

DRIVERLESS FUTURE

A POLICY ROADMAP FOR CITY LEADERS

AUTOPILOT
START/STOP

EXECUTIVE SUMMARY

The autonomous vehicle has arrived. With automakers and technology firms announcing pilot programs almost daily, it is clear that this technology is quickly becoming a reality on our roads and highways.

The introduction of the autonomous vehicle (AV) and its synergy with ridesourcing services such as Uber, Lyft, Via, Chariot and others, will force cities to confront a host of uncertainties on issues ranging from safety, ethics, insurance, and regulatory requirements to technological necessity, pricing, and the scale of widespread adoption. Cities will soon have to make complex decisions related to infrastructure, urban mobility, land use, and social equity and inclusion as people give up car ownership and take up ridesourcing and, in the near future, ridesourcing run by AVs.

Policymakers have to evaluate how an increasing share of AVs helps or hurts policy objectives, as a growing number of people shift to ridesourcing services and give up traditional public transit. A ridesourcing vehicle, with no driver and no labor costs, could offer extremely low prices, convenient service and be highly disruptive in many cities.

Cities that do nothing face major risks. If proper policies are not in place, transit agencies may lose revenues, professional drivers may be unemployed, cities may be left with large areas of empty parking spaces, and residents and businesses may move in large numbers to suburban and rural areas.

On the other hand, cities that prepare for this technology can reap many benefits, such as the removal of

millions of cars from the road, a more sustainable environment, increased mobility, efficiency and social equity, new employment opportunities for drivers and redevelopment of existing parking spaces.

Public policy will play a decisive role in shaping AV technology and guiding its impact on cities, as it did during past technological revolutions involving the railroad, the streetcar, and the automobile. Cities have a window of opportunity to shape how the autonomous vehicle is used and must act now to define policies that minimize risks and maximize the benefits of driverless technology.



DRIVERLESS FUTURE was developed by Arcadis, HR&A Advisors and Sam Schwartz to show the significant influence autonomous vehicles and ridesharing can have on our cities. This paper serves as a policy road map for complex issues related to this transportation revolution and its potential impact on equity, public transit, parking, land use and real estate development.

Benefits of Advanced Planning

- Lower vehicle ownership, congestion and vehicle miles traveled
- Equal access to transportation and jobs
- Increased access and mobility, complementary with public transit
- Decreased parking demand
- Growth in vibrant, mixed-use neighborhoods

There is a clear way forward. Cities are already experimenting with new policies, programs and partnerships to address the rise of shared mobility. Based on these experiments, many of which offer a roadmap to AV policy, we have identified six major priorities for policymakers:

1. Leverage technology to enhance mobility.

Cities should work with transit agencies and private companies to adopt smartcards, open data and universal apps to allow riders to compare, book and pay for trips that combine buses, trains, bikes and ridesharing vehicles. This will match customers with the most efficient travel choice.

2. Prioritize and modernize public transit.

The role of transit will evolve as AVs and shared mobility become widespread. Transit agencies should focus on high-frequency, high-capacity services in dense urban corridors (such as rail, bus rapid transit), provide first and last-mile connections through driverless shuttles, and expand kiss-and-rides/mobility hubs.

3. Implement dynamic pricing.

To ensure that AV use supports public objectives and complements public transit, cities should consider a dynamic road pricing plan that varies by origin, destination, number of passengers, congestion, and household income. This can be done through a combination of proven policy tools such as congestion pricing, zone pricing, variable tolls and vehicle miles traveled fee.

4. Plan for mixed-use, car-light neighborhoods.

AVs can unlock demand for living and working in mixed-use neighborhoods – whether they are urban or suburban. To shape this demand, cities need to plan for and incentivize mixed-use development, overhaul parking requirements, and reevaluate new public transit projects.

5. Encourage adaptable parking.

Fewer cars means fewer parking spaces, especially in city centers. Parking garages need to be built with housing or office conversion in mind and include level floors, higher ceiling heights and centralized ramps. These future-proof garages are already being contemplated in Boston and Nashville.

6. Promote equitable access to new jobs and services.

To support disadvantaged populations, cities must encourage public and private operators to provide alternative payment methods, access via dial-a-ride and equitable service coverage. Cities and private partners must also create new employment and training opportunities for drivers and others in legacy occupations.



REVOLUTION OF TRANSPORTATION CHOICE



Transportation shapes cities and is on the verge of a revolution. Over the past decade, changes in car culture and the integration of technology have led to a significant shift away from personal car ownership. Carsharing offered by Zipcar, Hertz, and other companies, as well as bikesharing systems offered by Motivate, B-Cycle and others, introduced alternatives to on-demand travel and personal car ownership. Over the past five years, new mobility apps such as Uber, Lyft and Via let people hail a ride from their smartphones, unlocking a slew of efficiencies in supply and demand. Riders can evaluate their options in real time, factoring in duration and cost along with convenience and accessibility.

In addition to traditional ridesourcing services, these private companies have introduced shared rides that provide a low-cost alternative to public transit. Lyft has launched Lyft Line and Uber has created uberPOOL. In the Bay Area, Chariot's 15-passenger vans provide neighborhood shuttle service, easing congestion in public transit. Prices are \$3.80 to \$5 a ride, and can be as low as \$2.50 a ride after accounting for pre-tax commuter benefits. Chariot has even expanded its offerings to commuters who live and work in less central areas. Via, a ridesharing service in New York, D.C. and Chicago, groups passengers by origin and destination, offering a flat rate of \$3 to \$5 in shared vehicles.

In parallel, automakers and major tech firms are racing to launch the first publicly available AV. While Google and Uber dominate the headlines, automakers and universities have been developing this technology since at least the 1980s. In August 2016, Uber announced the introduction of AVs into its Pittsburgh fleet, becoming the first U.S. company to provide AVs to the general public.



Ridesourcing vs. Ridesharing

Ridesourcing includes Uber, traditional taxis and other car services that allow riders to hail a car for point-to-point service.

Ridesharing includes UberPOOL, Lyft Line, Via, Bridj and other traditional carpooling services that allow riders to share rides, save money, and reduce their environmental footprint.



Outside of the U.S., nuTonomy in Singapore beat Uber to the market and tested autonomous taxis beginning in April 2016. NuTonomy announced that it will introduce fully driverless vehicles by 2018. In Europe, Volvo launched its Drive Me pilot program for Sweden, with plans to roll out Drive Me in United Kingdom and China. The Drive Me program aims to test vehicles with passengers, though families should not expect their own AVs until late 2017 or 2018. BMW, GM, Ford, Volkswagen, Tesla and a number of other automakers have announced plans to launch publicly available AVs by 2020 or 2021.

SHIFT AWAY FROM CAR OWNERSHIP



Automakers and tech firms are preparing to launch AVs within the next 3 to 5 years, with widespread adoption likely within the next 15 to 20 years. A recent McKinsey study estimates that AVs will represent 15% of global auto sales by 2030, with the potential to capture significant market share after this date. Assuming that consumer skepticism, technological hurdles related to issues such as security and bad weather and regulatory barriers can be overcome, major fleet owners and operators such as trucking and ridesourcing companies are likely to be early adopters of AVs. Given the imminence of AV technology, cities must begin preparing for the transformational impact of AVs today.



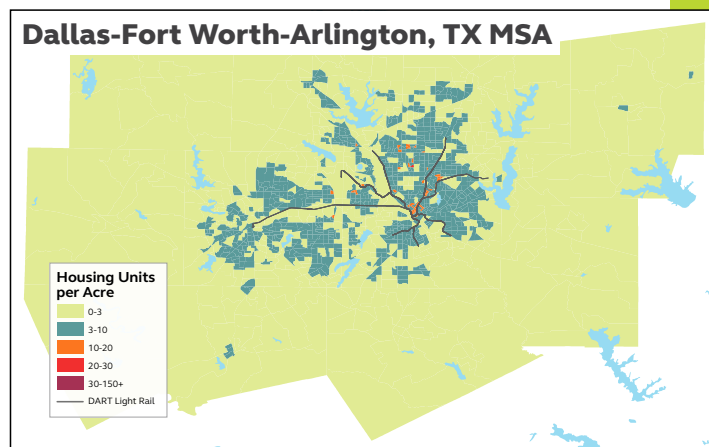
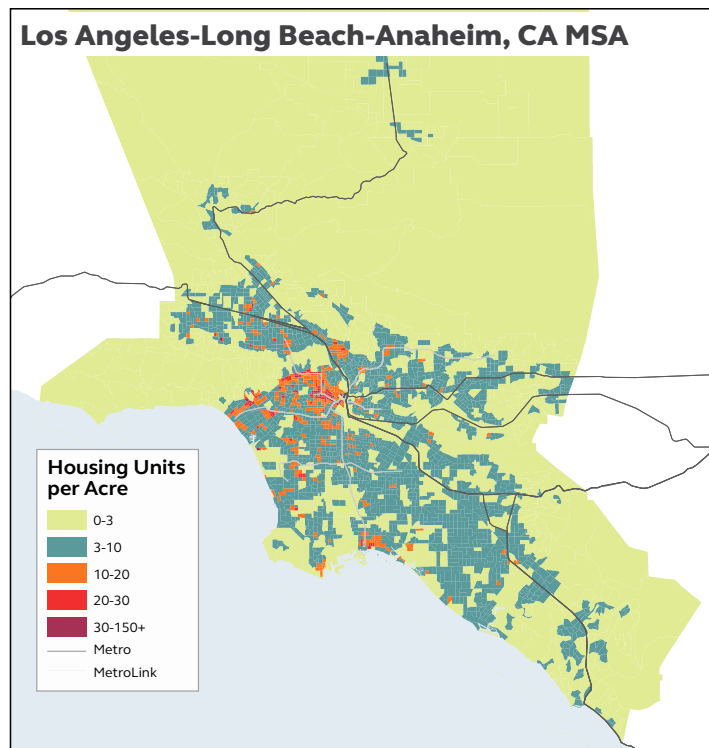
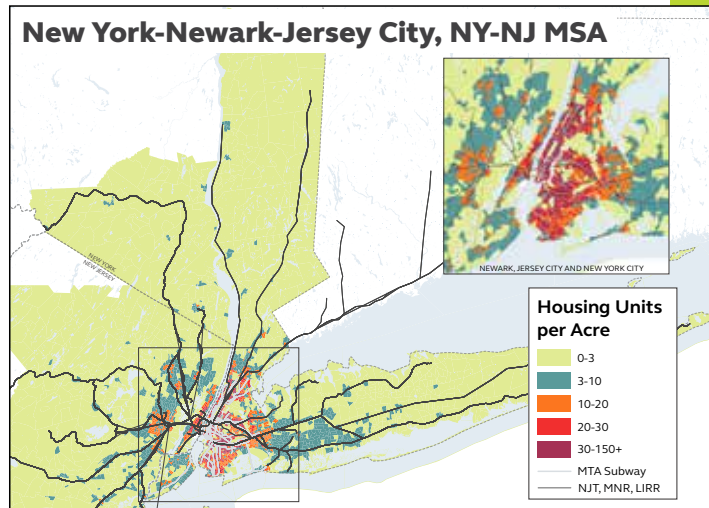
Population Density

Development has historically followed highways and public transit

AV technology will disrupt existing transportation systems and has the potential to significantly reduce car ownership in our cities.

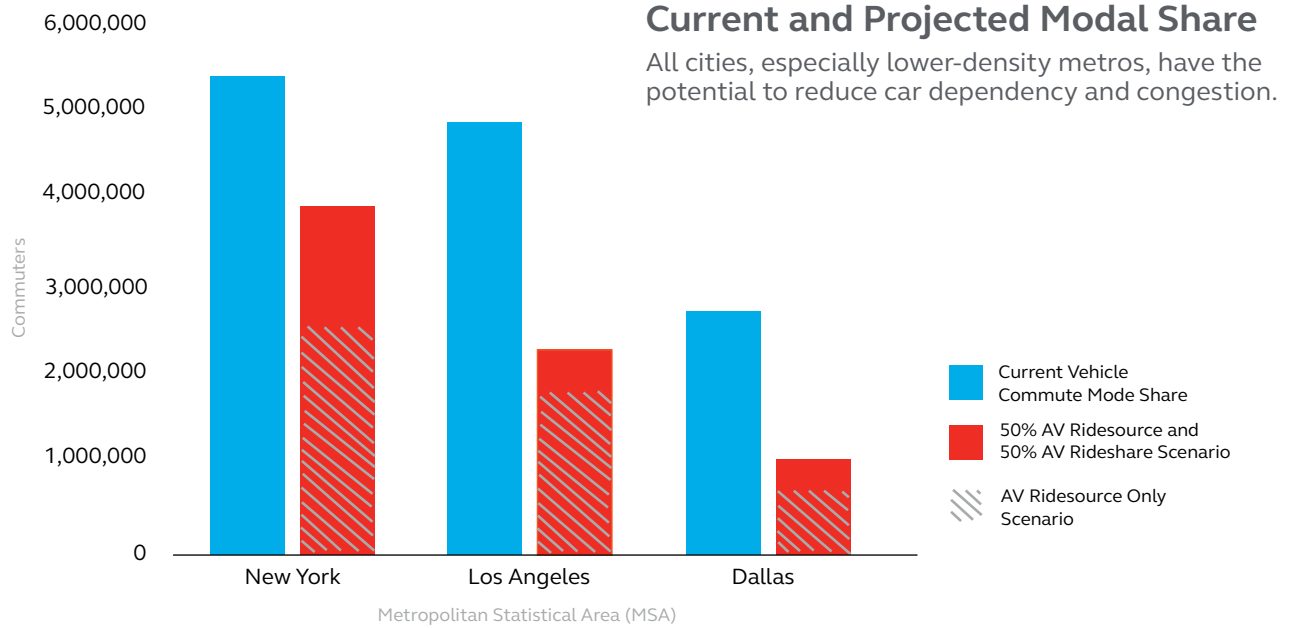
To forecast the size of this shift, we selected three sample cities across the United States:

- **New York City** was used to represent cities with significant population density, a walkable environment, low car ownership, and robust public transit options. In New York and similar cities that fit this paradigm, shared mobility is already established and thriving alongside public transit.
- **Los Angeles** represents cities with moderate density, uneven walkability, high car ownership, and rapidly expanding public transit. In Los Angeles and similar cities, shared mobility has the potential to play a big role, as transit is not yet robust and car ownership is dominant.
- **Dallas** represents cities with relatively low density, low walkability, high car ownership, and limited public transit. In Dallas and similar cities, both shared mobility and public transit use are low, with driving being the primary mode of transportation.





Using these three cities as a guide, we developed a model that compares the driver's cost of owning a car with the cost of using ridesourcing in an AV. We then predicted how many people could switch to AVs and stop owning cars. This cost model also shows how AVs and shared mobility could lead to a reduction in vehicle ownership and cars on the road. By comparing the cost of car ownership versus a hypothetical AV ridesourcing and ridesharing services, we determined the price point and Vehicle Miles Traveled (VMT) at which people were likely to give up their personal cars. The inputs to the model included the number of trips per day, the average VMT, parking costs and market segmentation by vehicle type.



The analysis also breaks down the results geographically by coupling the cost-driven shifts with an analysis of land-use density and its ability to support mass transit: 0-3 housing units per acre (auto-based), 10-20 housing units per acre (bus-based transit), 30-150+ units per acre (rail-based transit). The breakdown shows potential threats to transit by identifying the trips that could be displaced by new AV ridesourcing services.

Most of the transition is expected to be from lower-density areas where car ownership is highest. However, there is a possibility that transit ridership may also shift in higher density areas - increasing the number of cars on the road - if not correctly managed by cities. This reinforces the need for planning and coordination on a regional scale.

The results of this study show potential commuting shifts caused by AVs that could redefine mobility in metropolitan areas. The New York/Newark/Jersey City area could experience a shift of 46% to 60% (2.4 million to 3.6 million cars) from personal vehicle commuting to AV ridesourcing exclusively or to a mix of AV ridesourcing and AV ridesharing.

The Los Angeles/Long Beach/Anaheim area could experience a shift of 36% to 44% (1.8 million to 2.2 million) from personal vehicle commuting to AV ridesourcing only or a mix.

The Dallas/Fort Worth/Arlington area could experience a shift of 21% to 31% (0.6 million to 0.9 million) from personal vehicle commuting to AV ridesourcing exclusively, or a mix of the two.



Projected Shift from Car Ownership by Residential Density

All neighborhoods, including lower density neighborhoods, have the potential to realize a significant shift from driving to self-driving and public transit.

HOUSING UNITS
PER ACRE

0-3

3-10

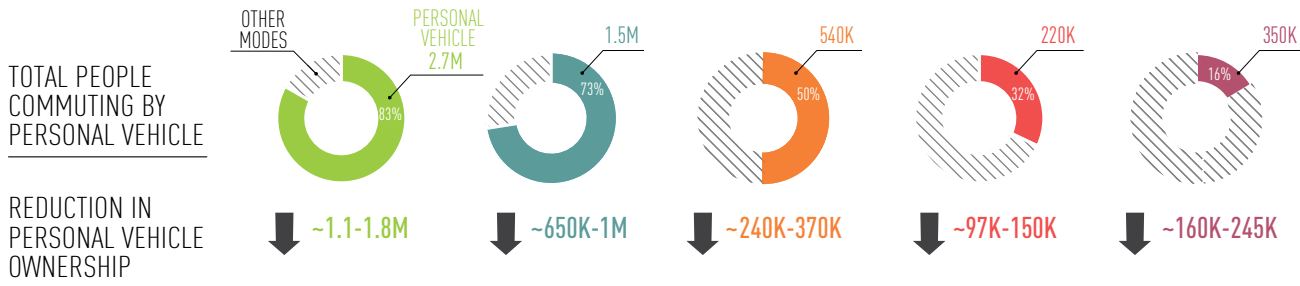
10-20

20-30

30-150+

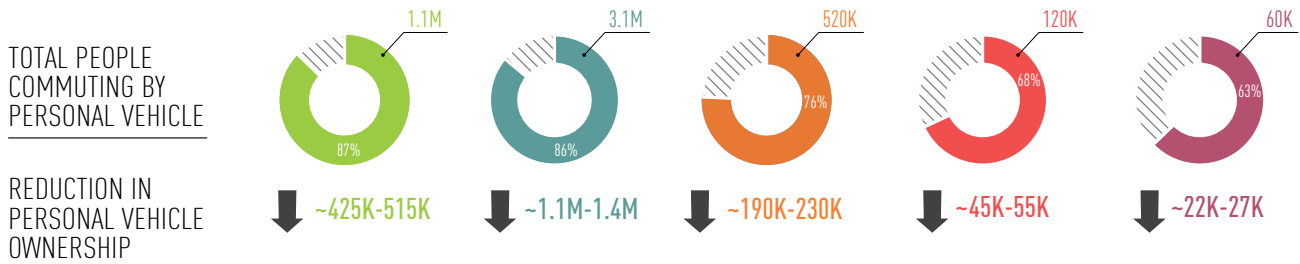
New York-Newark-Jersey City, NY-NJ MSA

Could experience a shift of 46% to 60% (2.4 million to 3.6 million cars) from personal vehicles to shared AVs.



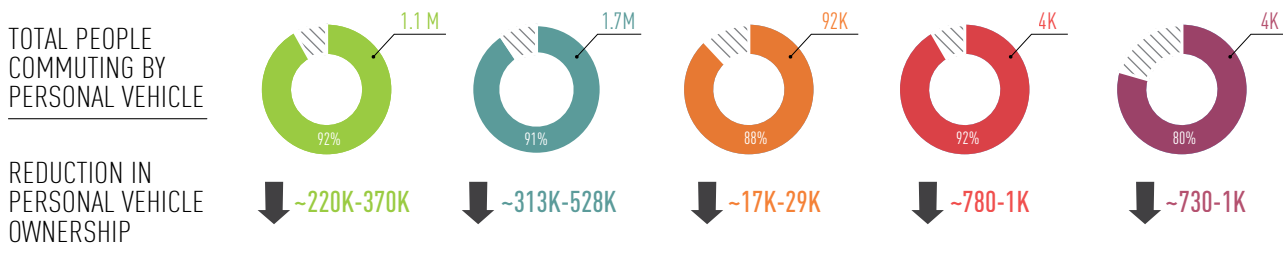
Los Angeles-Long Beach-Anaheim, CA MSA

Could experience a shift of 36% to 44% (1.8 million to 2.2 million) from personal vehicles to shared AVs.



Dallas-Fort Worth-Arlington, TX MSA

Could experience a shift of 21% to 31% (0.6 million to 0.9 million) from personal vehicles to shared AVs.



The possibility that millions of car owners could shift to ridesourcing and give up car ownership offers an opportunity to alleviate congestion, provide equitable access to jobs and services, and create development that is more inclusive and sustainable. However, it is also expected that vehicle miles traveled will rise as consumers are exposed to new mobility services. This would lead to more congestion.

Similar analyses can apply to any city, but our research reveals that in the three selected major metro areas, there is enormous potential for defection to AVs. In New York, for example, the total number of cars on the road could be reduced by half. In Dallas and Los Angeles, where a higher percentage of people commute by car, there is more potential for defection, but there could still be a significant reduction in vehicles.

KEY IMPACTS ON OUR CITIES



Equity and Inclusion

Equity must be central to the next generation of urban mobility. Maintaining a quality of life for all residents — including the provision of accessible, affordable, and reliable transportation — will be an ongoing challenge. With the introduction of AVs and the potential disruption of other forms of transportation, cities must ensure that vulnerable populations maintain access to jobs, education, retail outlets, and other major amenities important to day-to-day life.

Without proper policies in place seniors, low-income, or handicapped populations among others — may be left out of these new services because of technological barriers. There is potential for a new digital transportation divide between people with access to technology and those with limited or no access to digital services or financial institutions.

The adoption of AVs will also disrupt existing industries and labor markets. According to the Bureau of Labor Statistics, there are more than four million professional drivers in the United States today. In the near-term, drivers may still be needed for consumer acceptance and for extraordinary driving conditions. In the long term, it is possible that the taxi driving occupation may become obsolete while more technical or customer-oriented jobs (such as delivery drivers, truck drivers, fleet managers) may become more complex and require a higher level of training and qualifications.

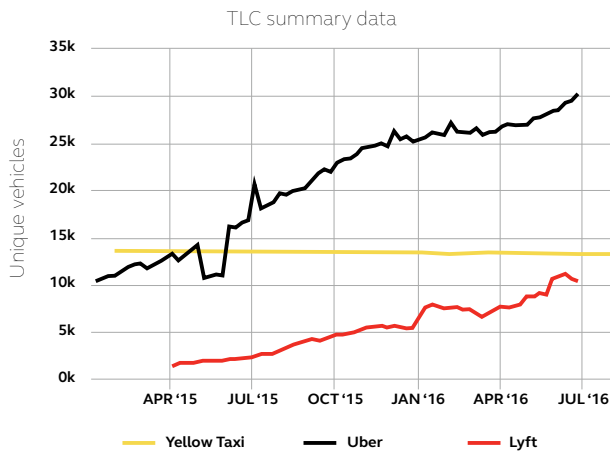
Increased competition for public transit

AV technology has the power to take riders and revenue away from traditional public transit. The increased competition and loss of revenue will limit public transit's ability to operate. Carsharing (e.g. Zipcar and car2go), ridesourcing such as (e.g. Uber and Lyft), and ridesharing services (e.g. Via, Chariot, Bridj) have proven their efficiency, and many will become more reliable and offer even lower prices with the adoption of AV technology. The low price of using AVs will spur more people to change their transportation mode. If transit riders switch to private services, transit agencies will see a significant decrease in ticket revenues, which currently account for 30% to 50% of a typical agency's operating budget.



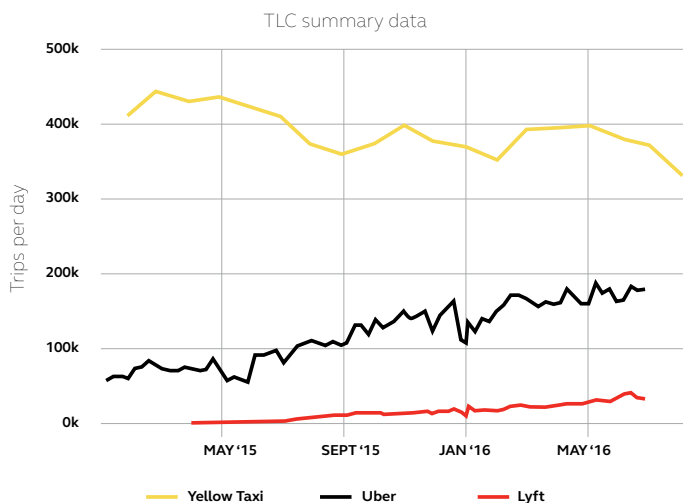
NYC Unique Vehicles, Dispatched by Service

The number of Uber and Lyft vehicles in NYC have increased significantly since 2015



NYC Daily Trips: Yellow Taxi, Uber, and Lyft

Uber and Lyft ridership has grown while yellow cab ridership has steadily declined



Transit agencies must re-evaluate their role in the transportation system. In high-density areas, high-capacity transit (subways, light rails and bus rapid transit) will continue to be the fastest, most efficient form of transportation, especially during peak hours. In low-density areas, low-capacity and low-frequency transit, such as buses or paratransit (special transportation services for people with disabilities), may need to be enhanced or replaced in order to remain competitive.

To prepare for AVs, agencies should conduct a comprehensive analysis of existing services to determine whether other public or private partners can deliver mobility more efficiently. Additional disruption will occur as regulators catch up to assessing fees on new transportation services under an evolving transportation landscape. The figures shown on the left show the number of vehicles and daily trips for Yellow Taxi, Uber and Lyft in New York City. Over the course of a year, the number of Uber and Lyft vehicles clearly increase and go on more daily trips while the number of Yellow Taxi trips taken decreases. We can expect this trend to continue as Uber and Lyft reduce prices and expand their market share.

Previously, Uber advertised that its service costs less than a taxi ride in New York City. The company now is attempting to introduce a system of unlimited uberPOOL rides that will be cheaper than a New York City MetroCard. Without proper policies in place, this shift toward ridesourcing companies can represent a major loss of revenue for the transit system. In 2009, all taxi fares in New York City included a new 50 cents surcharge paid directly to the Metropolitan Transit Authority (MTA). In addition, a 30 cents per-ride fee supports the city's wheelchair-accessibility expansion goals. In contrast, ridesourcing services do not pay either. Of the 8.875% sales tax ridesourcing services are subject to (which yellow and green cabs are not subject to), 0.375% goes to the MTA. From 2014 to 2015, the MTA saw a 10% decrease in revenue from the taxi surcharge due to the increasing popularity of these services. The MTA is in talks with legislators to require all for-hire vehicles to be subject to this surcharge.

Phasing out of parking and car infrastructure

Parking, roads and other auto-related uses occupy a significant amount of land. The U.S. contains as many as two billion parking spaces, occupying up to 16,000 square miles of land (the equivalent of Connecticut and Vermont combined). The quantity of parking spaces in the country amounts to as many as eight parking spaces for every car.

Parking consumes a significant amount of land, especially in suburban areas where auto use is highest and surface lots are more common than multi-story garages. At a typical suburban mall, parking or driveways make up 80% of the land, while only 20% is used for the mall. Even in denser, more urban areas, parking requires significant land area. For example, streets and parking take up 45% of land in downtown Washington, D.C. and up to 65% in downtown Houston.

In addition to parking, cars also require a significant number of supporting uses such as gas stations, repair shops and car washes. According to recent studies, there are 125,000 gas stations and 175,000 auto repair shops across the U.S.

AVs will reduce demand for parking, gas stations, and other auto-related land uses. Some uses, particularly those in highly desirable areas, may be reused and repurposed over time. AVs are highly likely to reduce parking demand by taking personally owned automobiles off the street. Past studies estimate that, depending on the success of merging AV into city infrastructure, parking demand may be reduced by up to 90%.



Parking will no longer need to exist right next to homes, offices and stores. Some parking facilities may relocate to lower-cost locations, gas stations, repair shops and car washes may follow suit and relocate from prime locations, freeing up land for uses like residential, office or retail use. The pace of redevelopment will depend on parking demand and market context. A parking structure in the suburbs, for example, could remain in use as parking, but a downtown surface parking lot or gas station could undergo redevelopment in the near-term.

The phasing out of parking will also have secondary impacts. Municipal budgets that rely on vehicle registration fees, metered street parking and garage parking will also face challenges. Any significant shift in vehicle purchases and parking may cause near-term disruptions in already strained municipal budgets and will thus need replacement fee programs.

Growth in walkable, mixed-use cities and suburbs

By reducing the time and cost of transportation, AVs may allow more people to live in the neighborhood of their choice, whether urban, suburban or rural.

According to a national preference survey conducted by Transit Center, 21% of Americans would like to live in a city — roughly equal to the 24% who live there today. In contrast, only 44% of Americans want to live in the suburbs, which is significantly lower than the 52% who live there now. Finally, Americans find small towns to be highly desirable, with 23% of the population interested in living there, compared to the 13% who reside there today.

More importantly, 58% of Americans prefer mixed-use neighborhoods with homes, restaurants, stores, offices and other activities. In contrast, only 30% prefer predominantly residential areas. These preferences suggest that cities, suburbs, and small towns that are mixed-use will attract new residents, while conventional single-use neighborhoods may be threatened by blight and disinvestment. This unmet demand for walkable, mixed-use neighborhoods, enabled by the mobility of AVs, presents a significant opportunity and threat for our cities. Urban areas, which traditionally contain more mixed-use areas, are poised to capture this growth. Suburban areas, which traditionally contain more single-use areas, may face more uncertainty.

In order to thrive in a driverless world, cities and suburbs alike must embrace mixed-use development. This revolution in transportation technology will trigger a migration of residents, workers, and businesses. With policies incentivizing mixed-use, cities and suburbs that were previously considered too far from work, family, or friends can capture this growth.

Lower cost for walkable, mixed-use development

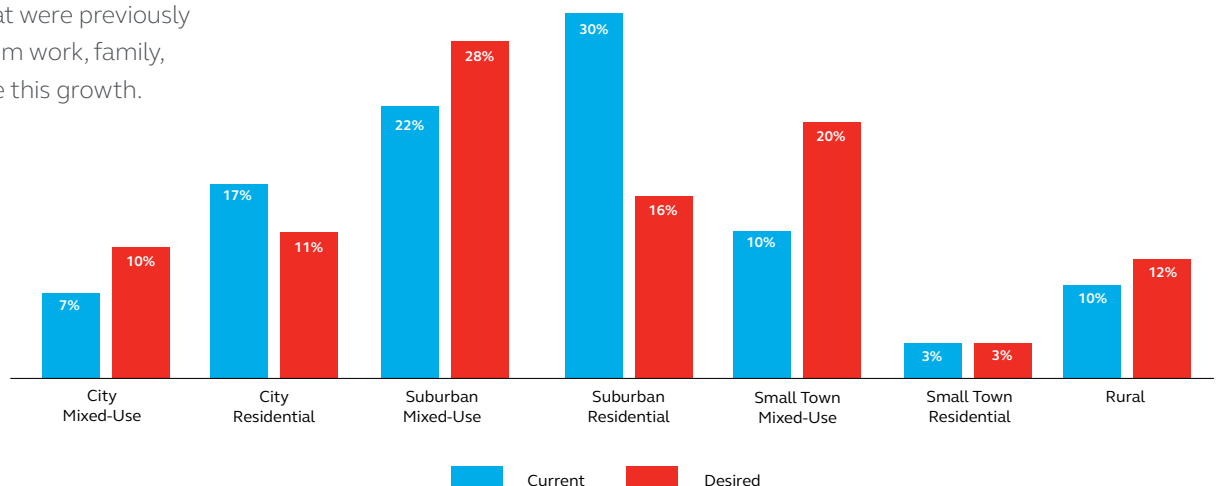
Today, mixed-use development is a challenge because of the high cost of parking development. Even in areas that are walkable and well-served by transit, driving is often the most convenient option and parking continues to be in high demand and is often required by lenders and local governments. Unlike single-use development, mixed-use development is often in higher density areas that require the construction of compact, but costly parking structures.

A typical parking structure costs \$25,000 to \$45,000 per space depending on location and design (e.g. above ground, underground). In a high-rise building, parking can take up to 20% of construction costs, and can also make new development financially infeasible without a public subsidy. In cases where development is feasible, developers may bear the cost initially but then pass it on to the people and businesses in the building. According to a national study by the Sightline Institute, parking adds an average of approximately \$225 a month to the rent of an apartment, a substantial amount to pay for the convenience of a walkable, mixed-use development.

Should parking demand decrease as a result of AV technology or shared mobility services, it will reduce parking construction costs and enhance the feasibility of walkable, mixed-use development. Developers often opt to build mixed-use development with limited parking near transit stations, AV use would enhance the financial feasibility and accessibility of mixed-use development outside of transit corridors allowing mixed-use development to be developed in more places.

Population by Current and Desired Neighborhood Type

Americans overwhelmingly prefer mixed-use neighborhoods



Source: 2014 Transit Center Mobility Attitudes survey, based on 11,842 respondents from 46 U.S. cities

PREPARING CITIES FOR THE REVOLUTION

Driverless technology has the potential to transform cities in many positive ways. Across the country, city leaders strive to provide residents with access to affordable housing, quality jobs and sustainable communities. Transportation, including future modes such as AVs, is critical to achieving all of these goals as it connects people to places they live, work and play. Policymakers have embraced multimodal transportation that allows people to walk, bike and take transit, in addition to driving. The introduction of lower-cost shared vehicles powered by driverless technology can accelerate this trend and encourage more people to leave their cars at home or abandon personal ownership of vehicles.

Public policy must evolve along with technology. In the last automobile revolution, public policy favored the suburbs by investing in highways, subsidizing gas and subsidizing single-family homes. Left unregulated, AVs may perpetuate business-as-usual operations and increase congestion, encourage sprawl and exacerbate growing inequalities. In addition, public agencies may face lower transit ridership and lost revenues from transit tickets, parking fees, traffic fines, and other once-reliable revenue sources. Conversely, if proper policies are in place, AV technology has the potential to dramatically reduce traffic congestion, enhance public transit, redevelop parking and encourage the growth of walkable, mixed-use communities.

Policymakers must seize the opportunity to steer our cities toward a more accessible, equitable, and sustainable future. In light of this challenge, we have identified six priorities for cities, transit operators and other public agencies to consider.





1. Leverage technology to enhance mobility



Open data: Public and private transportation providers need to embrace open data. A common standard for data can improve services, ensure equity, and create a competitive marketplace. Cities,

regions, states and the federal government should require that data is provided in exchange for access to publicly funded transportation infrastructure (e.g. parking, airport pick-ups) or financial subsidies. The most prominent example is New York City, whose Taxi and Limousine Commission requires all taxicabs, Uber, Lyft and other transportation providers to provide trip data.



Universal apps: Today, potential riders cannot easily compare the speed, convenience and cost of driving with other alternatives. While a range of apps have begun to fill this gap (e.g. Moovit,

Transit App, Swiftly, Moovel), data is often missing or outdated as transit agencies and private operators are reluctant to share data. In addition, payment systems don't work with each other, making it difficult to track and incentivize multimodal trips.

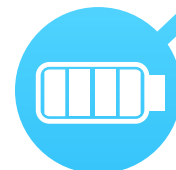
To create a level playing field between AV services and public transit, cities need to work with private operators and app developers to create universal apps that will schedule, book and pay for any transportation option under one platform. After entering a destination, riders could compare options to find the fastest, cheapest, lowest environmental impact trip. While some apps already offer scheduling and booking features, payment is often restricted to apps controlled by private operators (e.g. Uber, Lyft, CitiBike) and public operators (e.g. MTA eTix, DART GoPass, Metro Mobile). Cities should engage private apps and private operators to integrate universal payment with the mapping and booking of trips to improve the user transit experience.

A truly universal app is already here. In June 2016, MaaS Global of Finland launched the Whim app, the first universal app allowing for the planning, booking, and payment of buses, trains, bikes and taxi services across Helsinki. Users can subscribe to a monthly package of mobility services or choose to pay-as-you-go. Plans for similar apps are under development in major cities around the world.



Smartcards: To eliminate multiple forms of payment, cities should consider adopting a smartcard valid on any mode of transportation — driverless shuttles, rail, buses, taxis,

bikesharing, carsharing, ridesourcing, or other options. Compared to a universal payment app, smartcards do not require a smartphone and may represent a lower barrier for low-income riders. Smartcards are a proven technology and are used in more than 20 cities across the U.S. and hundreds of cities around the world. In Los Angeles, more than 60 public transit agencies in the metro area recognize the Transit Access Pass (TAP) card, and it applies to rail, bus rapid transit, bus and bikesharing services. In Hong Kong, the Octopus card lets people use not only public transit but also taxis, parking garages, parking meters, restaurants, convenience stores, supermarkets, theaters and other services.



2. Prioritize and modernize public transit

To compete with AV, public transit must become more convenient. Today, transit is not competitive with driving in most U.S. cities. Despite its lower cost, public transit is often slower and less convenient as riders have to walk, bike or drive to the closest station for their first and last miles. In addition, riders have to coordinate transit schedules and pay for each part of their trip separately.

With driverless technology, private taxi services may become so affordable that riders will opt for AVs for the full trip and bypass transit, especially in off-peak hours with low congestion. Services such as Uber already offer shared rides at prices that competes with public transit.

In peak hours, transit may remain competitive if it operates on a dedicated route (e.g. rail, dedicated bus routes) that bypasses congestion. In off-peak hours, transit operators must provide faster, more convenient service to remain competitive or create partnerships that provide access to difficult-to-serve areas of the city.

With AV technology, public transit can transform into a seamless, point-to-point service. To enable this vision, cities and transit agencies should consider:



Prioritizing high-demand corridors: Rail and bus systems are often the most efficient ways of moving people through congested high-demand corridors. In

contrast, ridesourcing is more advantageous in areas with lower demand where traveling via rail or bus routes would take longer. Given these considerations, transit agencies should provide improved service in these key corridors (e.g. higher frequencies, dedicated guideways) with the goal of strengthening public transit's role in moving people to their destinations.



Driverless shuttles for first and last-mile connections:

To close the first and last mile gap, driverless shuttles can provide low-cost connections

to nearby stations. Such shuttles can run on a schedule corresponding with arriving and departing trains, and can be operated by cities, transit agencies or private operators. Pilot programs in Philadelphia, Pinellas County, Florida and Centennial, Colorado, provide a framework for how cities and transit agencies can use private services to complement transit, albeit without AV technology. However, AV shuttles are already being tested in London, Singapore and Helsinki and will be introduced in the U.S. soon.



Kiss-and-Ride/mobility hubs:

To eliminate the hassle of transferring between transit and driverless shuttles, cities should consider expanding drop-off and pick-up zones,

commonly known as kiss-and-rides or mobility hubs, and reducing parking near major transit stations.



3. Implement dynamic pricing

Today, private services complement and compete with public transit. To close the first and last mile gaps, Uber and Lyft have partnered with SEPTA in Philadelphia to subsidize rides that begin or end at a transit station. At the same time, Uber offers shared rides at lower costs than public transit and in areas where transit is readily available. For example, in Manhattan below 125th Street, uberPOOL can cost as little as \$2 per ride (or \$79 for an unlimited monthly pass) during commuting hours.

As the diagram on this page details, some options are more beneficial from a social cost standpoint depending on the emissions and burden on the transportation network. Given the introduction of AV technology, private services will become even more affordable and compete more directly with public transit. While public transit must continue to improve (e.g. increased frequencies, dedicated guideways, driverless shuttles, smartcards, etc.), cities can also use dynamic pricing to create a more level playing field. A potential dynamic pricing plan may incentivize trips that complement public transit and disincentivize trips that compete with public transit. Trip pricing may vary depending on a combination of variables, including:

- Origin and destination
- Number of passengers
- Level of congestion
- Environmental impact
- Household income

Transit and Shared Mobility

Shared mobility services may complement or compete with public transit depending on public policy or lack thereof.



Dallas Area Rapid Transit Map

Dynamic pricing will have the most impact when riders can compare prices conveniently using a universal app and payment method. For example, in Los Angeles, the city may consider using the Go-LA app and Transit Access Pass to offer an incentive to riders who take the Metro and opt for bikeshare for their last mile.

Dynamic pricing can be enacted through any combination of vehicle miles traveled fee, greenhouse gas tax, weight-distance tax, congestion pricing, or variable tolls, with any revenues generated to subsidize public transit, driverless shuttle services, or other uses that support public policy objectives.

Finally, cities may also use dynamic pricing to address equity and to serve economically distressed areas. For example, a city may choose to subsidize low-income riders from an underserved neighborhood to the nearest transit station. As part of a revitalization plan, the city may consider subsidizing trips that begin or end in a neighborhood. To attract employment uses, cities may choose to subsidize trips that begin and end during commuting hours. Private businesses and property owners, many of which already operate shuttles, may also participate.

4. Plan for mixed-use, car-light neighborhoods

Previously less accessible places will attract development because of new transportation choices. Cities and suburbs must embrace walkable, mixed-use development to attract and retain residents and businesses. At the same time, smaller towns — with limited room for new development — may struggle to accommodate the new demand. This reinforces the need for regional planning and smart growth policies.

To prepare for a driverless future, cities may consider:



New criteria for public transit investments: When planning for future transit lines, cities and transit agencies often evaluate different alternatives based on the impact on

property values, new development, job access and other development goals. Should AVs become widely adopted, such analyses may need to consider bigger impact areas. For example, driverless shuttles may expand the catchment area for transit, allowing more riders to access jobs and educational opportunities elsewhere in a city.



Mixed-use in new neighborhoods: AVs will require cities to plan for walkable, mixed-use development outside of traditional areas. Today,

cities often plan for and incentivize mixed-use development within a quarter- or half-mile of a transit area. With driverless shuttles, neighborhoods that are farther away are now within reach of public transit and may not require as much parking. Cities should accommodate and call for more walkable, mixed-use developments in these areas. This may be done through a range of policies and tools, including rezoning, public realm improvements, financial incentives, tax abatements, assistance with land acquisition and reduced parking ratios. For example, Parkmerced of San Francisco is 1.5-miles away from the closest BART station, outside of a traditional half-mile station area. However, the apartment complex is providing new residents a monthly \$100 transportation credit for use on public

transit or Uber. In the future, when driverless technology is widely adopted, more developments may implement a similar approach.



Parking ratio reduction:

Many cities allow developers to reduce the number of parking spaces in a project if it exists within a quarter or half mile of transit. In light of AV technology, cities may

consider expanding eligibility to projects outside of a half mile of station areas, especially if a developer chooses to provide tenants with transit passes or driverless shuttles.



Parking in-lieu fees: More than 40 cities across the U.S. have adopted voluntary parking in-lieu fees, which allow developers to pay a fee to the city rather than

providing more expensive on-site parking spaces required by the zoning code. Revenues can be directed toward transit passes, driverless shuttle subsidies or other alternative modes of transportation. Cities may need to support developers as they persuade potential lenders that fewer parking spaces are justified.



Require or incentivize alternatives to driving: Cities can encourage developers to provide alternatives to driving. This can be mandatory in stronger markets or

incentivized through additional development rights, tax abatements or fee waivers. In February 2017, the City of San Francisco adopted a mandatory Transportation Demand Management program for new development projects, requiring developers to provide transportation amenities (e.g. shuttles, bikesharing) based on the number of parking spaces proposed. While this policy is still in its infancy and may be refined, its implementation provides a useful precedent for other cities.

5. Encourage adaptable parking

Driverless technology will change the quantity, size, location requirements and economics of parking. In the face of this uncertainty, parking lots and garages should be built with eventual redevelopment in mind. Design should allow parking spaces to be converted for residential, office, retail, community facilities or other uses. This may require the provision of level floors, higher ceiling heights and centralized ramps. As parking demand decreases, parking spaces may be converted over one or multiple phases.



Convert on-street parking to public space:

On-street parking can be converted to public use with minimal time and cost. One of the most congested places in the world — Times Square — is a good example. Beginning in 2009, New York City began to experiment

with the pedestrianization of Broadway near Times Square. After a successful pilot, the streets were permanently converted into open space and the idea spread throughout New York City and other cities across the U.S.



Redevelop parking lots: Parking lots in prime locations will likely redevelop with minimal public intervention. To accelerate redevelopment, cities may consider taxing surface parking lots at a higher rate to encourage redevelopment into more productive uses.



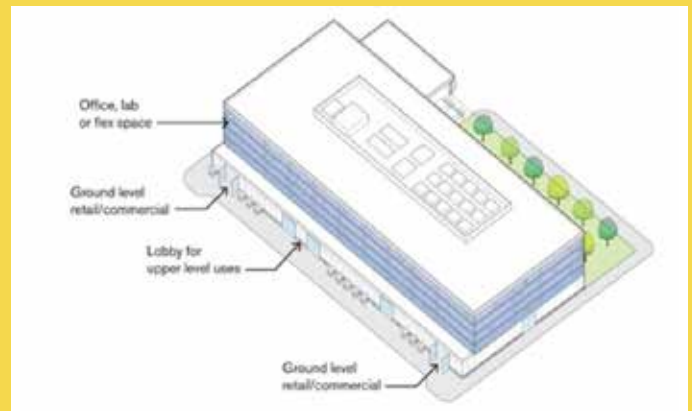
Mandate or incentivize adaptable parking garages: For existing parking structures, owners and operators should evaluate the lifespan and revenue potential of parking use versus the costs and revenue of a single- or multi-phase conversion. For new

parking structures, developers should weigh the upfront costs of an adaptive structure with the cost savings at the time of redevelopment.

From a policy perspective, cities may choose to mandate or incentivize adaptable parking structures. As part of a broader overhaul of parking regulations, cities should determine areas where mandates are viable or incentives may be necessary. If incentives are needed, cities may evaluate the value and feasibility of matching grants, tax abatements, lower parking requirements, additional development rights, or other forms of assistance.

Public agencies, including airports, convention centers, and economic development agencies, often rely on parking revenues to fund their operations, programming and capital budgets. As AV technology reduces parking demand, agencies should develop plans for diversifying revenue.

Adaptable Parking Garages



Boston Convention Center, Boston, MA

The Massachusetts Convention Center Authority is developing a universal structure that will be used for parking but, over multiple phases, can be converted to residential, office, retail, hotel, entertainment, etc. Key changes include the spacing of structural columns, location of elevators and mechanical spaces, provision of utilities, higher ceiling heights, location of ramps.



Assembly Row, Somerville, MA

Audi, the City of Somerville, Massachusetts and the Federal Realty Investment Trust, are partnering to build a garage of the future in Assembly Row, a major redevelopment in Somerville. AVs will drop off and pick up occupants in front, eliminating the need for stairs and elevators. Because AVs can maneuver with greater precision, lanes and spaces will be much narrower. Owners also have the option to rent out cars when they are not in use. The garage is expected to reduce parking square footage by 26%, with a mix of conventional and driverless cars. When the garage is used exclusively for driverless cars, parking square footage can be reduced by up to 60%.

6. Promote equitable access to new jobs and services

Disadvantaged populations may have unequal access to AV technology and services. To provide access to populations that are not connected to financial institutions, cities should encourage public and private operators to accept pay-as-you-go smartcards for payment or partner with local credit unions to provide financial services, as bikeshares in New York and D.C. have done.

For those without smartphone or internet access, cities should encourage private operators or third-party services to provide alternatives means (such as Dial-A-Ride) that can hail a ride on behalf of riders.

To ensure equitable service coverage, cities can choose to regulate or incentivize. As a regulator, cities should explicitly identify equity as a policy goal when approving new or expanded services and provide all operators clear, measurable outcomes (e.g. percent of rides taken by disadvantaged riders, percent of rides originating or ending in a low-income neighborhood) that must be met or exceeded. In addition to regulation, cities may also consider whether financial subsidies are viable and identify the most appropriate mechanism for providing it (e.g. smartcard, universal app).

For example, transit agencies may encourage paratransit riders to use more cost efficient private operators and use potential cost savings to subsidize other disadvantaged riders.

As AV adoption occurs over time, policymakers must also ensure that those in legacy occupations have the opportunity to participate in newly created industries. For example, professional drivers may need new training and certifications to operate and maintain an AV. Driver responsibilities may also shift from driving to providing and selling services to riders or managing a large-scale fleet. In most cities, a driving position is relatively accessible and requires minimal training and qualifications. To ensure that these drivers can remain competitive in the new economy, policymakers should partner with automakers and transportation companies to provide drivers with access to the training they need to meet the trends and demands of the industry.



THE ROAD FORWARD



The challenge posed by AV technology is significant but not unprecedented. In the past, cities have been transformed by revolutionary technologies such as the railroad, the streetcar, and the automobile. Each time, public policy has played a decisive role in shaping technology and its impact on cities.

Cities that are prepared for AVs have a generational opportunity to achieve long-stated goals in mobility, equity, and sustainability, and to deliver a higher quality of life to citizens. Cities that are unprepared may be left behind, or worse, they will watch while decades of economic, social and environmental progress are reversed.

While the speed and pace of AV technology adoption remain unclear, its imminence is certain. In the face of this, city leaders — together with transit agencies, private operators, developers, other stakeholders, and the public at large — have an obligation to define new policies that protect against risks while seizing new opportunities.

These new policies and experiments in shared mobility — and any lessons learned — should inform and provide the foundation for AV policy. In the prior section, we identified six major priorities for policymakers to consider. Many of these ideas are already proven or in the early stages of implementation around the world.

We believe cities will succeed if they have clear policy objectives, a deep understanding of these approaches and an appreciation for their interdependencies in a driverless future.

Leverage technology to enhance mobility

- Open data and technology standards (e.g. Taxi & Limousine Commission in New York City, MBTA in Boston)
- Universal apps (e.g. Go LA in Los Angeles, Whim in Helsinki, Finland)
- Smartcards (e.g. TAP card in Los Angeles, Octopus card in Hong Kong, Oyster card in London, and numerous others)

Prioritize and modernize public transit

- Prioritizing high-demand corridors (multiple cities)
- Last-mile shuttles (e.g. SEPTA in Philadelphia, Pinellas County Suncoast Transit, City of Centennial, Colorado)
- Kiss-and-rides (e.g. WMATA in D.C., MARTA in Atlanta)

Implement dynamic pricing

- Cordon/zone pricing (e.g. London, Singapore, Sweden)
- Variable tolls (e.g. High Occupancy Toll lanes)
- Vehicle mile traveled fee (e.g. OReGO pilot program in Oregon)
- Weight-distance tax (e.g. Kentucky, New Mexico, New York, Oregon, Washington)

Plan for mixed-use, car-light neighborhoods

- New criteria for transit investments (e.g. Seattle)
- Mixed-use in new neighborhoods (e.g. ParkMerced in San Francisco)
- Reduce parking ratios (multiple cities)
- Parking in-lieu fees (multiple cities)
- Mandate or incentivize alternatives to driving (e.g. San Francisco)

Encourage adaptable parking

- Convert on-street parking to public space (e.g. New York City, San Francisco, Los Angeles)
- Redevelop parking lots (multiple cities)
- Mandate or incentivize adaptable parking garages (e.g. Assembly Row in Somerville, Massachusetts Convention Center Authority in Boston)

Promote equitable access to new jobs and services

- Payment alternatives (e.g. Citibike in New York, Capital Bikeshare in D.C.)
- Dial-a-ride (e.g. Uber in India, GoGoGrandparent app)
- Equitable service coverage (e.g. Indego bikeshare in Philadelphia)
- Retraining and certification (multiple cities)

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ECONOMICS & PUBLIC POLICY



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