

## Urban Planners Shift Gears as Autonomous Vehicles Hit the Streets

# DRIVERLESS ED



Look ma no driver! Navya's autonomous shuttle in Las Vegas. Credit: John Locher, Associated Press

By Kathleen McCormick

LAST FALL, LAS VEGAS completed a yearlong pilot of the nation's first public self-driving shuttle. Over the course of the experiment, more than 32,000 people hopped aboard a blue electric minibus bearing the slogans, "The future is here" and "Look ma no driver." Designed and built by French start-up Navya and operated by Keolis North America, the eight-passenger shuttle traveled on a 0.6-mile loop through the downtown area. A human operator rode along, poised to override vehicle functions in an emergency using a converted Xbox controller.

The city partnered with the regional transit agency and AAA to run the pilot, which was deemed a success. Now accelerating their commitment to autonomous vehicles (AVs), city officials are planning for a second shuttle route and a "robotaxi" service by Keolis and Navya. And in December, the city and transit agency won a \$5.3 million grant from the U.S. Department of Transportation for a project called GoMed. Slated to begin in late 2019, GoMed will provide four autonomous electric shuttles on a four-mile route between the Las Vegas Medical District and a downtown transit center. The medical district includes four hospitals and the University of Nevada at Las Vegas School of Medicine campus, which serve 200,000 patients annually and will employ 6,000 people by 2020. GoMed will feature pedestrian safety devices and 23 smart transit shelters with Wi-Fi, information on shuttle arrival times and occupancy, and wayfinding kiosks.

When it comes to AVs, Las Vegas appears to be all-in—but planning for the impacts of rapidly emerging technology can be complicated. In a Big City Planning Directors Institute session on AVs hosted last fall by the Lincoln Institute of Land Policy, the American Planning Association, and the Harvard Graduate School of Design, Las Vegas Planning Director Robert

Summerfield acknowledged that it is challenging to regulate new mobilities and incorporate them into the urban fabric. This is especially true now, he says, when city leaders are juggling citywide master planning, form-based code regulations, thoroughfare standards, transit system changes, and downtown capital projects—all of which could need adjustments as new mobility options become more popular.

It's an era of contrasts: Public transit is enjoying a surge in metro areas, with expanding light-rail systems in Denver, Los Angeles, and other places, and demand for walkable and bikeable urban spaces is at an all-time high. At the same time, ride-hailing services like Uber and Lyft (which are also known as transportation network companies, or TNCs) have actually increased traffic congestion and vehicle miles traveled (VMT). So how do AVs fit into the picture, and what will they mean for cities? How are planning, transportation, and public works departments adjusting to this rapidly changing mobility landscape, and how can they ensure that the built environment will accommodate changes that haven't yet happened?

At the Planning Directors Institute, Andres Sevtsuk, assistant professor of urban planning and director of the City Form Lab at the Harvard Graduate School of Design (GSD), illustrated the "totally transformative" nature of AVs with an example from the past: When the Model T was introduced, he said, no one could have predicted that we would have 41,000 miles of paved highways across the United States 20 years later. It's just as difficult to predict the impact of AVs.

With so much buzz and uncertainty, the art appears to lie, at this point, not in finessing the AV future, but in managing the next few years of transition. Cars notoriously reshaped our cities in the twentieth century—the question is how AVs will reshape them in the twenty-first.

## Transformative Technology

“We know from our work with big city planning directors across the country that autonomous vehicles are seen as a disruptive technology that will require preparing for a range of impacts—both positive and negative—related to transportation systems and travel modes, land use and urban design, and access for low-income and underserved communities,” says Armando Carbonell, chair of Planning and Urban Form at the Lincoln Institute. Carbonell notes that these topics will be featured in a panel at APA’s 2019 National Planning Conference in San Francisco, with speakers including Los Angeles Planning Director Vince Bertoni and New York City Planning Director Anita Laremont, as well as experts from the fall Planning Directors Institute.

Many other organizations are thinking through the impacts of AVs, including Bloomberg Philanthropies and The Aspen Institute, which issued a joint report on the topic. “Automation is changing the automobile, mostly in ways that will help cities,” notes the report (Bloomberg 2017). “Cities have long struggled with the car’s demands for space. But AVs can be designed for many more forms and functions, creating new opportunities to right-size vehicles for urban use.”

Most AV pilots in the last decade focused on high-speed highways, “but the AV’s future is in cities, where its biggest market demographics are concentrated,” the report suggests.

This shift seems to align with the values of urban dwellers, especially younger generations; in a recent consumer survey by Arity, a data start-up launched by Allstate, 59 percent of

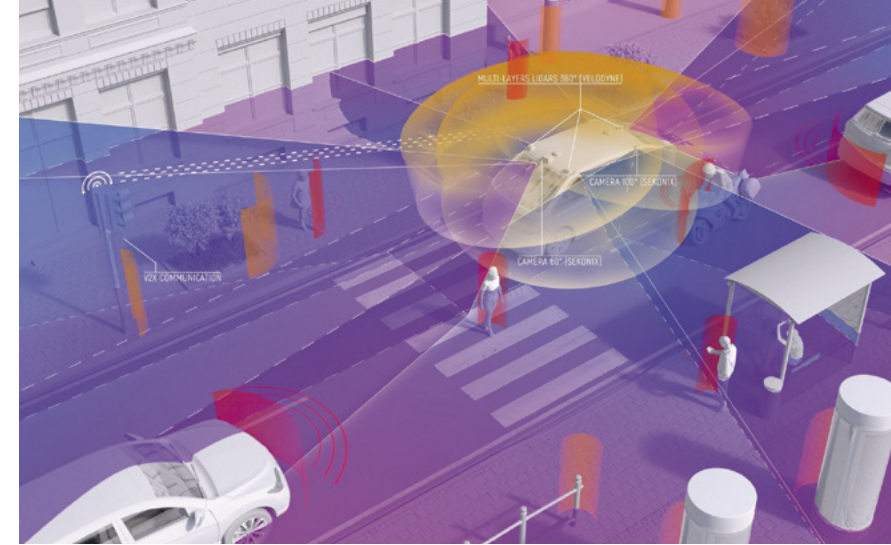
respondents between 22 and 37 years old say they’d rather spend time doing more productive tasks than driving, 51 percent don’t think owning a car is worth the investment, and 45 percent regularly use ride-hailing services (Arity 2018).

“AVs are coming just as our demographics and economy are very pro-urban for the next 20 years,” says David Dixon, who leads urban planning and design efforts at the global design and engineering firm Stantec and also presented at the Planning Directors Institute. “Change will come much faster in urban centers than in suburbs or rural areas because of a critical mass that allows for shared vehicles.”

That change is beginning to occur. After a decade of research and development, tech companies and car manufacturers (also known as OEMs, or original equipment manufacturers) are readying self-driving vehicles for market at a remarkable pace, with fully autonomous vehicles scheduled to roll out this year in pilot programs across the United States. Small, self-driving shuttle buses like the one in Las Vegas have appeared or will soon appear in cities across the United States, from Providence, Rhode Island, to Lincoln, Nebraska, and single-occupant AVs have been tested in cities from Boston to San Jose. Half of the country’s



Passengers board a driverless shuttle in Las Vegas during the city’s yearlong pilot program. Credit: AAA



Fully autonomous vehicles use a combination of sensors, cameras, radar, and artificial intelligence to travel between destinations without a human operator. Credit: Navya

How are planning, transportation, and public works departments adjusting to this rapidly changing mobility landscape, and how can they ensure that the built environment will accommodate changes that haven’t yet happened?

largest cities are preparing for self-driving vehicles in their long-range transportation plans, according to a National League of Cities report on autonomous vehicle pilots, which notes that 28 states were introducing legislation to support such pilots (Perkins 2018).

More comprehensive testing programs are also underway in cities including Austin, Texas, and Phoenix, Arizona. Last fall, Austin—which was the site of the first passenger ride on public roads in an autonomous car without a driver in 2015—began a pilot program with a free, 15-seat electric AV minibus deployed as a circulator in the downtown area.

In another pilot, the Austin Transportation Department is testing technology at five intersections that will allow the city’s traffic system to communicate with self-driving cars. Installed over the streets on traffic-light equipment, the technology can inform AVs about when the light is about to turn, if a driver has run a red light, or if pedestrians are present.

The Phoenix metro area also has evolved as an AV-testing hub for tech companies and OEMs thanks to its road infrastructure, weather, cross-border supply chain, favorable business climate, and access to tech talent. The area boasts 15 companies that are developing and testing driverless vehicles and related technology, according to the Greater Phoenix Economic Council, which says the AV industry will bring Arizona 2,000-plus jobs and \$700 million in capital investment by 2020.

One of those companies is Waymo, launched by Google, which has tested vehicles in autono-

mous mode for over 10 million miles on public roads across the country, from sunny California to snowy Michigan. A test group of 400 “early rider” volunteers has been riding Waymo’s Chrysler Pacifica minivans, modified and equipped with safety drivers, for more than a year in the Phoenix suburbs of Chandler, Gilbert, Mesa, and Tempe. (In 2018, Tempe was the site of the first pedestrian fatality caused by an AV. Uber, which had been testing the vehicle, temporarily suspended its AV operations in Phoenix and elsewhere as a result.)

In October 2018, Arizona Governor Doug Ducey announced the creation of a public-private enterprise to pave the way for self-driving vehicles. The state has pledged \$1.5 million for the project, the Institute for Automated Mobility, a consortium including Intel, researchers from Arizona State University, University of Arizona, and Northern Arizona University, and state transportation, safety, and commerce agencies. The institute will prepare for the expansion of AV technology nationwide, with a focus on liability, regulatory, and safety implications.

At least three dozen companies besides Intel, Uber, and Waymo are involved in developing or testing AVs, including Audi, BMW, Chrysler, Ford, General Motors, Jaguar, Lyft, Tesla, Volkswagen, and Volvo. While no fully autonomous vehicles are available to consumers yet, the current cost of a personal AV “hardware and software package” would add \$70,000 to \$200,000 to the base price of a vehicle, according to various estimates; those figures are expected to come down dramatically, to closer to \$5,000 to \$15,000, as the technology evolves and is adopted more widely.

## Planning for the Unplannable

What will this mean for cities? That's a source of much debate. The "utopian" perspective holds that AVs will usher in a seamless, door-to-door new-mobility system. Their potential benefits include increased roadway safety—the National Highway Traffic Safety Administration estimates that 94 percent of serious crashes are due to driver error—as well as impacts on urban planning and mobility:

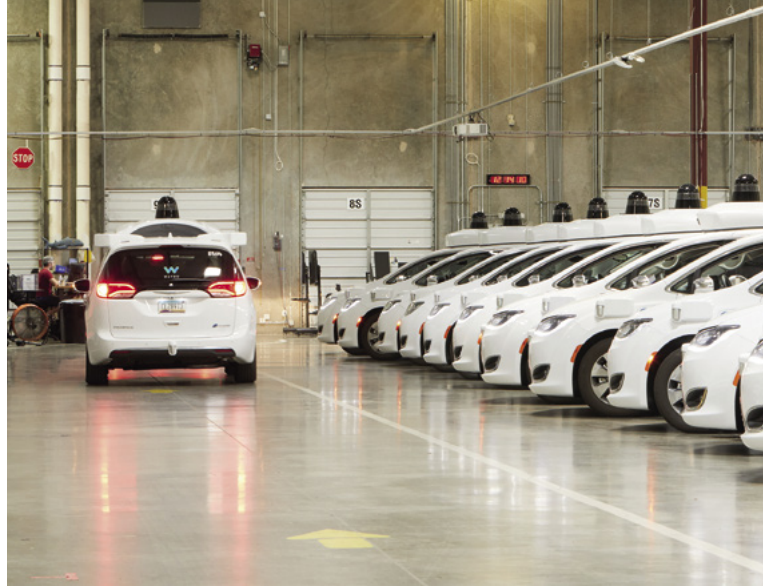
**Roadway efficiency.** Because of their tracking features and the elimination of driver error, AVs could improve transportation efficiency by enabling vehicles to travel closer together. This could allow road diets—modifications that create fewer or narrower lanes—that free up roadway strips for fast transit, alternative modes like protected bike lanes, or green infrastructure.

**Improved traffic flow.** With sensing technology and artificial intelligence fed by route data, AVs could reduce congestion and improve traffic flow through intersections, reducing travel time.

**Decreased travel costs.** AVs could supplant ride-hailing services and eliminate the need for and cost of private vehicles and drivers. Depending on local policies, they could also be deployed for greater transportation equity, to serve underserved populations including those who are elderly, disabled, poor, or live far from public transit (see sidebar, page 29).

**Sustainability.** If all AVs were electric, and powered by renewable sources, they could help cities shift away from fossil fuels, reducing urban pollution and carbon footprints.

On the "dystopian" downside, critics say, tightly spaced and continuously cruising AVs could have negative consequences for bicyclists and pedestrians. If they didn't have to sit behind the wheel, more commuters might opt for a longer commute to a larger house and yard, expanding sprawl, creating more low-density development, increasing municipalities' costs for providing public services, and inflating land and housing costs in the outer reaches. If AVs were predominantly privately owned passenger vehicles rather than shared shuttles, they would



A fleet of driverless cars, ready to be deployed on the streets of the Phoenix metro area. Credit: Waymo

increase congestion. Negative environmental impacts could be compounded by vehicles that were not renewably powered and by the high level of toxicity in manufacturing and disposal of electric batteries. Privately owned AVs could widen the divide between the transportation haves and have-nots.

Utopian, dystopian, or somewhere in between, one thing is certain: The AV future will require adjustments in the way urban planners think. "Because of the significant anticipated impacts of AVs on public infrastructure, land use, and public finance, it is vital that planners actively prepare now for their widespread arrival on city streets," says Carbonell.

As to how to do that, "most preparation for autonomous vehicles involves good-sense common planning principles," says David Rouse, research director for the APA. "Cities should start with visioning and goal setting, and look at development codes, street regulations, public investment, capital improvements," and other areas to guide planning. A key question, he suggests, is how do AVs serve those futures?

"The danger now is that the private sector and car manufacturers will drive how this rolls out," says Rouse. Cities will need help from new types of collaborations and public-private partnerships, he says. "OEMs also need to be brought to the table with cities and the public sector as we figure out how to introduce this technology."

Rouse suggests planners create a site plan review checklist for AVs and consider ideas contained in *Planning for Autonomous Mobility*, a 2018 APA report that aims to provide direction for planners as they update their communities' long-range plans (Crute 2018).

Nico Larco, an architecture professor and director of the Urbanism Next Center at the University of Oregon who presented at the Planning Directors Institute, says cities need to take control of how AVs are introduced and managed before they just appear on the streets, as happened with electric scooters.

Larco advises several steps to ensure control of new mobilities: First, identify and document city priorities. He pointed to Seattle's *New Mobility Playbook*, which identifies outcomes, values, and priorities for equity, economic opportunity, and environmental sustainability (SDOT 2017).

Second, "figure out how best to leverage the new technologies to get to the outcomes you want," he says. "High-density, mixed-use, built on transit are key pieces we need to focus on, and the new mobility gives us that ability. Make sure we frame it as, 'These are the outcomes we want,' and use new mobility to achieve that."

Third, define how data will be collected, owned, and shared. "Data is critical to regulating and evaluating mobilities to see whether they are doing what they said they'd do, and the city is getting the outcomes it wants," he says.

As the mobility landscape changes, San Francisco and other cities have ended or reduced minimum parking requirements for new development projects. Credit: stelianpopa/iStock



Because of their tracking features and the elimination of driver error, AVs could improve transportation efficiency by enabling vehicles to travel closer together. This could allow [more room for] fast transit, alternative modes like protected bike lanes, or green infrastructure.

## Parking Requirements

Parking is emerging as a critical issue as cities begin to look in-depth at the on-the-ground challenges of AVs. In 2018, Chandler, Arizona—one of the four Phoenix metro cities piloting Waymo shuttles—became the first U.S. city to change its zoning code in anticipation of AVs. The zoning amendments, which went into effect last June, allow for minimum parking requirements for new developments to be reduced by up to 40 percent in exchange for the inclusion of passenger loading zones for shared AVs. One passenger loading zone could achieve a 10 percent reduction in parking, with a cap at 40 percent, depending on the number of zones, land use, and building square footage. Planning staff had two primary objectives: to allow for more flexibility in parking minimums as demand for parking changes, and to promote the creation of passenger loading zones for shared rather than single-passenger vehicles.

"In the future, if AV usage picks up, we see the need for parking to be reduced drastically, and we need to be flexible now," says David de la Torre, Chandler planning manager and principal planner for the ordinance project. Reduced parking "presents a lot of opportunity for the city to redesign itself to be a better city for residents and businesses," he says. De la Torre adds that the zoning change is garnering support: at least five developers of multifamily and commercial mixed-use projects are interested in creating TNC-AV passenger zones.

With an estimated 1 billion to 2 billion parking spaces across the country, most cities are significantly overparked, says Larco. Seattle, for example, has about 29 parking spaces per acre, more than five times its residential density of 5.7 households per acre, according to a study of parking in five cities by the Research Institute for Housing America (Scharnhorst 2018). Cities including San Francisco and Hartford, Connecticut, have eliminated minimum parking requirements citywide to help speed up development projects and reduce the number of cars on city streets, and other cities have relaxed parking minimums or removed them in transit corridors.

When the nation shifts to AVs—and most experts agree that the question is indeed *when*, not *if*—cities will see “tremendous opportunities because we’ll need less parking,” says Larco. He estimates that AV shuttles could be in service half of the time, depending on their manufacturing and maintenance costs. Others say AV shuttles could run almost continuously except for brief recharging stops. When they’re not chauffeuring riders, AV fleets will still need a place to park at least temporarily—ideally on less expensive land near arterials or freeways with access to a substation to recharge.

AVs also could reduce the cost of urban development. The median cost of building parking in the United States is \$20,450 per space, according to WGI, a nationwide transportation and civil engineering firm. But that can vary greatly, depending on site factors and regional construc-

tion costs. In Denver, underground parking can cost \$40,000 per space and aboveground \$25,000. In Seattle, structured parking can cost over \$100,000 per space. These parking costs, which can amount to 20 percent of a project’s total development costs, could be used to build more affordable housing or public amenities, or to underwrite additional costs for sustainable buildings. According to the Lincoln Institute’s Carbonell, “One of the greatest potential benefits of the shift away from personal cars could be the freeing up of urban land currently used for parking for redevelopment at greater densities, with more affordable housing and a more livable public realm.”

## Goodbye to Garages?

Meanwhile, how do you decide whether to build that new municipal parking garage? Obtaining a parking construction bond now for 30 years could mean losing money. If you still need to build it, how should it differ from the parking garages of past decades?

Some cities and private developers are building parking garages with flexible design that allows for conversion to other uses later, like office space or housing. Two parking garages for the medical center that are under construction in downtown Las Vegas, for example, “are designed to be future-proof” and adaptable for other uses, says Summerfield.

Global design firm Gensler is helping clients develop AV-compatible buildings like the three flexible garage floors in its 84.51° Centre project, an eight-story, mixed-use building in Cincinnati. Gensler is also designing Giambrocco, a mixed-use project in Denver’s River North (RiNo) district that includes a five-story office building on top of three floors of flexible garage space.

Gensler and the Giambrocco developer, Tributary Real Estate, compared the cost of building a standard parking garage with slanted floor plates and ramp parking against a flex design with flat floor plates, 14-foot ceiling heights to accommodate office space, and external speed ramps that can be removed when the space is converted. They determined that the flexible garage design would cost 25 percent more for the same 375 parking spaces, a \$2.3 million difference on the \$80 million project, mostly because of higher construction costs, says Brent Mather, principal and design director for Gensler’s Denver office. The developer determined that it made financial sense to build the flex plan, he says, because “ultimately when the demand for parking is reduced in 10 to 15 years, converting it to office space will provide bigger returns on investment.”

Cities have compelling reasons to build flexible municipal parking garages “because they’re long-term holders of the properties and have public money invested,” says Mather. For maximum adaptability in buildings, he advises, cities should develop only aboveground, flexible parking, as underground parking has limited reuse potential beyond concepts such as data centers, gyms, or drop-off areas for buildings serving thousands of people. Airports will have to determine what to do with their massive and revenue-rich parking areas and how to provide more efficient drop-off and pick-up areas, he says, “as part of this paradigm shift.”

“We’re at peak parking in the next year or two,” says Stantec’s Dixon. “Any project being planned and permitted today should demonstrate it can increase density for the kinds of projects that will be at the forefront of the AV shift—new urban districts and large mixed-use developments. Any parking we build or that exists today



One of the potential benefits of autonomous vehicles is that they require less room, which could free up roadway space for bike lanes, green infrastructure, and other uses. Credit: Paul Krueger/Flickr CC BY-NC 2.0

should be able to support 50 to 100 percent more development in 10 years. That’s an unprecedented opportunity to double our density in urban cores.”

Dixon and other AV advocates advise that urban planners and municipalities should look at every possible alternative to building structured parking, and consider surface parking only as a placeholder for a site. They also suggest requiring district parking for large development areas and shared parking for mixed-use residential development, which can reduce by a third the number of parking spaces needed by residents and office or retail spaces.

## Rethinking Roads

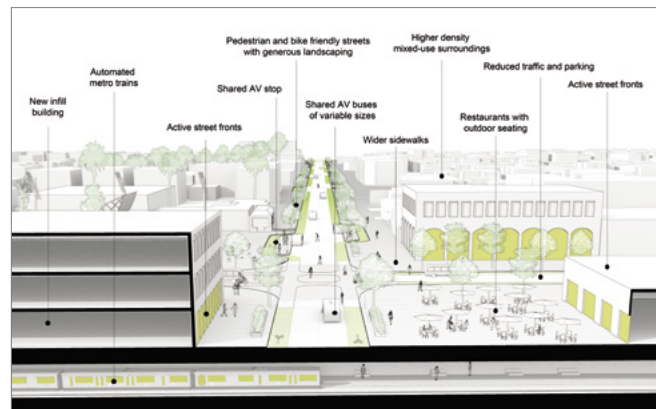
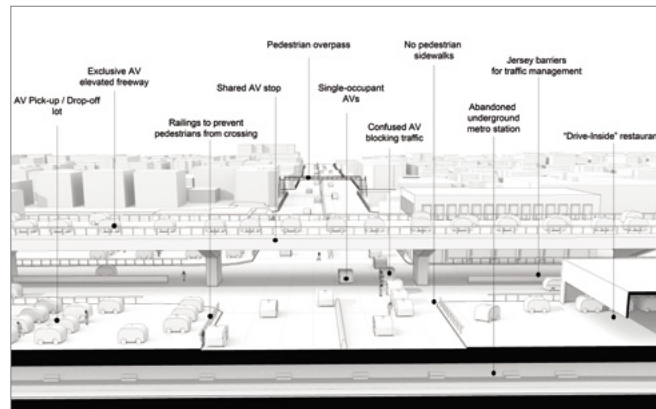
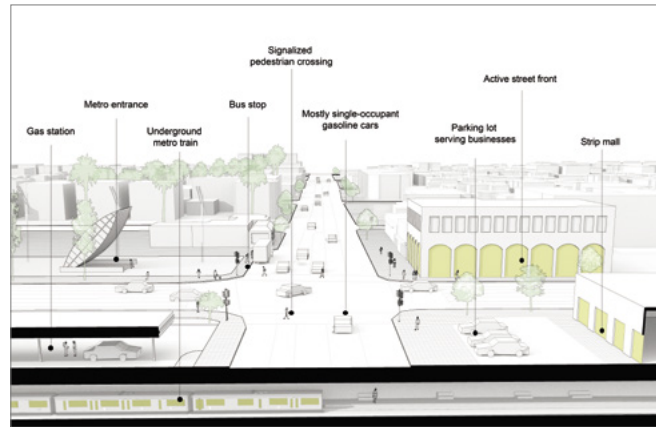
“The million-dollar question is, ‘What’s the minimum we have to do to redesign streets?’” says Larco. “None of us are building for this new technology, and most of us want to make as few changes as possible.”

AVs will require rethinking roadway and street design for elements such as separation of lanes by speed, lane width, and prioritization, locating pick-up/drop-off zones, and paying more attention to how buildings meet sidewalks and streets. During the transition to a fully automated AV fleet, narrower lanes could be designated and striped like HOV lanes are now. But as AVs are adopted more widely, roadways might be designed with narrower lanes, which would leave more public-realm space for active streetscapes, pedestrian and bike infrastructure, open space, and green infrastructure.

Giambrocco, a mixed-use project in Denver, includes three floors of flexible garage space that can be converted into office space. Credit: Gensler



A series of images produced by Harvard's Future of Streets project shows a current depiction of the intersection of Vermont Avenue and Santa Monica Boulevard in Los Angeles, then "hell" and "heaven" scenarios for how it might evolve with the advent of new mobilities. Credit: City Form Lab at the Harvard Graduate School of Design



Harvard GSD's Future of Streets project, led by Andres Sevtsuk, created 24 scenarios for how cities might adapt streets to emerging transportation technology—ride-hailing, as well as electric and autonomous vehicles—in ways that ideally would maximize multimodal, socially inclusive, and environmentally sustainable outcomes. The research project is partnering with the Los Angeles and Boston planning and transportation departments.

At key intersections in each city, Sevtsuk explained at the Planning Directors Institute, his team assessed the current scenario, then outlined "heaven" and "hell" alternatives. At LA's busy downtown Vermont/Santa Monica intersection, site of a new Red Line rail station, the "heaven" scenario for shared electric AVs included improved public transport systems, shared AV pick-up and drop-off zones, continuous bike lanes, active retail facades, and street trees and landscaping. The potential "hell" scenario for the same intersection included an AV-exclusive freeway prone to being blocked by disabled vehicles, an elevated highway for private AVs, drive-in restaurants, and railings and barriers that prevented pedestrian crossings. More than two-thirds of the AV scenarios created as part of the project's research pointed to more congestion.

Sevtsuk advises cities to begin making urban design and infrastructure changes that can help manage TNCs and the transition to AVs, beginning with passenger pick-up and drop-off areas. "Hong Kong and Singapore, very dense cities, have highly regulated pick-up/drop-off zones on every city block," he says, adding that the lack of such zones in U.S. cities is causing major traffic and public safety issues. The Future of Streets project is also exploring the use of HOV lanes for multi-passenger AVs, as well as for bus rapid transit, as an incentive for using shared mobility. This promotes the idea that "if you share your rides, you'll get through cities much faster," says Sevtsuk.

In some cities, these changes are starting to appear. Las Vegas is working on a change to its zoning code to allow for downtown ride-share lots that would eventually also serve as AV

passenger zones, says Summerfield. Local companies Lyft and Zappos partnered on creating a downtown art park and pick-up/drop-off area on a privately owned parking lot. The city approved the pilot last year as a special event project, a one-off to prove the concept could work. The city then entitled the project through the normal process as a plaza/parking facility, and is trying to replicate it with other private landowners and city properties as a public amenity that can help reduce traffic congestion.

## Preparing for Change

The shifts caused by AVs will affect municipal budgets. In fiscal year 2016, the 25 largest U.S. cities netted nearly \$5 billion from parking-related activities, camera and traffic citations, gas taxes, towing, and vehicle registration and licensing fees (Governing 2017). But gas tax revenues will shrink if most AVs are electric. There could be fewer vehicle registration fees as car ownership dwindles. Parking tickets could become a thing of the past. The list goes on.

"The change will be stepped, and not gradual," says Larco. He advises cities to consider VMT fees, congestion pricing, and new municipal revenue generators, such as taxes or fees for empty seats, charging stations, use of curb access, fees for fleet parking, GPS, data, advertisements, mobile business, and retail, as well as tax credits for vehicles full of passengers.

So far, cities have approached companies like Uber and Lyft with mostly "stick" dissuaders of fees and taxes for their impacts, notes Sevtsuk. Some U.S. cities are considering a congestion toll, such as those levied in European cities like Stockholm. But congestion charges are hard to implement, he says, and have to be approved at the state level. He says a combination of carrots and sticks, with more progressive ways to welcome this new technology on the streets, is more likely to gain public approval.

As the AV industry gains speed, cities will also have to factor in many other considerations, ranging from the location of electric charging stations to the redesign of traffic signals, from

## NEW MOBILITY OPTIONS AND EQUITY

In cities and suburbs alike, many people who are elderly or disabled, who live too far from public transit stations, or who can't afford transit fare are left without convenient mobility options. How do cities equitably share the benefits of new mobility options for all their residents?

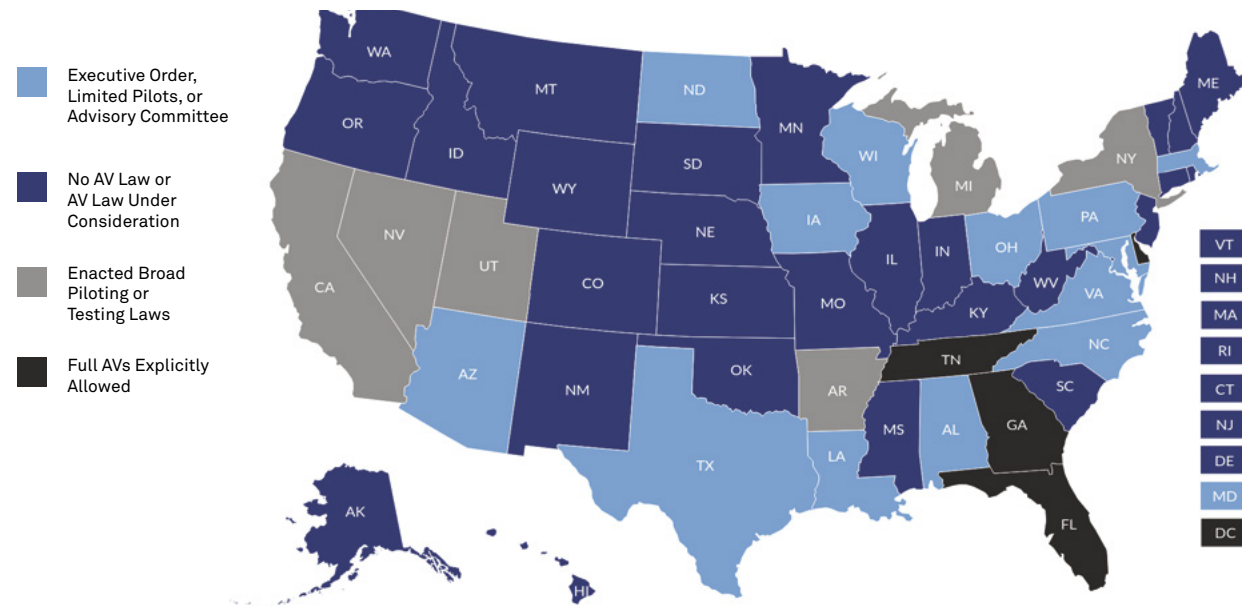
Some cities are making it a priority. In Washington, DC, Ford is piloting a citywide AV project in both wealthy and low-income neighborhoods. The city's interagency AV Working Group, composed of transportation, disability rights, environmental, and public safety officials, is focused on ensuring that AVs will benefit all eight wards of the city. Last October, Ford Autonomous Vehicles announced a job training program in conjunction with the AV project, in partnership with the DC Infrastructure Academy and Argo AI, an artificial intelligency company.

In other cities, AVs are playing a role in on-demand transit programs. In what may be the first-of-its-kind partnership between an AV tech company and a public transit system outside of a controlled environment, Waymo and the Phoenix area's Valley Metro Regional Public Transportation Authority (Valley Metro) have been using Waymo's self-driving vehicles as robotaxis to help fill some mobility gaps across the metro area.

"Think of it as the start of mobility on demand or mobility as a service," says Scott Smith, CEO of Valley Metro, which provides regional bus service and a 26-mile light-rail system slated to expand to 66 miles by 2034. Bloomberg reports the first wave of paying Waymo customers likely will draw from the Early Rider Program for trips such as first- and last-mile transportation to transit stations, but the partnership also holds promise for addressing transportation inequities.

In California, a \$12 million pilot program launched last fall by the City of Sacramento and Sacramento Regional Transit is providing low-cost rides in electric shuttles to connect people in the lower-income neighborhoods of disinvested South Sacramento with jobs and services as part of a larger effort to provide greater social and economic equity around transit. The shuttles cost less than ride-hailing services, and rides are free for groups of five or more. So far they are traditionally operated vehicles, but in a city that prides itself on being, in the words of Mayor Darrell Steinberg, "a center of innovation in new transportation technologies," that could soon change. -KM

Figure 1  
Status of State Policies Related to Automated Driving



Source: National Conference of State Legislatures and individual state legislation. Created by Ann Henebery/Eno Center for Transportation

redevelopment opportunities to workforce impacts. And they don't have much time to do it.

By some estimations, 2030 will be the tipping point for tech companies and OEMs to produce AVs exclusively and for the public to adopt AVs on a massive scale, with the potential for a completely autonomous fleet by 2050. Some states are already preparing for an AV future (see Figure 1): The Colorado Department of Transportation is planning for communications between vehicles and the highway along the I-70 corridor that traverses the state from east to west through the Rocky Mountains.

But AVs also might not dominate the landscape as soon as some tech companies and OEMs hope. In a recent consumer survey, 50 percent of survey respondents from the United States indicated they do not believe AVs will be safe, and 56 percent were not interested in ridesharing services. Nearly two-thirds of respondents were concerned about biometric data being captured via a connected vehicle and shared with external parties (Deloitte 2019).

Regardless of how quickly AVs will be adopted, says Larco, "they will have impacts on all sorts of things in cities, and we need to prepare." He advises urban planners, municipal officials, economic development directors, environment and equity advocates, and others to be proactive about making policy and infrastructure changes. Cities historically have had trouble with change, he says, and the pace of change is much faster now. When it comes to evolving mobility options, cities will need to "be nimble in their approach, create responsive regulations, and change the culture of risk with stakeholders and constituents by letting them know, 'We're going to try things out.'" □

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As the AV industry gains speed, cities will have to factor in many other considerations, ranging from the location of electric charging stations to the redesign of traffic signals, from redevelopment opportunities to workforce impacts. And they don't have much time.

A driverless shuttle at the University of Michigan in Ann Arbor, where researchers are studying consumer acceptance of autonomous vehicles. Credit: Levi Hutmacher, University of Michigan

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