts. We propose four major areas of research to inform development of more robust resources and tools for use by local governments:

www.pedbikeimages.org – Adam Coppola Photography

Street design standards will need to address both the current mix of motorized and nonmotorized road users as well as automated and nonautomated vehicles.

1. Most current work on the impacts of AVs, and potential benefits such as freeing up land from parking, assumes full deployment of the technology, which according to prognosticators is likely several decades in the future. With pilot programs and commercial applications rolling out with increasing frequency in the short term, better understanding is needed of the time line to widespread adoption, the dynamics of mixed (conventional and AV) fleets during the transition, and implications for street design, land use and parking, transit, access and equity, municipal finances, etc.

2. Given the present level of uncertainty, more robust scenario planning tools incorporating reasonable assumptions regarding deployment of AVs over time are needed for communities to use in long-range planning processes. These tools should be informed by the latest research on the transition to/phasing of AV technology as described in 1 above.

3. More specific, "nuts and bolts" planning guidance—model comprehensive plan language, parking ordinances, street design standards, public-private partnership prototypes, etc.—needs to be developed and tested for use by communities in local contexts. Such guidance should account for the uncertainty of transition to widespread adoption of AVs (1 and 2) by incorporating monitoring and feedback mechanisms that enable communities to adapt planning tools as conditions change over time.

4. Most work to date has addressed the implications of AVs for urban areas. Much less work has been done on the implications for suburban and particularly rural areas, which lack the density on which many

of the projected benefits are predicated and could be affected by secondary impacts such as sprawl and reinforcement of the urban-rural divide. Research is needed to better understand the impacts of AVs in different geographic contexts and to develop resources and tools for use by suburban and rural communities.

In January 2018 the APA Board of Directors adopted principles and policy recommendations for integrating AVs within the fabric of communities through planning, urban design, placemaking, and infrastructure investments, including the following that build on the four major research areas:

Principles

Principle 9: APA supports efforts to research and address equity issues created by AVs; equity concerns include the rural-urban divide and the increasing suburbanization of poverty and how these will be impacted or exacerbated by AV adoption.

Principle 15: APA supports research and development efforts focused on creating a more sustainable transportation network resulting from the possibility of more compact development, reduced pavement requirements, improved vehicle performance, modified roadway maintenance schedules and equipment, and any other factors that contribute to an overall more sustainable transportation system.

Policy Recommendations

3. Adopt local ordinances that enable communities to be responsive to autonomous vehicles, while providing flexibility to reclaim abandoned infrastructure for public use. APA, working with partners, should consider developing a model ordinance for states and localities.

4. Emphasis should be placed on creating model state enabling legislation to authorize localities to control public infrastructure for public benefits and fully implement sustainable land-use policies that fully exploit the opportunities presented by the shared mobility model of AV adoption.

6. Work with partner organizations to develop common guidance for the design of future buildings, public spaces, facilities, roads, highways, bridges, and other infrastructure.

7. Develop flexible parking policies that can allow for the reduction or elimination of certain parking requirements as AV market penetration increases.

12. Study the fiscal implication for governments at all levels from the large-scale implementation of AV technology as it relates to the impacts on income streams currently derived from transportation taxes and fees, personal property taxation, parking fees and fines, and traffic violation fines, fees and forfeitures to ensure that the public services and infrastructure currently funded by such revenues can continue to be funded consistent with the needs and opportunities of AV mobility.

13. Support planning-focused research, professional development, and education programs related to ongoing AV technology research and breakthroughs to help planners keep pace with the state of the practice in this rapidly evolving field.

The above list underscores how important it is that planners, allied professionals, and the public sector play a proactive role in developing approaches and solutions to manage the impacts of AVs on communities, as opposed to communities reacting to change driven by the private sector and market efficiencies. This report, the APA Policy Principles on Autonomous Vehicles, and the resources developed by many other organizations, agencies, and researchers (listed at the end of the paper) represent only the beginning of this process, which will continue to evolve over the coming years.

VI. Checklists for Autonomous Vehicle Planning

One of the main takeaways from the symposium is that communities need to start planning for autonomous vehicles now. These checklists provide suggestions for getting started in your community. This review includes not only autonomous technology, but trending and emerging technology your community can incorporate now into policies and plans. In your review, feel free to delete, add, or modify tasks.

Internal Engagement

Goal

Reach across departments and regional agencies to coordinate training, planning, and other activities related to transportation technology.

Challenges

- Traditional planning and budgeting silos among agency offices and departments
- Training budgets stretched at a time the needs for new technology skills accelerating

What success looks like

Staff works across agency and departmental lines to create near-, medium-, and long-term strategies for integrating transportation technology into internal functions (training, technology purchases, job descriptions, standard operating procedures) and planning (policy, plans, civic engagement, budgets). These activities result in cost savings, faster policy development and strategic positioning for attracting investment and pilots.

Comments from the symposium:

- Determine data needs across sectors/internal departments to bust silos.
- Use scenario planning to assess impacts of different AV scenarios, focusing on early indications of who wins and who loses.

Strategies and Tasks to Get Started

Quick wins

- ❑ Brief city/county manager on need to communicate priority for preparing for transportation technology.
- ❑ Develop a fact sheet on existing and trending transportation technology (shared-use mobility, mobile apps).

Form internal working group on preparing for autonomous vehicles

- ❑ Identify staff already working on transportation technology.
- ❑ Working with the city or county manager's office, identify internal stakeholders in key internal and regional offices—the local metropolitan planning organization, IT, transit, mobility, economic development, unions.
- ❑ Determine what activity is under way in your city/town/region, for example pilot projects on campuses or local technology companies with connections to the transportation technology industry.
- ❑ Conduct an internal scenario planning exercise(s) to scope trending and likely technology impacts, as well as desired scenarios.
- ❑ Identify the top "hot button" issues internally (e.g., lack of budget, legacy technology contracts).

Develop an internal transportation technology communications strategy

- ❑ Working with communications, create and test initial messages for staff.
- ❑ Create a package for management and elected officials (PowerPoint presentation, handouts).

Conduct a cross-departmental technology audit

- ❑ List existing forecasting, modeling, and decision support software/hardware. For each, note information on subscriptions and licenses (date, price, users).
- ❑ List the types of technologies needed to support autonomous technology (pilot phase, scale, and fully autonomous). Include smart city and communications technology.
- ❑ Conduct an audit of upgrades needed, and strengths and weaknesses.
- ❑ List new or emerging technology desired.
- ❑ Update previous memos to include new technology and trends.

Assess training needs

- ❑ From the scenario planning, compare current versus future skill sets needed by Department
- ❑ Research current training opportunities (webinars, online courses, conferences, University).

External Engagement

Goal

Initiate or expand public outreach and engagement on transportation technology to develop a shared vision of future mobility and gain a competitive economic edge.

Challenges

- Many cities are overwhelmed with "the basics," much less new technology
- Initial research reveals broad public skepticism on autonomous technology in general, and disruptive technology overall.

What success looks like

Transportation technology sparks widespread public interest and engagement, leading to shared goals on improving the current transportation system and expectations of future mobility. The effort leads to higher adoption of existing technology to improve mobility such as the transit experience, parking and active transportation. The city documents public priorities, giving the city (1) a stronger position to negotiate with technology companies and (2) a public prepared to act proactively to harness benefits while limiting risks.

Comments from the symposium:

- Use storytelling and new visualization.
- Focus on using technology to solve existing problems first.

Strategies and Tasks to Get Started

Quick wins

- ❏ Develop a common vocabulary on transportation technology to describe the categories and technologies to be used internally and externally.
- ❏ Work with local news outlets to run a series on mobility of the future.
- ❏ Identify local champions for the effort (e.g., universities, aging-in-place advocates, young professionals groups, local chapters of planning/ mobility groups such as APA & ULI).
- ❏ Identify likely "hot topics" with the public (e.g., potential/perceived job losses, costs, equity).

Develop an external transportation technology communications strategy

- ❏ Working with communications, create and test initial messages for the public.
- ❏ Plan presentations and outreach around transportation (e.g., Bike to Work Day in May).
- ❏ Create a plan update calendar over the next one to four years (e.g. corridor plans, sector plans).
- ❏ Update existing materials with shared-use mobility and mobile apps (e.g., transportation demand management, websites, brochures).

Form a local task force on transportation technology

- ❏ Identify local champions and transportation advocates (including skeptics).
- ❏ Determine task force products: Resolution, scenario planning events, pilot projects.

Initiate outreach by establishing the definition of success

- ❏ Build stories around how trending and emerging technology can improve mobility (including transit and active transportation).
- ❏ Build an initial outreach campaign around asking questions (rather than making statements).

Hold a series of scenario planning exercises as civic outreach

- ❏ Research scenario planning for new technology.
- ❏ Hold small scenario planning "practice runs" before engaging the public to see how best to organize content, build prompts/questions, and determine the end deliverable (if applicable).
- ❏ Build events around scenario planning.

Plan Audits

Goal

Identify and align the universe of local, regional, and state planning updates over the next five years to determine (1) resources, (2) schedules, (3) budgets, (4) public outreach, and (5) consistent language across plans. Identify resource gaps (e.g., new skill, software, training).

Challenges

- Many budgets and project scopes of work have already been established
- Many plans are hundreds of pages long, making audits cumbersome

- Plan and code audits for transportation technology are new, hence there is little guidance on what to look for during an audit.

What success looks like

Staffs works across agency and departmental lines, identifying the top opportunities to update planning documents with consistent language on transportation technology. The audit reveals outdated process and improvements. This exercise facilitates faster action, efficient budgeting, and reduced legal risk.

Comments from the symposium:

- Understand the value impacts of various scenarios (e.g., land supply) and determine how to turn that value into revenue or where there could be dilution to value (e.g., TOD).
- Include technology disruption in other spheres (retail, offices, housing preferences).
- Job/workforce development training.
- Asset management: long lived versus short lived.

Strategies and Tasks to Get Started

Quick wins

❏ As an exercise, audit a recently completed plan as if transportation technology were included in the scope. Ask what aspects of the analysis, plan details, and supporting process would have changed with shared-use mobility and planning for autonomous vehicles.

❏ For plans under development, insert a minimal statement on planning for autonomous cars into a current planning process or an out-of-cycle plan amendment (particularly if testing/pilots are already under way).

❏ Develop a short add-on task to existing contracts to examine codes/plans and make recommendations for near- and medium-term action.

Compiling plans

❏ Form an interagency and/or interdepartmental plan audit committee.

❏ Define audit scope and types of plans and policies needed for the audit.

Spotting barriers and opportunities in plans

❏ Look for language that allows/prohibits pilot projects.

❏ Look for language that allows/prohibit flexible, experimental design for buildings and infrastructure.

❏ Look for language that acknowledges the need to incorporate technology and innovation.

❏ List investments and planning elements that will change with autonomous technology such as parking and broadband.

❏ For budget audits, check whether there is a category for funding innovation or technology. This may include funds available at the manager's discretion.

List of Potential Plans

1. Statewide transportation plan and subplans (intelligent transportation plan, asset management)
2. The long-range transportation plan (MPO)
3. The comprehensive or general plan with supporting chapters on transportation/mobility, transit, land use (local government)
4. Capital Improvement plan and budget (local government)
5. Transit development programs (local government and/or transit agency)
6. Technology or Information technology plan (local government)
7. Corridor, sector and small-area plans – Because AV adoption will be incremental, smaller scale plans can provide a more manageable starting point to coordinate AVs, infrastructure, and land use (local government, business improvement districts, public and private campus)
8. Topical plans – Vision Zero, transportation technology, and new mobility roadmaps

❏ For asset management plans, see where technology can augment existing equipment/assets. Flag assets that will change with autonomous technology.

Identify resource gaps

❏ Identify new investments in analytic software, hardware, communications, and smart city technology.

❏ Identify new skills needed for training and/or new hires.

Planning for Transition – Corridor Plans

Cities and towns around the country are actively redeveloping corridors to spur economic development and meet demand for walkable, accessible, vibrant communities. Autonomous technology is expected to increase interest further for several reasons:

- Transit agencies will focus on higher capacity transit lines as AVs begin to serve areas where transit ridership is low (or transit is not available).
- Straight routes offer less complexity for programming service.
- Wide arterial roadways provide flexible rights-of-way.

Existing Planning Approaches (current)

Common Goals

1. Prioritize redevelopment.
2. Increase walkability and transit to encourage economic development.
3. Identify parking improvements for shared parking.
4. Create a protected, low-stress bicycle network.
5. Improve connectivity to address congestion and access to transit.

Trending Technology (0–3 years depending on technology availability)

Example Goals

1. Integrate shared-use mobility and enhance first/last mile to transit.
2. Use scenario planning, pilot projects and small-scale planning to test new concepts prior to investing in larger scale corridor plan.
3. Create zoning code overlay districts that adapt to changes in demand for housing, workspace, and retail
4. Identify a network of mobility hub locations that feed riders to the corridor.
5. Designate pickup and drop off zones for ride-hailing and delivery zones.
6. Harness first-generation smart city technology for data-driven decisions.
7. Expand the bicycle master plan to include e-bikes, free floating bike share, and master bicycle parking plans.

Emerging Technology (3–10 years)

Example Goals

1. Begin pilot projects and small, fixed-route autonomous shuttle service with more complex services over time.
2. Manage air and ground drones to avoid conflict with other system users.
3. Create district-level plans for energy, water management, and parking.
4. Institute rapid and iterative planning and project delivery.
5. Create performance-based planning using smart city technology and data analytics.

VI. Additional resources

This section offers a snapshot of APA's Research KnowledgeBase collection on autonomous vehicles and includes all 77 resources in the collection as of January 31, 2018. The KnowledgeBase is continually updated to provide the most current and timely resources on AVs (as well as other planning topics).

BACKGROUND RESOURCES

Autonomous Vehicles | Self-Driving Vehicles Enacted Legislation

This website contains up-to-date, real-time information about state autonomous vehicle legislation that has been introduced in the 50 states and the District of Columbia.

Autonomous Vehicles: A Policy Preparation Guide

This guide provides an overview of AV technology and answers frequently asked questions for city leaders on manufacturers, public policy considerations, municipal coordination, and infrastructure investment.

City of the Future: Technology and Mobility

This report focuses on the nexus between mobility and technology and draws conclusions from a variety of sources, including existing literature, expert interviews and transportation plans.

Federal Automated Vehicles Policy: Accelerating the Next Revolution in Roadway Safety

This federal policy provides agency guidance to speed the delivery of an initial regulatory framework and best practices to guide manufacturers and other entities in the safe design, development, testing, and deployment of highly automated vehicles.

Taming the Autonomous Vehicle: A Primer for Cities

This briefing paper offers insights on the big trends taking shape in AV, and the consensus among experts about the nature and pace of future developments over the next 15 to 20 years.

Ten Rules for Cities About Automated Vehicles

This article offers 10 suggestions for cities to consider how autonomous vehicles can help maximize mobility for the greatest number of people, with the most positive outcomes for society.

The Future is Now: The Technology and Policy of Self-Driving Cars

This report presents background information on AV technology, the roles of state and federal government, and considerations for state policy.

REPORTS

Adopting and Adapting: States and Automated Vehicles

This report provides guidance on how states should prepare for an automated future by adapting their approach to motor vehicle regulations, infrastructure investment, and research.

Automated and Connected Vehicles: Summary of the 9th University Transportation Centers Spotlight Conference

This report summarizes plenary sessions focused on institutional and policy issues, infrastructure design and operations, planning, and modal applications.

Autonomous Vehicle Implementation Predictions: Implications for Transport Planning

This report explores the impacts that autonomous vehicles are likely to have on travel demands and transportation planning.

Autonomous Vehicles and the Future of Parking

This report explains how travel behavior is changing and suggests initial policy-making efforts to guide decision making.

Beyond Speculation: Automated Vehicles and Public Policy

This report offers a set of 18 recommendations that address the most pressing policy issues for AVs at the city, state, and federal levels.

Blueprint for Autonomous Urbanism

This report shows how city policies must proactively guide the technology to prioritize people-centric design.

City of the Future: Technology and Mobility

This report focuses on the nexus between mobility and technology and draws conclusions from a variety of sources, including existing literature, expert interviews and transportation plans.

Connected and Autonomous Vehicles 2040 Vision

This report assesses the implications of connected and autonomous vehicles on the management and operation of Pennsylvania's surface transportation system.

Connected Vehicle Planning Processes and Products and Stakeholder Roles and Responsibilities

This report assesses how connected vehicles should be considered in transportation planning processes and products developed by states, metropolitan planning organizations, and local agencies.

Environmental Justice Considerations for Connected and Automated Vehicles

This report highlights how automated vehicles could either address the needs of environmental justice populations or further transportation inequities.

Envisioning Florida's Future: Transportation and Land Use in an Automated Vehicle World

This report envisions the impact of automated vehicle technology on Florida's communities and how it might impact the built environment in the coming decades.

Managing the Transition to Driverless Road Freight Transport

This report explores how a transition to driverless trucks could happen.

National Summit on Design and Urban Mobility: Summary Report

This report offers recommendations to help guide cities to more effectively integrate transportation innovations in their communities.

NC Readiness for Connected and Autonomous Vehicles (CAV)

This report provides an activities roadmap for the state of North Carolina in response to the introduction of connected and autonomous vehicle technology in the marketplace over the next 10 years.

New Mobility: Autonomous Vehicles and the Region

This report examines the role that autonomous vehicles should play in the future of the New York-New Jersey-Connecticut metropolitan area.

Planning for Connected and Automated Vehicles

This report examines the potential impacts that autonomous vehicles may have on government entities and offers recommendations on how regional partners can prepare for the potential policy and land use implications.

Re-Imagining Retail

This report looks at the transformation retail is currently going through and the shift from brick-and-mortar, to e-commerce, to omnichannel approaches.

Rethinking Transportation 2020–2030

This report examines the disruption of transportation and resulting collapse of the internal-combustion vehicle and oil industries, and considers social, economic, environmental, and geopolitical implications.

Stick Shift: Autonomous Vehicles, Driving Jobs, and the Future of Work

This report addresses the potential economic impacts of autonomous vehicle technology on those employed in driving occupations.

Surveying Florida MPO Readiness to Incorporate Innovative Technologies into Long Range Transportation Plans

This report provides a set of recommendations for MPOs to consider in the planning process.

The Future is Now: The Technology and Policy of Self-Driving Cars

This report presents background information on AV technology, the roles of state and federal government, and considerations for state policy.

The Future of Equity in Cities

This report how technological advances in the areas of infrastructure, public safety, and economic development will impact equity in cities.

The Impact of AVs and E-Commerce on Local Government Budgeting and Finance

This report walks through a city's budget —both revenues and expenditures — and describes the areas that will be affected as AVs become commonplace and e-commerce takes on an even larger role in retail.

Urban Mobility System Upgrade: How Shared Self-Driving Cars Could Change City Traf c

This report examines the changes that might result from the large-scale uptake of a shared and self-driving fleet of vehicles in a mid-sized European city.

Warehousing

This report looks at the changing nature of distribution networks with the rise of e-commerce and the effects this will have on the size, number and distribution of warehouses in cities.

ARTICLES

Assessing the Long-term Effects of Autonomous Vehicles: A Speculative Approach

This article explores how autonomous vehicles could affect the attractiveness of traveling by car, how this in turn could affect mode choice, and how changes in mode choice would affect the broader transportation system.

Automated Vehicle Regulatory Challenges: Avoiding Legal Potholes Through Collaboration

This article offers an introduction to the regulatory landscape and challenges that come with automated vehicles.

Autonomous Vehicles: Developing a Public Health Research Agenda to Frame the Future of Transportation Policy

This article examines the prospective public health implications arising from the widespread adoption of fully autonomous vehicles and analyzes how they can be considered in the development of transportation policy.

Autonomous Vehicles: Hype and Potential

This article states that the best of AV technology is in shared vehicles and a new generation of transit options.

Cautious Optimism About Driverless Cars and Land Use in American Metropolitan Areas

This article looks at the potential for driverless cars to enable beneficial changes in land use.

Choice and Speculation

This article highlights the labor savings that can result from replacing human with machine labor and the separation of vehicle from owner/operator made possible by the technology.

Driverless Cars and the City: Sharing Cars, Not Rides

This article speculates that driverless cars will not significantly impact urban form but will expand opportunity and quality of life for the disabled and other people who are unable to drive.

Driverless Vehicle Best Practices

The Commissioner addressed city policy opportunities related to driverless vehicles in December 2016.

Emerging Vehicle Technologies & the Search for Urban Mobility Solutions

This article examines the potential of autonomous vehicles to improve road safety, lower fuel consumption and emissions in vehicles, and provide mobility options for vulnerable populations.

Getting Ready for Driverless Cars

This December 2017 edition of Zoning Practice discusses basic facts about driverless cars and summarizes how changes in travel behavior associated with fully autonomous vehicles will likely affect local zoning codes over the next 20 to 30 years.

Here Come the Robot Cars

This April 2017 Planning article outlines how autonomous vehicles will impact the built environment, and the need for planners to take the lead in directing the impact of AVs on our communities.

How Autonomous Vehicles Will Redesign Cities: Transportation's Future Goes Beyond Roads

This article discusses the ways in which autonomous vehicles will free up space previously needed for vehicles and how it can make way for new amenities.

How Driverless Cars Could Be a Big Problem for Cities

This article discusses how AV could negatively impact city budgets that depend on parking tickets, traffic citations, gas taxes, and other auto-related revenue.

How Governments Can Promote Automated Driving

This article presents steps that governments can take now to encourage the development, deployment, and use of automated road vehicles.

Ten Rules for Cities About Automated Vehicles

This article offers ten suggestions for cities to consider how autonomous vehicles can help maximize mobility for the greatest number of people, with the most positive outcomes for society.

The Evolution of Connected Vehicle Technology: From Smart Drivers to Smart Cars to... Self-Driving Cars

This article looks at the last two decades of transportation innovation as perspective for visualizing the changes that autonomous vehicle technology will bring.

Transitioning to Driverless Cars

This article speculates that the key transitional problems of autonomous vehicle adoption will be about the political economy of the regulation of driverless cars and the cohabitation between driverless cars and cars driven by human beings.

Understanding the Hurdles Facing Autonomous Vehicles in Busy Downtowns

This article looks at the challenge of integrating driverless vehicles into city traffic, including the management of curb space, lane usage, and signage.

Urban Form and Function in the Autonomous Era

This article explores the potential impacts of the autonomous era on transport infrastructure demand and urban form.

When Autonomous Cars Take to The Road

This May 2015 Planning article considers the optimistic and pessimistic views of the impacts of driverless vehicles and suggests what planners can do to prepare.

BRIEFING PAPERS

Autonomous Vehicle Technology: How to Best Realize Its Social Bene ts

This research brief examines the current state and potential benefits of autonomous vehicles and provides guidance for policy makers.

Can We Advance Social Equity with Shared, Autonomous and Electric Vehicles?

This brief focuses on the need for autonomous vehicle policy development to have an intentional focus on equity so that it does not exacerbate existing barriers or increase inequality.

Land Use and Transportation Policies

This briefing paper explores how revolutions in vehicle sharing, automation and electrification present both new challenges and great opportunities for land-use and transportation planners.

Local Government 2035: Strategic Trends and Implications of New Technologies

This paper illustrates how technological advancements, including autonomous vehicles, will introduce data privatization challenges and destabilize existing governance systems.

Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations

This paper explores the feasible aspects of AVs and discusses their potential impacts on the transportation system.

Taming the Autonomous Vehicle: A Primer for Cities

This briefing paper offers insights on the big trends taking shape in AV, and the consensus among experts about the nature and pace of future developments over the next 15 to 20 years.

GUIDES

Autonomous Vehicle Technology: A Guide for Policymakers

This guide explores policy issues, communications, regulation and standards, and liability issues raised by the autonomous vehicle technology and concludes with some tentative guidance for state and federal policymakers.

Autonomous Vehicles: A Policy Preparation Guide

This guide provides an overview of AV technology and answers frequently asked questions for city leaders on manufacturers, public policy considerations, municipal coordination, and infrastructure investment.

Discussion Guide for Automated and Connected Vehicles, Pedestrians, and Bicyclists

This guide presents key challenge areas related to AV, pedestrians, and bicyclists that should be at the center of AV discussions along with a glossary of important terms and key references.

Driving Towards Driverless: A Guide for Government Agencies

This guide outlines the role of government in the integration of driverless vehicles in society.

New Mobility Playbook

This guide offers a set of plays, policies, and strategies to foster new mobility options in Seattle while prioritizing safety, equity, affordability, and sustainability in the city's transportation system.

Paths of Automated and Connected Vehicle Deployment: Strategic Roadmap for State and Local Transportation Agencies

This guide looks at two scenarios for the deployment of automated and connected vehicle technologies within state and local transportation agencies.

Preparing for New Mobility: Writing Effective Resolutions

This guide offers advice to help cities prepare for autonomous technology by passing formal resolutions and setting smart mobility plans in motion.

FUNCTIONAL PLANS

Arlington, Texas. Connect Arlington: A Transportation Vision Connecting People and Places

This functional plan provides recommendations from Arlington's Transportation Advisory Committee on how to best connect citizens to and from destination points within six priority corridors.

Arlington, Texas. Connect Arlington: A Transportation Vision Connecting People and Places

This plan offers Austin's approach to shared, electric, and autonomous vehicle technologies.

Capital District Transportation Committee. New Visions 2040 Regional Transportation Plan

This transportation plan for the Albany, New York, area includes a section on new visions and technology, such as self-driving cars, that will have wide-reaching impacts on future transportation.

Los Angeles. Urban Mobility in a Digital Age

This plan presents a transportation technology strategy for the city of Los Angeles.

San Antonio, Texas. Multimodal Transportation Plan

This transportation plan is a long-range blueprint for travel and mobility in San Antonio and Bexar County, Texas.

San Diego Association of Governments, San Diego Forward: The Regional Plan

This regional plan focuses on sustainability and financing for 19 city and county governments within the San Diego region.

Ulster County, New York. Rethinking Transportation: Plan 2040

Adopted September 29, 2015
This long-range transportation plan sets 25-year goals, objectives, and performance measures for transportation within Ulster County, NY.

Washington, District of Columbia. moveDC

Adopted October 2014
This long-range transportation plan sets the 25-year vision for the transportation system in Washington, DC.

STAFF REPORTS

Adoption of a Resolution Authorizing the City Manager to Regulate Operation of Personal Delivery Devices, also known as Autonomous Robots, within Palo Alto

This staff report contains a draft resolution that was adopted by the city of Palo Alto, California, to create a procedure for allowing autonomous delivery vehicles to operate within the city right-of-way.

WEB PAGES

Autonomous Vehicle (AV) Initiative

This web pages summarizes Beverly Hills, California's initiative to test and deploy a municipal fleet of driverless vehicles.

Autonomous Vehicles: Boston's Approach

This web page summarizes Boston's plans for testing autonomous vehicles and their potential future within the city.

Autonomous Vehicles: Planning for Impacts on Cities and Regions

This web page contains information on APA's work to develop a playbook for cities and regions to maximize the benefits and minimize the potential negative consequences associated with the deployment of autonomous vehicles. It features four videos from an October 2017 symposium.

Driverless Future: A Policy Roadmap for City Leaders

This web page identifies six major priorities for policy makers to protect against the risks and maximize the potential benefits of AV.

GoMentum Station: Collaborations

This web page discusses the Contra Costa (California) Transportation Authority's testing facility for autonomous and connected vehicle technology.

How Will Automated Vehicles In uence the Future of Travel?

This web page provides findings from a test of how AVs might change the predicted outcomes of seven regional travel models from around the United States.

Smart Autonomous Vehicles Initiative (SAVI)

This web page summarizes Portland, Oregon's initiative to work with transportation providers and the public to implement testing and piloting of AV technology.

Ultimate Urban Circulator (U2C)

This web page provides information on the Jacksonville Transportation Authority's plan to convert its existing elevated skyway to a driverless shuttle guideway.

VIDEOS

Autonomous Vehicles: The Public Policy Imperatives

This video discusses five areas where AVs will have significant implications for public policy and service: infrastructure investment, licensing and road traffic regulations, revenue, spatial planning, and security.

Impact of Emerging Technologies on Complete Streets

This video examines the ways in which emerging technologies impact how cities will operate, accommodate growth, manage congestion, improve the economy, increase safety, and improve quality of life.

Innovative Transportation: ON TO 2050 Alternative Future

This video considers how rapidly evolving transportation technology rapidly can be harnessed to improve lives, local communities, and the Chicago region's economy.

NPC17 Special Plenary: How Technology Will Shape Urban Density

This video featuring Rohit Aggarwala of Sidewalk Labs delves into the complex issues surrounding the future of technology's role in the realm of planning, and contemplates if 21st century technology makes cities more attractive, or less.

On Demand: Driverless Cars: Changing How You Plan

This recorded session from NPC 2017 discusses how autonomous vehicles will change the way we think about land-use needs, residential preferences, parking management, workspace needs, and myriad other planning topics.

On Demand: Envisioning the City with Automated Vehicles

This course presents the results of facilitated sessions at the 2015 Florida Automated Vehicle Summit, where planners, engineers, academics, auto industry representatives, and elected officials collaborated to envision the future with automated vehicles.

On Demand: Greater Sustainability with Autonomous Vehicles

This recorded session from NPC 2017 explores the state of autonomous vehicle research and development, the range of challenges and opportunities automated vehicles present, and what planners can do now to enable autonomous vehicle policies that have the greatest positive impact.

On Demand: The Future of Cities and Planning

This recorded session from NPC 2017 discusses the future of cities through three main trends: the use of technology in smart city design, the increase in automated vehicles and their effect on transportation and land use, and a focus on sustainable design.

Road Updates Bene t Both Autonomous Vehicles and Human Motorists

This video discusses California's push to modify roadways to accommodate driverless car technology.

Transportation Q&A—Disruption: AV and Tiny Cars

Planning Editor in Chief Meghan Stromberg has a conversation with Josh Westerhold, senior manager of Nissan's Future Lab, in the April 2017 issue of Planning magazine.

Watch a Fully Autonomous Tesla Drive Through the City and Find a Parking Spot

This video shows how an autonomous vehicle navigates through a city and parks itself without any human input.