Autonomous Vehicles: How U.S. Cities are Preparing

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Executive Summary

As fully-autonomous vehicles become closer to reality than fiction, cities race to prepare for the emerging technology that promises to all but erase the need for parking while simultaneously threatening to make cities explode in sprawling development. Self-driving cars have just one key variance from conventional transportation options – the lack of a driver – but could affect travel behavior and city development as strongly as the automobile did in the 20th century.

The literature is consistent in its recommendations for promoting active, multi-modal, and public transportation in the arrival of autonomous vehicles (AVs), and for using AVs to improve safety, reduce congestion and emissions, and persuade riders to switch from privately-owned vehicles to ride hailing or ride sharing. However, the absence of a history with AVs means that there is a deficiency in understanding how cities in the US are altering their transportation plans to prepare for autonomous vehicles. This leads to this study's driving research questions:
1. What does the literature suggest the impacts of autonomous vehicles will be, and how does the literature suggest preparing for these impacts?
2. How are cities in the US preparing for autonomous vehicles in their transportation plans?
3. How do city plans for AVs compare to what the literature says cities should be doing?

After identifying commonly found themes and recommendations for implementation in the literature, a systematic literature review of cities recognized as having plans for autonomous vehicles reveals if and how US cities are preparing for AVs. In general, the city preparations show a mutual agreement with the goals given in the literature, such as prioritizing public transit and ride sharing, using electric vehicles, curbing sprawl and congestion, and aiding first/last-mile connections. Themes that were not as comprehensively discussed by cities as by the literature are planning for point-to-point services and active or multi-modal transportation.

A comparison of how the study cities are preparing in relation to the counsel from the literature shows that there is a wide range of preparedness. Some cities with plans for AVs have only a few stated goals, such as preferring AVs that are used for public transit or shared, and electrically powered. Other cities have dozens of policies that depict how AVs will be allowed to operate as public transit, ride hailing services, and privately-owned vehicles; including details about payment for services, which vehicle models will be used, and how AVs will provide more equitable transportation. Conclusively, city preparations acknowledge the themes given by the literature, but do not always address it at thoroughly as the literature would demand.

Acknowledgements

Introduction

Autonomous Vehicles (AVs) are appearing more and more in the news as car manufacturers and computer software companies become ever closer to making self-driving cars a reality. Car manufacturing companies such as Tesla, Uber, Lyft, Ford Motors, Volvo, and Mercedes[1,2] are striking out on their own or partnering with Transportation Network Companies (TNCs) such as Uber and Lyft[3] to produce autonomous vehicles that will carry passengers to their destinations, either as a privately-owned vehicle or using Uber and Lyft for ride sharing services. The sprint to producing the first fully autonomous car is not limited to car manufacturers; computer software companies such as Waymo (owned by Google) have joined the race[4].

The thought of autonomous vehicles is exciting and daunting. There's an inherent cool factor to new technology, especially something that's been dreamt about and "right around the corner" since the 1950s[5]. AVs could make commutes easier and allow unfettered access for those with mobility challenges (such as children under the age of 16, seniors who have lost the ability to drive safely, and those with mobility or vision impairments). AVs will improve safety by reducing traffic collisions, ease congestion with their superior driving skills and closer proximity to each other, and AVs could possibly reduce the amount of parking needed by 90%. All of these are exciting outcomes of autonomous vehicles, and they're praised by the media and planners alike. However, this new method of transportation might have consequences for transportation habits and city development. The outcomes of AVs are anxiety-inducing because planners cannot predict with certainty if AVs are going to fulfill all of their promises for easing congestion or if AVs will induce sprawl, or possibly worse, create problems that have as of yet been unanticipated.

AVs are quickly approaching – some estimate that half of the cars on city streets will be autonomous by 2040[6] - and while much has been said about how AVs *should* be utilized, little has been written in transportation policies and plans for how AVs *will* be utilized. It will be up to municipal governments to fund the infrastructure and provide the legislature necessary for AV adoption. If there is a race to produce AVs for public use, then the finish line of that race is also a deadline for knowing how AVs will be used on public streets.

Research Questions
4. What does the literature suggest the impacts of autonomous vehicles will be, and how does the literature suggest preparing for these impacts?
5. How are cities in the US preparing for autonomous vehicles in their transportation plans?
6. How do city plans for AVs compare to what the literature says cities should be doing?

Objectives
1. Understand how the emerging technology of AVs could affect travel behavior and city development.
2. See what plans, if any, US cities have for the implementation of AVs for public use.
3. Compare the themes of the literature review with the themes found in transportation plans.

Process

To see how the ideas for AVs found in the literature review compare to the transportation plans and policies found in US cities preparing for AVs, I needed to understand two things: what the literature is anticipating for the potential impacts of AVs and the ideas to mitigate or leverage those impacts, and how cities in the US are preparing for those impacts. This formed the focus of my literature review.

My literature review examined a range of sources to evaluate news articles and videos, National Highway Traffic Safety Administration guidelines, action plans targeted at policymakers, thesis and dissertation reports, scholarly articles, and white papers. This review addressed the question, *How could the emerging technology of AVs effect travel behavior and city development*? This background research identified the themes in my literature review that answered my first research question – *What does the literature suggest the impacts of autonomous vehicles will be, and how does the literature suggest preparing for these impacts?*

To answer my second research question – *How are cities in the US preparing for autonomous vehicles in their transportation plans?* – I found a helpful source in Bloomberg Philanthropies; whose Initiative on Cities and Autonomous Vehicles operates a website which lists which cities around the world are piloting or preparing for AVs.[7] I used the list detailing cities preparing for AVs, as it is focused on Cities creating policies and action plans. The other list available is of piloting cities, that is, cities that allow autonomous vehicles to be tested within their boundaries.

The sources given by the website for each city varies; some cities are listed with Transportation Plans while some only have news articles discussing the City's plans. For each city I started with the source given by Bloomberg Philanthropies and looked for references to other documents or articles that discussed transportation in the City. A web search for Transportation Plans, Comprehensive Plans, staff memorandums, reports, news articles, or other published transportation-related documents was done for each city to find all potential sources. A few had lengthy, detailed planning-level reports written by consulting agencies that only discuss AVs and the City's plans for them. Some cities had a few paragraphs included in their Comprehensive Plan or Transportation Plan. Some had supplements to their Transportation Plan that detail the City's initial pilot for AVs, and clarified that more plans would come once the City has had the chance to study how well the pilot has met their expectations. The documents for one city include memorandums between City staff and their consulting agency, because the official amendment to the Transportation Plan hadn't been adopted yet.

For each of these sources, a word search looked for the key words of 'autonomous', 'automated', and 'self-driving'. I did not distinguish by the type of document or plan available, for example, Jacksonville, FL did not mention AVs in any planning documents but had a consistent narrative shown in multiple news articles, all of which included interviews with City transportation planners. The topic of self-driving cars is only recently recognized as a viable idea and there hasn't been much time for cities to write plans that could accurately discuss how AVs would be used. Of all the cities identified, the earliest transportation planning document found that discussed AVs was written in 2015[8].

After having identified potential cities and reading their plans, I filtered my options to cities that were planning for how AVs will be used by the public and had what I considered a robust game plan – by robust, I meant ideas detailed enough to be enacted by city planners. Some of the cities that Bloomberg Philanthropies identified as preparing I thought were better classified as piloting, because the plans didn't allow the general public to use the AVs but was focused on how engineers and testers from the AV manufacturing companies could use the AVs. Testing procedures are not representative of standard travel behavior and are less likely to be included in transportation plans, so this didn't accurately reflect how cites desire for AVs to be used within their boundaries. I also noticed that a few of the preparing cities had very little to say about their plans (even if discussed in Comprehensive or Transportation Plans); sometimes as little as a sentence or two that amounted to, 'welcome the future and prepare for autonomous vehicles'. Since such a vague sentiment isn't able to inform a transportation planner as to *how* to prepare for AVs, I next filtered the options by deciding what were the most basic criteria for making plans for AVs robust:

- Does the City know how it wants AVs to be deployed- such as using AVs for public transit, as shared vehicles, or as private vehicles?
- What are the City's priorities for using AVs? There were frequently repeated priorities found in the literature review – such as promoting public transit, first/last-mile connectivity, or managing congestion – did the cities address any of these or other priorities?

After filtering the plans with just two conditions, I was able to narrow the list to 14 cities. These cities have plans that are substantial enough to indicate how the City staff should prepare for AVs, how the general population will be able to use AVs, and what the City hopes to achieve with autonomous vehicles. The 14 cities were:

1. Ann Arbor, Michigan
2. Atlanta, Georgia
3. Chamblee, Georgia
4. Columbus, Ohio
5. Jacksonville, Florida
6. Lincoln, Nebraska
7. Los Angeles, California
8. Nashville, Tennessee
9. Palo Alto, California
10. Portland, Oregon
11. Sacramento, California
12. San Diego, California
13. SeaTac, Washington
14. Seattle, Washington

For each of the 14 cities I did a systematic literature review of all transportation-related materials found that mentioned AVs, aiming to address my second research question: *How are cities in the US preparing for autonomous vehicles in their transportation plans?* This literature review delved into the plans in greater detail by looking for the 14 themes identified by the literature review:

1. Prioritizing public transit
2. Planning for point-to-point services
3. Prioritizing ride sharing
4. Aiding first/last-mile connections
5. Prioritizing active transportation
6. Prioritizing multi-modal transportation
7. Managing sprawl
8. Reducing congestion
9. Reducing emissions
10. Improving equity and/or accessibility
11. Making automated vehicles electric
12. AVs using dedicated lanes
13. Estimations of the financial cost of AVs for the City budget
14. Estimations of the financial cost of AVs for users

After understanding how each city is planning to use or will allow AVs to be used, I could address my third research question: *How do city plans for AVs compare to what the literature says cities should be doing?* For this I had three parameters to guide my comparison:

1. Are the themes identified in the literature review addressed? (coded for binary answers, yes or no)
2. If the theme(s) are addressed, what does the city have to say for them? (coded open answer, qualitative)
3. Are there new themes that the cities are addressing? (coded open answer, qualitative)

Limitations

The most notable limitation to understanding how cities in the US are preparing for autonomous vehicles is the short list of cities with published preparation plans. The possibility of AVs driving on local streets did not become a reality until recently, so understandably few cities have prepared (of the more than 19,000 municipal governments in the US[9], I found only 14 cities that fit my specifications). This provides a small sample size from which to assess trends and analyze how cities are preparing compared to the advice given by the literature.

Literature Review: Transportation Themes Identified

The literature regarding autonomous vehicles can be termed as speculative; there hasn't been enough time with AVs being a possible transportation choice to definitively say how AVs will or will not affect transportation behavior and city development.[10] The speculations of an automated future describe how AVs could bring Utopia or Dystopia to cities; with Utopia being characterized as an increase in active and public transit[11], more ride sharing[12], a 90% reduction in parking needs[13], and higher development density[14]. Dystopia is described in these conjectures of the future as worsened congestion and sprawl as the public flocks to cars where they can watch Netflix or nap instead of driving themselves or taking the bus.[15]

Agreed-upon goals AVs need to strive for so transportation Utopia can be realized includes: better transportation that decreases congestion, equitable transportation that is accessible to all, pushing the public to shift to active and multi-modal transportation, and not encouraging sprawl.[16] AVs will be able to drive closer together tail-light to headlight[17] (which is called platooning[18]), won't drift side-to-side while driving (thus allowing narrower lanes[19]), and either wouldn't need to park or would use different methods of finding parking[20]. These improvements – along with ride sharing – would make street retrofitting easier than ever and make cities more compact and pedestrian-friendly[21].

Other topics include the changes to land use when auto-oriented uses such as parking, mechanic and autobody shops, and car dealerships aren't needed any longer[22]; how AVs are going to be electric[23]; how electric vehicles and street retrofits (which always promote active and multi-modal transportation in the literature) will change the physical design and density of cities[24]; how much cheaper AVs will be for users and for service providers[25]; what effects land use and altered transportation will have on real estate[26]; and the expected economic and employment impacts of losing all driving jobs and most jobs repairing cars[27]. Not all of these topics are found in transportation plans, but they show how difficult it can be to separate the transportation qualities of autonomous vehicles from the holistic changes they could bring to cities.

The themes found in the literature review are overlapping, often combining transportation and land use issues (an often-repeated example is how everyone should use autonomous public transit, that this will encourage multi-modal transportation and remove the need for parking which will change real estate and encourage higher density and street retrofitting, and that this will reinforce a cyclical transition to public and multi-modal transportation). Not all of the themes are specific to transportation (such as density and plans to remove parking), so I separated the codependent themes and kept those that were likely to be mentioned in transportation documents:

1. Prioritizing public transit
2. Planning for point-to-point services
3. Prioritizing ride sharing
4. Aiding first/last-mile connections
5. Prioritizing active transportation
6. Prioritizing multi-modal transportation
7. Managing sprawl
8. Reducing congestion
9. Reducing emissions
10. Improving equity and/or accessibility
11. Making automated vehicles electric
12. AVs using dedicated lanes
13. Estimations of the financial cost of AVs for the City budget
14. Estimations of the financial cost of AVs for users

The themes are discussed in further detail here. Each theme is defined, includes an explanation of why the literature thinks it is an important topic, and if applicable lists actionable advice that is often repeated in the literature.

Prioritizing public transit

Promoting and prioritizing public transit as the primary type of vehicular-transportation is discussed frequently as a more efficient mode of transportation than cars that are used for ride hailing, ride sharing, or as privately-owned vehicles. Public transit is defined as light rail services such as subway, bus, or shuttle services. Public transit is space efficient, equitable, and environmentally more sustainable than both ride hailing and privately-owned vehicles. The theory for using AVs to improve public transit is mostly that AVs will be much cheaper to operate, so more AV busses could be used than a City's current number of traditional busses.[28] More busses lead to improved service through more routes, higher capacity, and shorter headway times.[29]

The literature discusses some concerns with the ability to successfully prioritize public transit[30] given that the convenience of ride hailing and privately-owned vehicles will only become stronger as AVs make the services cheaper and freedom from parking easier. It was estimated that vehicle miles traveled will increase by 22% if public transit is removed[31], and a 46% drop in transit use was predicted because of the influence of AVs. This prediction is based on the assumption that AVs will be so convenient that public transit will lose all allure, and that AV ride hailing in particular will replace public transit.[32] The literature did not discuss how to use AVs to start public transit systems in cities that don't already have the service.

Ideas to promote or improve public transit using AVs include:
- Improving multi-modal transportation, to make it easier to access and use public transit. This includes improving pedestrian and bicycle infrastructure and connectivity and installing public transit stops at the same location or very close to the location of bike share hubs.[33,34]
- Using the cheaper costs of AVs (due to the absence of labor costs and cheaper maintenance and operating costs of electric vehicles) to operate more vehicles. More vehicles would enable more routes and more frequent service.[35]
- Maintain cheaper prices for public transit than ride hailing and privately-owned vehicles.[36]
- Use the money garnered from charging privately-owned vehicles for the use of infrastructure to pay for public transit, switching the status-quo of transportation infrastructure.[37]
- Consider a city-owned fleet of ride hailing services to act as a new form of public transit; attempt to configure it to use as few cars as possible and promote ride sharing.[38]
- Install mobility kiosks to request rides so that users without smart phones or credit cards can use the service.[39]
- Consider incentives to promote using ride hailing for trips to or from public transit stops.[40]

Planning for point-to-point services

Ride hailing (Uber, Lyft, other Transportation Network Companies, and taxis) provide rides that start and stop at passenger's doorsteps, discussed here as point-to-point services. Point-to-point services is differentiated from ride hailing because automated public transit might also be hailed, but public transit is confined to route systems (sometimes fixed, sometimes flexible) and does not provide point-to-point services. Point-to-point service is more convenient than a fixed-route

service and could detract from public transit ridership. Riders can request TNC services through phone apps, and it's speculated that ride hailing AVs will also use similarly designed apps.[41]

The benefits to point-to-point services is that parking is not required, and in theory ride hailing could mean there are fewer cars on the road. However, on-demand services have so far not reduced congestion or the number of cars on the road (a study of seven major cities reports that congestion has increased due to Uber and Lyft and the number of vehicles has not decreased[42]). It is unlikely that autonomous ride hailing will be an improvement unless rides are also shared, and a sophisticated operating algorithm uses the fewest cars needed based on real-time data of rides requested.[43]

Ideas to implement point-to-point services without increasing congestion include:
- Creating a data-sharing agreement with ride hailing service providers so that information relevant to managing congestion can be shared with the City, so the City can make informed decisions regarding transportation planning. Necessary information for this includes the number of trips requested and the time of day requested (to know when more/less service is needed) and origins and destinations. This information would help the City make informed decisions about where in the City the transit system could use improvement, what times of day are especially busy (for providing more service, but also for applying peak-hour surcharges if desired), and what times of day are less busy (so service can be appropriately scaled back). Data is easier to collect and analyze because of the level of detail acquired from TNC phone apps.[44]
- Asking for anonymized, basic demographic data in the data-sharing agreement so the City can see who is not using the services and question why. The most necessary information for this is income, so the City can gesticulate if the cost too high to be equitable.[45]

Prioritizing ride sharing

Ride hailing (paying for a ride through a Transportation Network Company) has the option of being shared; that is, to share your Uber/Lyft/TNC ride with another person (or multiple persons) who do not share your origin or destination but needs a ride in the same area of the City as you. Ride sharing is incentivized by having a cheaper price than a private trip. With AVs, ride sharing could be more precisely planned to keep trips quick (currently, Uber/Lyft drivers accept or deny passengers, and can choose to add passengers to shared rides that may be on-the-way of trips they're already driving, or that could add significant trip time to the passengers already in the car). Ride sharing decreases congestion by putting fewer cars on the road (for every car with five seatbelts, that could be one ride sharing car compared to five private ride hailing cars). The speculative literature did not reach a consensus on how to make ride sharing the default choice for ride hailing; it's already financially incentivized, but ride sharing increases trip time for users and car culture has taught users that riding alone is more natural than carpooling, and it would take more than a small discount to change widespread human behavior.

Ideas to promote ride sharing include:
- Financial incentives such as congestion pricing to make ride sharing cheaper than single or low-occupancy vehicles.[46]
- Make ride sharing the default for ride hailing services, not an option.[47]

Aiding first/last-mile connections

The first/last-mile of a trip is defined as the connection between a starting point (such as home) and where passengers will board public transit (such as the closest bus stop). The struggle is that 0.25 miles is said to be the furthest distance someone is willing to walk to a transit station[48], but many cities don't have enough transit stops to make the connection this short, thus the distance can make it difficult to use public transit. It is in a City's best interest to improve first/last-mile connections if aiming to increase ridership. Improving infrastructure and access is helpful, but not a service provided by AVs. AVs are thought to be useful for connectivity if used for ride hailing to/from transit stations.[49] Uber reports that 1/3 of trips start or stop at a public transit station[50], which shows that users are willing to use public transit if they can get to it.

Ideas to improve first/last-mile connections to public transit include:
- Improved pedestrian infrastructure.[51]
- Improved bicycle infrastructure.[52]
- Promoting multi-modal transportation.[53]
- Promoting ride hailing for use as a first/last-mile connection.[54]

Prioritizing active transportation

Active transportation is defined as any sort of human-powered mode of transportation in the literature, but most commonly uses walking for examples. Active transportation is favored in the literature because it is environmentally friendly, requires far less space than cars[55], and promotes healthy living[56]. City transportation plans sometimes give a hierarchy of modes preferred by the City, and active transportation is often given as a higher priority than cars. However, the link between walking, biking, or other active modes and AVs is a feeble relationship, and the speculative literature doesn't explain how making it easier to use a car (from not having to drive, not having to park, and cheaper pricing[57]) will make active transportation more popular. AVs will make car culture easier, which won't make drivers want to ditch their cars and walk, it will make drivers more likely to use AVs. In fact, ride hailing has been seen to replace active transportation for short trips; 49-61% of ride hailing trips wouldn't have been made if the service wasn't available.[58]

Ideas to promote active transportation were not always not directly linked to AVs, but include:
- Improved pedestrian infrastructure.[59]
- Improved bicycle infrastructure.[60]
- Promoting multi-modal transportation.[61]
- Implementing bike share programs.[62]

Prioritizing multi-modal transportation

Multi-modal transportation (using more than one mode of transportation per trip, such as walking or biking to a bus stop and then taking the bus) was strongly connected in the literature to active transportation, ride hailing, and public transit. The idea is that public transit may be used for the majority of a trip, but active transportation or ride hailing will fix the challenges with first/last-mile connections. Multi-modal transportation was usually described as a hybrid of active transportation for as long a distance as a person is willing, and public transit for the majority of the trip.

- Improved pedestrian infrastructure.[63]
- Improved bicycle infrastructure.[64]
- Implementing bike share programs.[65]
- Making it easier to bring bikes onto public transit, or, having bike parking or bike share hubs at transit stations.[66]
- Creating a trip-planning app that can plan for multiple modes of transportation in one trip, and pay for any fees (such as bus ticket, bike share, and ride hailing) within the app.[67]

Managing sprawl

Self-driving cars will make commutes easier and more pleasurable, which might make commuters less likely to care about how long their commute is. To what extent this is true is unknown. Longer commutes could mean that traffic is slow, or, that cities are spread out and sprawling. AVs could make previously inadvisable areas open to new development, perpetuating sprawl just as the proliferation of cars did in the 1950s.[68] The literature is unfavorable towards sprawling city development characterized by low-density and irregularly designed street patterns. Part of the excitement about AVs is the idea that the technology will make users more likely to give up cars and switch to public transit, ride sharing, or active transportation. If this is assumed not to happen, then the frequently repeated 90% reduction in parking won't happen either. Parking and the ease of car-culture are two of the driving forces behind sprawl, and if parking and driving habits don't change, then AVs could make sprawl worse. If AVs are able to be leveraged and combined with an increase in public transit, ride sharing, and active transportation, then AVs could contribute to curbing sprawl.[69] Not needing to park could affect land use by making much of the land given to parking available for infill development, which would make cities denser and less likely to search for land to develop on the outskirts of city development.

Ideas to manage sprawl include:
- Implementing a Vehicle Miles Traveled tax, to discourage lengthy trips.[70]
- Promoting active transportation.[71]

Reducing congestion

The potential for AVs to reduce traffic congestion (and also parking, which I will not discuss in detail) is at the crux of the Utopia vs. Dystopia conversation that is frequently included when discussing AVs. AVs are able to drive closer together because of their ability to communicate with each other, thus making roadways more efficient from the higher capacity.[72] The capacity of roadways is expected to increase 2-4 times because of AVs.[73]

On the Dystopia side of the conversation, AVs could make congestion worse. When cars do not need to be parked, they might circle the block instead, and they could be free of any passengers while doing so (referred to as 'zombie cars'), creating congestion without being purposeful in any way. The space saved by driving closer together would initially decrease congestion but could fall into the familiar nature of latent demand.[74] There is no guarantee that privately-owned cars will be replaced by ride hailing, public transit, or active transportation. If privately-owned cars were replaced by ride hailing because of the convenience and lowered costs, there is not much reason to think that autonomous ride hailing will be a noticeable improvement from human-driven ride hailing. A study of congestion found that congestion has increased due to

Uber and Lyft and that the number of vehicles on the streets has not decreased[75]. Additionally, ride sharing is already an option (and was included in the previously mentioned study), and the TNC companies still created congestion.

Ideas for reducing congestion include:
- Promoting public transit.[76]
- Promoting ride sharing, possible tools include charging higher prices for low-occupancy vehicles.[77]
- Promoting active transportation.[78]
- Discouraging zombie cars.[79]
- Implementing a Vehicle Miles Traveled tax, to discourage lengthy trips and trips that are short enough to walk.[80]

Reducing emissions

Reducing greenhouse gas emissions is featured as a potential benefit of AVs for two reasons: using electric vehicles and leveraging AVs to convince the population to use fewer cars. Fully electric vehicles release no tailpipe emissions, though the pollution-reducing benefits can vary depending on the source of electricity powering the electric vehicles. Electricity sources such as solar or wind power are more environmentally beneficial than fossil-fueled electricity sources.[81] Reducing vehicle miles traveled also reduces emissions.

Ideas for reducing emissions include:
- Using electric vehicles.[82]
- Increasing ridership for public transit.[83]
- Incentivizing ride sharing to more efficiently use vehicles.[84]
- Promoting active transportation.[85]

Improving equity and/or accessibility

Because autonomous technology is new, and new technology is usually more expensive, there are potential issues with AVs providing transportation that is equitable and accessible to all. Privately-owned AVs will be expensive to purchase, and ride hailing is not cheap enough for many households to use as their primary transportation choice (though it might be once labor costs aren't included). More importantly, AVs will probably be controlled through phone apps, and 23% of the US population doesn't have a smart phone.[86] Phone apps also require a credit or debit card for payment, which 35% of the US population over the age of 30 doesn't have.[87] If about 1/3 of the population is unable to summon a ride from their phone then AVs will not be accessible to all, and it's inequitable if access is determined by income.

Ideas for improving the equity and/or accessibility of AVs include:
- Installing kiosks at transit stops so rides can be summoned without a smart phone.[88]
- Creating a pass for AV systems that can have funds added by cash and providing stations to fill up the pass in commonly accessible public locations (such as grocery stores and libraries).[89]

Making automated vehicles electric

One of the common ideas found in the literature is the notion that AVs should (and will) be electrically powered. Electric vehicles are better for the environment than internal combustion engines and are frequently lumped together with reducing emissions. Electric vehicles are also cheaper to maintain because the engines have about half-a-dozen moving parts, and don't require refilling as many fluids or replacing parts that break over time.[90] Lastly, electric vehicles are cheaper to charge than conventional cars are to fill up with gasoline.[91]

Ideas to promote electric vehicles include:
- Installing electric charging stations[92], so that they are as easily found as gas stations.
- Purchase electric vehicles for all city-owned vehicles.[93]

AVs using dedicated lanes

Some autonomous vehicles navigate by tracking a specially marked line on the road, which is different than the lane striping that human drivers use to stay within the lane. This marked line is in the middle of the lane, and the vehicles follow it by using their cameras. This is one way that AVs would use dedicated lanes, as these models cannot drive without their markers to follow. However, many AV models don't rely on this method, but will use sensors, cameras, and LiDAR (invisible lasers used to detect surroundings) to safely stay within the lane.[94] Another method for AVs to use dedicated lanes is by having AV-only lanes[95], which is an idea that has a mixed reception in the literature. One perspective is that AVs are not ready to be mingling in mixed-traffic, and it would be safer to sequester them in an AV-only lane where the vehicles can communicate clearly with each other and won't need to rely on their cameras, sensors, and LiDAR to understand how other vehicles, bikers, or pedestrians are moving. In particular, AVs are having trouble understanding bike behavior.[96] Another perspective is that making AV-only lanes more convenient than regular lanes (such as by being curbside) would incentivize AV usage, and that this is a benefit. Another perspective is that AV-only lanes will simply take up more space, and would they really be much of an incentive?

Ideas for using dedicated lanes include:
- AVs following specially marked lines within their lane, to help navigate.[97]
- AV-only lanes.[98]

Estimations of the financial cost of AVs for the City budget

Hypothesizing how much AV programs will cost for city transportation budgets is a gap identified in the literature review. Much of the literature knows why AVs will be cheaper to operate, but not by how much. AVs will not have any labor costs for drivers. If AVs are electric, then the vehicles will cost about 1/3 as much in maintenance as internal combustion engines,[99] and switching from gas to electric will cut driving costs in half.[100] Many AV brands are electric, so they would cost less to fuel and maintain. Lastly, if AVs are as infallible as it is predicted they will be, insurance might not be needed.[101] Some insurance companies already give discounted rates for drivers with sophisticated crash avoidance systems,[102] so it's possible that in future AVs will not require insurance, or that insurance will be much cheaper than it currently is. The literature also did not discuss the purchasing or leasing price of autonomous vehicles.

Estimations of the financial cost of AVs for users

The cost of using public transit is cheaper than owning a vehicle and paying for the responsibilities that accompanies it (including insurance, fuel, maintenance, and parking fees: about 10% of the average household's budget is spent on purchasing and fueling privately owned vehicles[103], and the average US driver spends $345 a year on fuel while looking for parking[104]), but the cost of using ride hailing is an additional expense some users are unwilling to pay for regularly, even with the discount of ride share. Some people in cities with great public transit and walkability have saved money by selling their cars and switching to ride hailing on an as-needed basis[105], but for everyone who lives in a city that doesn't have walkability on par with New York City, the financial feasibility of depending on ride hailing isn't encouraging. The typical UberPOOL commute is $5-7[106]. However, AVs could make ride hailing much cheaper because labor charges won't be necessary and electric vehicles are cheaper to operate and maintain than internal combustion engines. UberPOOL's current fares for shared rides are $1-1.50 per mile but rideshare could be as low as $0.08 per mile with electric AVs.[107] Privately owned vehicles would be cheaper as well, though the initial purchasing cost will likely be more expensive while the technology is new.

Adding charges to transportation presents a possible equity issue, which makes implementing additional, or new, fees politically unpopular. However, if done in a way that is affordable (but still negative reinforcement for congestion causing habits) and done concurrently with improving public transit to the point it is considered equal to cars, congestion-charging pricing mechanisms are feasible. Apps for Uber, Lyft, and taxis have been able to track mileage, price depending on congestion and rush hour traffic, give discounts for shared rides, and retain all necessary information for congestion pricing. Using similar apps for AVs that garner the same information will enable pricing schemes for AVs. The challenge with this is privately-owned vehicles; it's expected that they will also be controlled by apps or similar technology, but that's not yet confirmed, and it is not as familiar to be charged for mileage in personal cars, unlike when using a ride hailing service.

Pricing systems to prioritize transit and high-occupancy shared rides include:
- Tiered pricing system. An example of a tiered system includes an elevated surcharge for zero-occupant cars, a base surcharge for single-occupant cars, and a reduced surcharge for cars with two or more occupants. The discounted surcharge could be further reduced depending on the number of occupants in a vehicle, making it cheapest to fill cars to capacity.[108]
- Charge per-mile. This will disincentivize excessively long trips and sprawl (because longer trips would be more easily seen as expensive, if notified for each ride rather than for a monthly gas bill). This would also disincentivize very short trips, which the literature thinks to be better suited for active transportation.[109]
- A surcharge for peak travel periods.[110]
- Charge for parking. Charging for parking isn't new, but it could be utilized to a greater extent to discourage personal-use vehicles.[111] One of the reasons passengers use public transit or ride hailing services is to avoid the trouble and fees associated with parking; in a survey of 6,000 US drivers, 63% said they avoided driving somewhere because of parking challenges.[112]

- Charge for curbside usage.[113] Since – if ride hailing is widely used – most passengers will be dropped off and will not be parking a private vehicle, stopping at the curb will be the equivalent of finding a parking space. A small fee could be used as a replacement, with increasing amounts for time the car spends waiting for its passengers to arrive (to discourage owners making their cars wait for them while they run errands, and in an effort to disincentivize curbside congestion).
- Adding fees to private vehicles to charge equivalently (or more) than ride hailing services. Adding fees for curb space or zombie cars (cars devoid of passengers) or other usage characteristics will disincentivize wastefully-used ride hailing services, but it will also encourage using privately-owned vehicles if they do not also pay the same fees.[114]

Findings: How are cities in the US preparing for autonomous vehicles in their transportation plans?

This section discusses what the 14 Cities studied have to say about each theme (if it is addressed) and includes examples of policies and action plans the Cities gave for the theme.

A few cities touched on nearly all topics, while others focused more narrowly on only a few themes. I found two new themes to include because about half of cities discuss them in their plans. The two new themes are the vehicle brands cities are planning on using, and if AVs will operate in dedicated regions or along planned routes.

To clarify how I judged whether or not a city addressed a theme with examples: if a city planned on using AVs in a dedicated region but does not know exactly which neighborhood the region would be using (such as planning to use an underserved neighborhood as the dedicated region, but does not list which neighborhood that is), the city received a ✓ in acknowledgment for addressing the theme as part of their plans. For another example, if the City wrote something along the lines of 'we expect AVs to be cheaper for users' but does not give an estimate of how much cheaper, the City does not meet expectations for addressing the topic.

Table 1: What Transportation Themes Do Cities Address?

	Ann Arbor, MI	Atlanta, GA	Chamblee, GA	Columbus, OH	Jacksonville, FL	Lincoln, NE	Los Angeles, CA	Nashville, TN	Palo Alto, CA	Portland, OR	Sacramento, CA	San Diego, CA	SeaTac, WA	Seattle, WA
Prioritizing public transit		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Planning for point-to-point services		✓			✓		✓	✓					✓	✓
Prioritizing ride sharing		✓	✓				✓	✓	✓	✓				✓
Aiding first/last-mile connections	✓	✓	✓	✓		✓							✓	✓
Prioritizing active transportation		✓	✓				✓			✓				✓
Prioritizing multi-modal transportation		✓	✓	✓		✓	✓							✓
Managing sprawl		✓					✓		✓	✓				
Reducing congestion		✓	✓	✓		✓	✓			✓		✓	✓	✓
Reducing emissions		✓	✓	✓		✓	✓		✓	✓			✓	✓
Improving equity and/or accessibility	✓	✓	✓	✓		✓	✓		✓	✓		✓	✓	✓
Making automated vehicles electric	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
AVs using dedicated lanes	✓		✓		✓		✓						✓	✓
Estimations of the financial cost of AVs for the City budget			✓		✓	✓								
Estimated cost for the User														✓
Choosing a vehicle brand	✓	✓	✓		✓									✓
Using dedicated region(s) or known routes of deployment	✓	✓	✓	✓	✓	✓					✓	✓	✓	
Number of themes addressed	6	13	13	8	7	9	11	4	6	7	3	4	10	12

Prioritizing public transit

For 13 of the 14 cities, public transit is seen as a transportation mode that needs to be promoted for its efficiency, equitability, and environmental benefits. The overall impression is that cities are planning to use AVs to support a pre-existing objective of prioritizing public transit, and the cheaper costs and convenience of automated systems might be what's able to make public transit competitive with privately-owned cars. Public transit is discussed as using AVs to improve service (frequently by using shuttles carrying 8-16 passengers), being complemented by point-to-point services, being a higher priority than ride hailing and privately-owned vehicles, and in need of improved first/last-mile connections. The only city that does not discuss public transit or prioritize it as the City's preferred mode of transportation is the plan for Ann Arbor; the plan is confined to University of Michigan students and faculty (to sign up for the shuttle's app, users must provide a University of Michigan email address).

Atlanta's plan discusses improving transit now, before it becomes autonomous, so that high ridership will be able to enjoy automated transit: *"Ensure that high capacity transit is available, especially along major corridors, as quality will be more important than ever to encourage ridership."* Another action plan is to, *"Encourage AV deployment for transit and shared mobility fleets over personal private vehicles."*[115]

One of **Columbus's** objectives for its AV plans is to provide more inclusive mobility, which it will address in the future by, *"Following a successful pilot deployment, the intention is to launch a full deployment across all public transit services in the City"*. AVs in Columbus will help address first/last-mile connectivity, particularly for mothers seeking medical services (Columbus has an infant mortality rate 4x higher than the national average, so part of Columbus's motivations for AVs is to provide better access to health care). The overall plan is summed by the action plan to, *"Work with Transit, Autonomous and Multi-Modal Systems in the City to boost ridership, lower carbon intensity, and implement electrified autonomous vehicles."*[116]

One of the strategies in **Los Angeles's** Transportation Technology Strategy handbook is focused on preparing for an automated future. An action plan to be accomplished within the two years of adopting the plan is to, *"Expand LADOT connected bus technologies fleet-wide"*, and while connective technology is not autonomous, it is the precursor that makes it easier to transit to automated vehicles. Within the next three to five years, Los Angeles will, *"Develop an AV road network along transit and enhanced vehicle networks"*. After this, AVs in Los Angeles will infiltrate public transit, *"Convert the public transit vehicle fleet to fully automated."*[117]

Lincoln's plan is to expand and enhance the public transit in an area of Lincoln's downtown with the highest concentration of people and attractions: businesses, the University of Nebraska, the state capitol, hotels, parking garages, retail, food, and an entertainment district. Lincoln's initial test-run will try to bridge the gap between traditional, fixed-route transit and point-to-point TNC services. Autonomous shuttles will operate on a route in the downtown area.[118] Desired outcomes from the test-run include to, *"Test the viability of micro-transit as a component of a transit system"* and, *"Test the viability of demand-responsive transportation as a way to reinforce transit"*.[119]

The section of **Portland's** Transportation System Plan dedicated to connected and autonomous vehicles promises to, *"Ensure that connected and automated vehicles advance Portland's Comprehensive Plan multiple transportation goals and policies, including vision zero, climate pollution reduction and cleaner air, equity…cost effectiveness, mode share, and reducing vehicle mile traveled."* Portland's prioritization of modes lists transit as more highly prioritized than AVs, so in Portland AVs will either support transit (such as through providing first/last-mile connections) or, if not used for public transit, be secondary to it.[120]

Seattle's playbook for AVs prioritizes active and public transportation above any other modes. This can be seen by Policy RP3, which will hard-code the base operating parameter into AVs that transit gets priority at all intersections along frequent transit corridors. Related to infrastructure and street design, Seattle has many policies regarding transit:

- *"Policy 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, biking, and high-occupancy automated vehicles only.*
- *Policy IS3: Work with our region's transit agencies to ensure automated vehicles support safer transit operations and grow the public transit market.*
- *Policy IS5: consider the loading needs of shared automated fleet services at shared mobility hubs to ensure seamless connections to and from high-quality transit."*[121]

Planning for point-to-point services

The Cities planning fixed-route systems for AVs generally didn't discuss point-to-point services (ride hailing from origin to destination), and if they did, it was mentioned as an option for the future. Point-to-point services was thought of as a way to supplement public transit, ease parking demands, and provide service in areas with ridership too low to support public transit.

Atlanta's Transportation Plan discusses how point-to-point services could boost public transit by providing first/last-mile services and being effective where low density prevents public transit from being so. The plan suggests arranging a pilot partnership between TNCs and public transit to arrange services that are helpful but not too competitive with public transit, one option for doing so is giving a discounted rate for TNC services starting or ending at transit stations, another is using TNC services for passengers with limited mobility as paratransit services could be much cheaper with AV point-to-point services. Atlanta's plan discusses how TNCs have increased competition for potential transit users, citing this as a reason to be wary of TNC services and proceed cautiously.[122]

Los Angeles plans on using point-to-point services to provide first/last-mile connections, and as a general transportation service. Los Angeles thinks the taxi and ride hailing industries are *"prime opportunities for the deployment of private automated vehicle fleets"* in high density areas and expects that Uber and Lyft will inevitably deploy AV fleets that the City could leverage as an AV pilot.[123]

Nashville has a few actions listed to try and use point-to-point services to their advantage, including, *"Allow taxis and high-occupancy on-demand car services that provide Metro with trip data to access future transit priority lanes"* and, *"Launch a mobility-on-demand program at Nashville MTA to provide demand-responsive transportation using technologies currently installed on a few of MTA's AccessRide vans. These could include demand-responsive services that operate in a certain geographical area, as well as hybrid, fixed/flex routes with both scheduled stops and deviations for on-demand pickups and drop offs."*[124]

Prioritizing ride sharing

City plans discuss ride sharing in autonomous vehicles as an improvement of ride hailing and declare that shuttle AVs (which are commonly found in City plans as supplemental to public transit and for providing first/last-mile services) fall under the distinction of shared mobility. Shared mobility is defined as transportation services that allow individuals to access and share the use of a common vehicle, including bicycles, cars, shuttles, busses, or other options.[125] With this definition of ride sharing, any city with AV shuttles (including **Atlanta, Chamblee**, and **Lincoln**) will be offering ride sharing as an option.

Atlanta notes that shared mobility has been seen to attract a certain demographic (young, urban, and well-educated, with smartphones and credit cards) so Atlanta's plan expresses concern about equity and access. The plan notes that City parking departments need to reorient to start, *"managing access for carshare pods and other shared use mobility spaces"* and, *"organizing TNC and AV pick up and drop off strategies"*, both actions are not specific to ride sharing but apply to ride hailing in all of its forms. The action plan to, *"Incentivize the sharing economy and "super sharers" as much as possible in order to best position Atlanta for a low-impact automated future"* strongly implies that ride sharing is a way to resist congestion. Shared mobility is also discussed as a way to overcome first/last-mile challenges by changing what it means to be 'near' transit.[126]

Nashville's plan calls for AVs that are shared, electric, and carefully integrated; this will be accomplished by, *"expand[ing] car-sharing and develop[ing] partnerships with transportation-network companies."* Believing that car-sharing is a more efficient use of the road network, Nashville's plan prefers car-sharing to privately-owned vehicles, but also notes that ride sharing can move only 7% of the people that transit can when given the same amount of space. Ride sharing will not be encouraged to replace public transit in Nashville.[127]

Portland's plans include the suggested legislature of,
- *"Policy 9.XA: "Prioritize connected and AV that are fleet/shared ownership, fully automated, electric and, for passenger vehicles, shared by multiple passengers (known by the acronym FAVES).*
- *Policy 9.XB.b: Design and manage the mobility zone, curb zone, and traffic control devices, e.g. to limit speeds to increase safety, to minimize cut-through traffic, evaluate future demand for pick-up and drop-off zones, and to prioritize autonomous electric vehicles carrying more passengers in congested times and locations*
- *Policy 9.6, the Transportation strategy for people movement, to implement a prioritization of modes in the following order:*

- *Walking*
- *Biking*
- *Transit*
- *Fleets of electric, fully automated, multiple passenger vehicles*
- *Other shared vehicles*
- *Low or no occupancy vehicles, fossil-fueled non-transit vehicles."*[128]

Seattle's plan includes multiple policies and actions aimed at promoting ride sharing. One such action is to, *"Establish a behavioral economics pilot to understand price elasticities of automated mobility and incentivize shared rides through the Mobility as a Service platform(s)".* The City is preparing for shared automated fleets that could supplement public transit and reduce the reliance on privately-owned vehicles. An action targeting this is to, *"Explore options to introduce special fares targeted for shared mobility trips that feed public transit"*, which can be seen in Seattle's tiered pricing system for AVs that makes shared rides cheaper than private or low occupancy trips. Three policies that are targeting ride sharing in Seattle's plan are,

- *"Policy ME2: Incentivize shared automated vehicle trips that provide access to public transit service at shared mobility hubs*
- *Policy ME3: Integrate shared automated vehicle fleet application programming interfaces (API) into Mobility as a Service platforms to ensure all shared fleet options are available to consumers*
- *Policy ME6: Provide road use fee discounts or incentives for automated vehicles with three or more passengers."*[129]

Aiding first/last-mile connections

The primary way AVs are connected to first/last-mile connections is by using ride hailing to bridge the first/last-mile gap. Some cities gave this as an intent for AV usage; another idea is to use AVs to improve public transit's coverage of the City so that there were fewer first/last-mile gaps.

Ann Arbor's purpose for their AV shuttles was inspired by first/last-mile connection problems, and the purpose has been expanded to help graduate students who live within two miles of the University of Michigan get to the campus.[130]

An action that **Atlanta's** Transportation Plan includes for first/last-mile connectivity is to: *"Create mobility hubs to provide convenient, clustered gathering spaces, particularly in areas of Atlanta with lower rates of smartphones and households with high-speed internet. Hubs should have multiple travel options for first mile/last mile connectivity and provide good bicycle and pedestrian access on-site and along travel corridors."* Atlanta's plan is especially concerned with equal access for those without smartphones and has plans to place the mobility hubs in areas with poor cell service and in lower-income areas. Another action plan discussing first/last-mile connectivity for Atlanta is: *"Pilots will be prioritized that provide first and last mile service to Metropolitan Atlanta Rapid Transit Authority (MARTA) stations and strengthen the transit network."*[131]

Chamblee's Feasibility Study and Concept Plan states that, *"the plan focuses on first/last mile connections to the Chamblee MARTA train station."* As the driving goal of the plan, the

dedicated region, vehicle type and capacity, and point-to-point service was chosen to support first/last-mile connections.[132]

Columbus's plan intends to use, 'Smart Neighborhood hubs' to address first/last-mile challenges and has addressing first/last-mile challenges as one of the intended outcomes of the plan, *"with greater mobility options and better addressing first and last mile challenges, will provide residents better access to jobs, fresh food, services, education, and recreation."*[133]

Seattle's plan promises to consider a pilot for AV first/last-mile and late-night service shuttles, and their Policy ME2 is aimed at first/last-mile connections: *"Incentivize shared automated vehicle trips that provide access to public transit service at shared mobility hubs"* along with Policy IS5: *"Consider the loading needs of shared AV services at shared mobility hubs to ensure seamless connections to and from high-quality transit."* In suburban areas with high vehicle ownership, the plan suggests considering partnerships with TNCs to provide first/last-mile solutions for regions with transit service gaps or certain demographics that might benefit the most from the service.[134]

Prioritizing active transportation

The literature gives ideas for promoting active transportation, but most of it is not dependent on AVs or even aided by the implementation of AVs (especially given that TNC usage has been seen to replace active transportation). Overall the Cities separated active transportation and autonomous vehicles into binary concepts, unless they were referencing that AVs need to operate safely for the pedestrians and cyclists around them.

Atlanta's transportation plan states that walkable communities are a timeless goal, and their vision for a safer system lists *"boosting active transportation opportunities"* as a component. The plan also mentions that TNC and micro-transit will be a good choice for the city, *"provided they support rather than detract from public transit and active transportation options"* and discusses that active and public transit needs to be more attractive than ever to compete with new mobility options.[135]

One of the goal for **Los Angeles's** plan, Infrastructure as a Service, claims that, *"Infrastructure as a Service can help shift behavior by incentivizing shared mobility, promoting staggered commute times and other active transportation alternatives."*[136]

Portland's plan discusses promoting active transportation and improving pedestrian and bicycle infrastructure, but more relevantly, includes a hierarchical prioritization of modes in the order of walking; bicycling; transit; electric, shared AVs; shared vehicles; and low or no occupancy vehicles powered by fossil fuels.[137]

Seattle's plan for AVs includes convincing residents to give up their cars, which rather naturally means that reduced vehicle ownership will encourage other transportation alternatives such as public transit, ride share, and active transportation. A section of Seattle's Mobility Playbook includes a list of questions that the City invites innovators to help the City answer; one of the questions is, *"How might we use technology to make the street friendlier to people walking and biking?"*, which is possibly referencing the safety concerns surrounding AVs, or possibly referencing making active transportation more welcome and prioritized. One of Seattle's plans is

to, *"Continue prioritizing the needs of people walking, biking, and taking transit by leveraging the growth of our robust transit network"*, which will be autonomous in the future.[138]

Prioritizing multi-modal transportation

Similar to promoting active transportation, the literature focuses on improving pedestrian and bicycle infrastructure to promote multi-modal transportation. This notion is found in a few cities; though full street retrofits is not found in any of the city transportation plans. Also found is using a trip-planning app that plans for multi-modal use, which is also recommended by the literature. Neither of these suggestions from the literature are specific to AVs, and the plans cities have for prioritizing multi-modal transportation are not contingent on using AVs either. Rather, the plans are for multi-modal transportation, and AVs are just an added detail for vehicle use.

Chamblee's Feasibility Study and Concept Plan discussed why the final plan was chosen out of the possible options, and part of that reason was that, *"it integrates with and enhances the multi-modal network"* better than the other options, clearly signifying that multi-modal transportation was an important determining factor.[139]

Los Angeles gives, *"adopt a multi-modal smart fare system"* as an action to take within the next 3-5 years. The smart fare system might include the potential strategies of income-based fares, time of day pricing (especially peak period pricing), distance-based pricing, usage-based pricing, bundling with other offers, and loyalty schemes for the most frequent travelers.[140]

Seattle's plan for AVs includes a policy related to infrastructure and street design that mentions multi-modal transportation. Policy IS2 says to: *"Establish multimodal level of service (MMLOS) or another vehicular level of service alternative as the default intersection performance measure to ensure efficient person movement, but also safer and more comfortable intersections."* Seattle's plan also calls for creating a multi-modal fare payment system.[141]

Managing sprawl

The literature reveals that some thoughts around managing sprawl using AVs comes from switching from privately-owned cars to public transit, ride sharing, or active transportation. Sprawl is frequently discussed in Utopia vs. Dystopia debates, but the concept of sprawl is only addressed by four cities in their transportation plans (this is possibly because sprawl is a land use issue as well as a transportation issue, and so references of it might be found in other documents that were not included in this study).

Los Angeles likened the arrival of AVs to the influence cars had on city development and transportation systems when they were introduced on a mass-scale. Los Angeles advised thinking about and planning early for the potential impacts of changing transportation technologies, since infrastructure is built to last 50-100 years. The City acknowledged that, *"Los Angeles is a huge consumer of transportation but the status quo is unsustainable"*, and explained that cars are not the solution to the problem. As the plan states, *"...a failure to proactively address the impacts these technologies will have on our city and region can reap potential disastrous outcomes – leading to greater sprawl, congestion and pollution. The intent of this strategy is to provide a policy framework and series of actionable next steps to make sure these benefits are realized, and negative impacts are mitigated as best as possible."*[142] **Palo Alto**

briefly explains that the City is worried about AVs contributing to sprawl[143], and **Portland** mentions that sprawl is a consequence of not promoting active transportation.[144]

Reducing congestion

Congestion is discussed as a byproduct of privately-owned vehicles. Addressing congestion is often done in the same sentence as addressing air pollution, indicating that the two ideas are frequently linked together under environmental goals. AVs will be able to reduce congestion by making streets more efficient (from driving closer together), promoting ride sharing (through ride hailing), promoting public transit (the most efficient use of space that uses vehicles), and promoting active transportation. The cities that discuss AVs as a way to reduce congestion sometimes cover one or more of these topics, or, include reducing congestion as one of the goals of the plans concerning AVs but do not discuss in detail how AVs will do this.

Atlanta has reduced congestion as a transportation system goal and discusses reducing congestion as a potential benefit that could be realized through combining shared mobility with public transit, reducing the time spent on parking, and the general effects of ride hailing. The City also discusses how congestion could increase with AVs if their use made residents live farther away from their jobs and commute longer distances. Atlanta plans on making AVs pay congestion feeds to *"alleviate overcrowding"* and trying to time urban freight deliveries to off-peak times to reduce or avoid congestion.[145]

For **Columbus**, decreasing congestion is a goal specifically applied to one of its initial piloting districts. The Logistics District (a multi-modal logistics hub with a cargo-dedicated airport) will be using (driver assisted, for the time being) truck platooning to decrease congestion and increase productivity and efficiency.[146]

One of the transportation policy goals in **Los Angeles** is to improve air quality by decreasing congestion, which the city plans to do primarily through encouraging ride sharing. Los Angeles is considering using a transparent pricing scheme to discourage low-occupancy trips and making transportation users realize how they are contributing to the problem of congestion.[147]

Portland's plan includes policy suggestions for reducing congestion, including,
- *Policy 9.XA.b: "Ensure that connected and AVs improve travel time reliability and system efficiency by*
  - *Maintaining or reducing the number of vehicle trips during peak congestion periods;*
  - *Reducing low occupancy vehicle trips during peak congestion periods;*
  - *Paying for use of, and impact on, Portland's transportation system including factors such as congestion level, VMT, vehicle occupancy, and vehicle energy efficiency."*[148]

Reducing emissions

Reducing emissions is usually given as part of a city's environmental goals to improve air quality. Prioritizing public transit, reducing the number of cars on the road, promoting active transportation, and using electric vehicles were methods that cities mentioned to reduce emissions.

Chamblee plans to reduce emissions through electric vehicles.[149] **Lincoln** plans to reduce emissions through *"low or no emission transit buses and related equipment"* but does not clarify

if those transit buses and related equipment are electric.[150] **Los Angeles** considers AVs helpful for meeting goals for reduced emissions because of improved traffic flow – unless AVs put more cars on the road from latent demand.[151]

Palo Alto's plans has policies aimed at reducing emissions, including Policy T-1.5: *"Support the introduction of autonomous, shared, clean motor vehicles with the goals of improving roadway safety (especially for vulnerable road users), improving traffic operations, supporting core mass transit routes, reducing air pollution and GHG emissions, enhancing transportation opportunities for the disadvantaged and reclaiming valuable land dedicated to motor vehicle transportation and parking."*[152]

Portland's plan includes suggested language for adoption for Connected and Autonomous Vehicle Priorities and Outcomes, including the suggest policy 9.XA.c: *"Cut vehicle carbon pollution by reducing low occupancy "empty miles" traveled by passenger vehicles with zero or one passengers."*[153]

SeaTac makes it clear that reduced emissions are part of why the City is pursuing AVs, *"The City of SeaTac entered into a contract with the Center for Advanced Transportation and Energy Solutions (CATES) to develop an action plan with guidance for deploying advanced transportation technologies that have the potential to reduce accidents, emissions, and congestion, with the initial focus being on the feasibility of automated mobility services."*[154]

Improving equity and/or accessibility

Purchasing autonomous vehicles will initially be expensive and renting their point-to-point services will require an app on a smartphone that will need to be paid for by credit card. These are financial challenges some users will have to contend with, and there is a possibility that public transit will also utilize phone apps to summon or board rides. If so, the cheapest mode of vehicular transportation will become more expensive and burdensome to riders. Much of the concerns cities have with the equitability of AVs is the necessity of smartphones and credit cards, and what that means for accessing automated services. To address this, some cities have stated intentions to create mobility hubs or kiosks to summon rides and pay with a transit pass. Others have stated concerns with equity or included a goal to make AVs an equitable source of transportation for the City. The other form of access discussed with AVs is proximity to transit, which many Cities are trying to help by providing first/last-mile connections with point-to-point AV services.

Atlanta is worried about the equity and access of requiring smartphones and credit cards. This will be countered by mobility hubs that provide convenient, clustered gathering spaces with multiple travel options for providing first/last-mile connectivity. The mobility hubs will be placed in areas of Atlanta that have cell service that's unreliable enough to have trouble using an app.[155]

Chamblee references the accessibility of AVs for users with mobility impairments and is leaning towards choosing a shuttle model that is wheelchair accessible, noting that the shuttles currently on the market are working on offering more ADA features.[156]

Columbus considers one of the desired outcomes of AVs to be transportation that is accessible to all. Columbus would also like to have a multi-modal trip planning app that can work in an offline mode so that underserved communities can access travel guidance without a cellular data plan. The app would also be available in multiple languages. A smart pass would address residents who are cash based or credit challenged; the smart pass would allow users to pay for all transportation options within the City. Kiosks would be placed around the city that could provide transit and transportation services information, Wi-Fi, adding money to the smart pass, and access to social services. Neighborhood hubs would help address first/last-mile connectivity by supporting multiple transportation options; each hub would have a kiosk.[157]

Lincoln's plan expresses concern by saying, *"It's imperative that transit remain the backbone of Lincoln's transportation, providing access in an equitable manner to the City's population."* This concern comes from the attractiveness of point-to-point services. The flexible-route designed for Lincoln's downtown was intended to be *"easy to use, easy to understand, and provide enough stops to be easily accessible."* Lincoln also notes the ADA features available in shuttle models, as another form of accessibility.[158]

Palo Alto's Comprehensive Plan clearly says that the City wants AVs that are shared, electric, safe and equitable; and that Palo Alto is worried about sprawl and inequity. This will be done by *"enhancing transportation opportunities for the disadvantaged"*.[159]

Portland addresses equity in one of the Transportation System Plan's outcomes, which is to, *"Ensure disadvantaged communities benefit as much or more than non-disadvantaged communities"*. Equity is also addressed in the suggested Policy 9.XA.d, *"Make the benefits of automated mobility available on an equitable basis to all segments of the community while ensuring traditionally disadvantaged communities are not disproportionately hurt by connected and autonomous vehicle use."*[160]

Seattle's playbook reports that it prioritizes equity and explains that AVs could help or hinder equity and affordability. Ride hailing is noted as being more difficult to be, *"equitable geographically and financially"* than other modes of transportation. Lower costs for services is thought to be a way to address this. Transit is stated as being the top priority for increasing mobility and equitable access. Seattle's plan has seven policies targeting equity and accessibility in transporting passengers specifically, and one regarding mobility economics, equity and accessibility:

- *"Policy 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 on traditionally marginalized communities.*
- *Policy EA2: Ensure shared automated vehicle fleets consider the safety needs of vulnerable population and loading needs of seniors, families with children, and individuals with mobility impairments.*
- *Policy EA3: Establish equitable performance standards and penalty structures for shared automated vehicle fleet wait time and declined rides as a way to eliminate discriminatory practices.*
- *Policy EA4: Require a percentage of shared automated vehicle fleet vehicles to be ADA-compliant to meet the needs of people with disabilities.*

- *Policy EA5: Identify and require shared automated vehicle fleets to serve markets that are underserved by transit and focus on connecting people to high-quality transit spines.*
- *Policy EA7: Conduct a publicly visible community consultation and outreach process to understand concerns, needs, and opportunities related to the impending automated mobility paradigm.*
- *Policy EA8: Establish a City-owned transportation network company digital platform to incubate smaller shared automated vehicle fleet businesses, mitigating the risk of mobility monopolies in Seattle.*
- *ME3: integrate shared AV fleet application programming interfaces (API) into Mobility as a Service platforms to ensure all shared fleet options are available to consumers."*[161]

Making automated vehicles electric

When discussing using electric vehicles for AVs, discussions range from explaining why electric vehicles are the environmentally wise choice to simply stating that the potential AV brands are electric, as if gasoline-powered brands aren't an option available for purchase. Some cities include specific goals that AVs will be electric, and others did not.

When discussing its environmental goals, **Chamblee** discusses that electric vehicles help reduce greenhouse gas emissions and improve air quality. When discussing vehicle options, it is stated that the AVs will be electric.[162] In **Jacksonville**, it is simply stated that the self-driving vehicle used will be electric.[163]

For **Los Angeles**, the plan says, *"The City of Los Angeles is working to deploy the City's first carsharing fleet of electric vehicles."* Los Angeles also notes that it is trying to follow the National Association of City Transportation Officials (NACTO) policy guidelines for fully-automated vehicles, which recommends to, *"Incentivize shared, automated, electric vehicles to reduce the environmental impacts of vehicular travel and refocus planning on the principle of mobility as a service"*.[164] **Nashville** boldly says, *"AVs are coming to American cities, but in Nashville we want them to be shared, electric, and carefully integrated to buttress mass-transit so these technologies can address concerns around urban livability…."*[165]

Palo Alto's Comprehensive plan says, *"…this plan focuses on autonomous vehicles that are shared, electric, safe, and equitable."* A specific policy example to support this is Policy T-1.4: *"Ensure that electric vehicle charging infrastructure, including infrastructure for charging e-bikes, is available citywide."*[166]

AVs using dedicated lanes

Using dedicated lanes means different things depending on the City. For **Ann Arbor**, the AVs use dedicated lanes by following a specially-marked track in the lane that helps the AVs navigate. Because the AVs follow these markings, the AVs have to follow a pre-determined route and are not allowed to drive in other lanes.[167] For **Chamblee**, using dedicated lanes means using certain lanes (following a prescribed route, as part of the operations planning) but sharing the space with other vehicles and active transportation.[168] **Jacksonville** will be using AV shuttles on their Skyway system, which currently runs a monorail system, and the Skyway system has elevated regions that are not compatible with human-driven vehicles. Over time, the Skyway system will be expanded, and for surface-level operations in the expanded routes the AVs will

not use dedicated lanes. **Los Angeles** will use dedicated lanes by using AVs for public transit and having bus-only lanes during peak travel periods. **SeaTac** AVs will use designated lanes on a planned route; the routes will use a combination of technology along with on-board maps to keep the AVs within an operating domain, and the AVs will not be allowed to stray from the prescribed lanes on their route.[169] **Seattle** will have dedicated lanes that are only used by level-5 automated vehicles and a network of 'smart' lanes for vehicles with levels 4-5 automation for peak travel periods. A policy from Seattle's Mobility Playbook that mentions this is:

- *"Policy RP3: Hard code the following base operating parameters into connected vehicles and automated vehicles…*
  - o *Functional classification system for automated vehicles and network of peak period smart lanes dedicated to level 4 and 5 AVs (including, not limited to)*
    - ▪ *Lanes for fully automated vehicles*
    - ▪ *Full access for automated vehicles with levels 1, 2, 3, and 5*
    - ▪ *Limited access for low-occupancy automated vehicles*
    - ▪ *Zero access for automated or human-operated vehicles."*[170]

Estimations of the financial cost of AVs for the City budget

It is not uncommon for the study cities to acknowledge that AVs would have cheaper operating costs due to the absence of labor costs (thought to be 70% cheaper for shuttle AVs than for traditional busses[171]) and that electric vehicles are cheaper to operate and maintain, but only three cities have real estimates for how much it would cost to purchase, lease, or operate the vehicles.

Chamblee's Feasibility Study and Concept Plan found that the leasing costs for AV shuttles (EasyMile, etc.) ranges from $12,000-14,000 per month per vehicle. If operating 6 days a week from 6am-9pm, the operating costs of the AVs equates to $30-40 per hour. By comparison, the national average for fixed route bus systems is an average cost of $136 per hour. Chamblee considered the primary financing models of purchasing the vehicles or arranging a leasing contract, and their initial recommendation is to lease the vehicles for a set monthly fee. AV leasing arrangements were found to typically have an all-inclusive service that covered testing the vehicle, mapping the route (if needed), ongoing maintenance and vehicle inspections, vehicle replacement in the event of malfunction, and sometimes included on-board attendants and nightly cleaning.[172]

Jacksonville is planning on retrofitting their Skyway system (currently a monorail system) to use AV shuttles, and estimates that the construction costs for AV-based network expansions will be 50% as expensive as it would be if planning for monorail vehicles. The cost would be reduced by 75% where the tracks can be run at surface level. AV shuttles in Jacksonville would be a 25% reduction in operating costs from the current vehicles.[173]

Lincoln estimated how much it would cost the City, and also how much revenue could be made from ridership and advertising. For revenue from ridership, the City assumes an average of 100 rides a day for 2 years, generating $73,000 in funding. Breaking it down further, this would equate to roughly $1 per ride. For advertising on the City's shuttle fleet, a typical bus wrap garners between $2,000-8,000 for a 4-week wrap, so assuming a price of $5,000 for 4-weeks, the City could make $130,000 in funding. Lincoln found that purchasing the vehicles directly offers the most control for the city, but an individual vehicle costs approximately $350,000 a year and

has an added operating cost of approximately $47,000 a year. Contracting with a third-party is estimated to be $725,000 per year for a four-vehicle deployment and one full-time employee. For leasing, the cost is estimated to be $140,000 per vehicle per year (this is equal to the low-end range determined by Chamblee). For a four-vehicle deployment, the cheapest option according to Lincoln's metrics would be to lease.

Lincoln is the only city to address the cost of supplementary infrastructure such as Dedicated Short-Range Communication radios and GPS signal repeaters. DSRC radios are used for connective infrastructure and can help AVs orient themselves and stay on their intended path. GPS signal repeaters are useful to combat the 'urban canyon effect' of driving down streets with tall buildings on either side that block the GPS signals that AVs use to know where they are. Lincoln calculates that each DSRC radio costs $1,400 with installation and labor being an additional $2,000 each, with annual maintenance costs of $2,250 each. GPS repeaters are $300 each with installation and labor being $2,000 each and annual maintenance of $1,000 per year. Remembering that AVs are expected to be electric, Lincoln found that upgrading the electricity to renovate charging facilities costs $2,5000 per linear foot.[174]

Estimations of the financial cost of AVs for users

The only city that addresses how much AVs will cost for users was **Seattle**. Other cities have notions that AVs would make costs cheaper for users but do not give real estimates for how much that would be or include plans for what the City will charge their riders. Without regarding AVs, Seattle includes some price estimates for how much users would save if they gave up their vehicles and switched to public transit, ride hailing, and bike share services (roughly $10,000). Seattle uses this cost-savings estimate to help justify why residents should give up their cars.

Specifically for AVs, **Seattle** has two scenarios to base a tiered pricing system on: ride sharing, and ride splitting. AV ride share costs are assumed to remain similar to existing rideshare costs but discounted by 50% to account for the removal of labor costs. This assumption is based on a variety of conversations with transportation industry professionals, who gave a range from 50-80% for the decreased cost of operating a vehicle. For ride sharing, the base fare is going to be $1.65/trip, with a mileage fee of $0.69/mile, and a time fee $6.60/hour. Ride splitting was defined as carpooling and splitting the costs between users; ride sharing does not let passengers choose who they share a vehicle with, but with ride splitting a group of friends could take the same trip and each pay for their portion. The AV ride split costs were further reduced by 20% from the AV rideshare costs. The base fare will be $1.32/trip, with a mileage fee of $0.55/mile, and a time fee of $5.28/hour. Seattle's Mobility Playbook includes a section on 'Mobility Economics', which gives policy ideas for how to charge for transportation services and how to do so equitably. Pricing policies include,

- *"Policy 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 AVs*
  - *Tier 2 (base surcharge): Single-occupant automated vehicles*
  - *Tier 3 (reduced surcharge): Automated vehicles using smart lanes with less than three passengers (see policy RP3 for more information)*
  - *Tier 4 (no surcharge): Automated vehicles using smart lanes with three or more passengers*

- o *Tier 5 (additional surcharge on Tiers 1-3): Peak travel period surcharge for all non-public transit vehicle trips with less than three passengers, including freight.*
- *Policy ME5: Assess and establish alternatives to parking and state gas tax revenue sources, including, but not limited to, zero- and low-occupancy fees, curb-side dwell time fees, per mile road use charges, cordon tolling, and peak period surcharges.*
- *Policy ME6: Provide road use fee discounts or incentives for automated vehicles with three or more passengers."*[175]

Choosing a vehicle brand

The vehicle brands available for public transit or ride sharing use is not a theme identified in the literature, but in examining the plans cities have for autonomous vehicles there is a pattern that the Cities who do mention vehicle brands commonly mention the same brands and models, and that these models were all autonomous shuttles. Those brands are EasyMile by EZ10, Olli by Local Motors, and Navya by Arma. **Chamblee** and **SeaTac** both discuss EasyMile by EZ10, Olli by Local Motors, and Navya by Arma as potential shuttles for use based on their passenger capacity and use in other piloting projects.[176,177] **Jacksonville** has chosen to test multiple shuttle models, starting with the EasyMile by EZ10. Jacksonville will be asking for the public to provide feedback during testing times to help choose which brand will be chosen.[178] The exception to mentioning these brands is **Ann Arbor**, who uses RITMO in a partnership with Ford Motor Company.[179]

Using dedicated region(s) or known routes of deployment

Dedicated region(s) or known routes of deployment is not a theme often discussed in the literature but is a theme found in more than half of the study cities. A dedicated region is characterized as a neighborhood or geographic area within the City that AVs will be used in, and these dedicated region(s) are often the pilot test pre-cursory to allowing AVs to be used city-wide. I did not distinguish preparedness strictly on whether or not the Cities knew which areas in the City this would be; I thought the choice for, as an example, AVs being first deployed in a neighborhood that's underserved by transit or has lower-income residents (to address transportation equity and accessibility, often) is more important than knowing which neighborhood fits the characteristics the City has chosen to target. Known routes is defined as plans that know exactly which streets the AVs will be using; this often is a bus line, either for replacing the conventional busses on the route with AVs for a before-and-after comparative study of how AVs improved service along the route, or as a new route to expand the bus network. I did not discriminate if the City does not know which bus line the route will be. A trend noticed is that the Cities that have dedicated region(s) or known routes of deployment are also likely to plan for dedicated lanes of some kind. This is because the dedicated lanes are often following a predetermined route.

For **Ann Arbor**, the AVs follow a marked-path along a pre-determined route, and also operate on the University of Michigan campus grounds.[180] **Chamblee's** AV shuttles will be replacing a bus route.[181]

Columbus's plan has identified four regions for the initial deployment. One is a residential neighborhood; it is one of the most challenged communities with high unemployment, poverty, and infant mortality. Columbus will provide infrastructure with Wi-Fi service in the area because the region has slow internet speeds, and considering the lower-income demographics of the

neighborhood it would be helpful to be able to use Wi-Fi to use the phone app or the mobility kiosks installed in the area. The next region is a commercial district of a large size that will be focused on using AVs to address first/last-mile challenges. The commercial district has three routes within it as well that will use AVs for public transit. The downtown district lacks parking, so AVs will be used to see if they can alleviate the need for parking.[182]

In **Jacksonville**, AVs will be replacing monorail trains for the City's existing Skyway system. **Lincoln** is planning for AV service along a fixed loop route with a possible short-cut in case one section of the route doesn't have any passengers requesting a ride in that area. Riders will request a ride using an app but will be directed to the nearest pick-up location.[183] **Sacramento** is deliberating between two routes, both chosen to link a light rail station to Sacramento State University's campus.[184] **San Diego** has 3 test zones proposed: a 20-mile segment of I-15, a 10-mile stretch of the South Bay Expressway, and city streets in Chula Vista (the second largest city in the San Diego metropolitan area, not within San Diego itself[185]).[186] **SeaTac** has plans for using dedicated lanes following a fixed route that is in a geofenced operating domain. The routes would eventually be flexible or provide point-to-point services.[187]

Findings Discussion: How do city plans for AVs compare to what the literature says cities should be doing?

Many of the themes identified in the literature are addressed by the study cities, but the study cities do not always use the ideas recommended in the literature for how to do so. This section reiterates the ideas found in the literature that directly relate to AVs and tallies which cities use the idea. A brief discussion shows the comparisons between city preparations and the advice given in the literature review, both for what ideas from the literature are used and what new ideas the Cities use to approach the themes. Some of the ideas created by cities are more specific than ideas from the literature and directly relate to the pilot plans cities have for implementing AVs.

Prioritizing public transit

Idea	Cities that use the idea	Number of Cities
Improving multi-modal transportation, to make it easier to access and use public transit. This includes improving pedestrian and bicycle infrastructure and connectivity and installing public transit stops at the same location or very close to the location of bike share hubs.	Atlanta, GA Chamblee, GA Columbus, OH Lincoln, NE Los Angeles, CA Seattle, WA	6
Consider a city-owned fleet of ride hailing services to act as a new form of public transit; attempt to configure it to use as few cars as possible and promote ride sharing.	Chamblee, GA Columbus, OH Jacksonville, FL Lincoln, NE Los Angeles, CA SeaTac, WA	6
Consider incentives to promote using ride hailing for trips to or from public transit stops.	Ann Arbor, MI Atlanta, GA Chamblee, GA Lincoln, NE SeaTac, WA Seattle, WA	6
Install mobility kiosks to request rides so that users without smart phones or credit cards can use the service.	Atlanta, GA Columbus, OH Lincoln, NE Los Angeles, CA Seattle, WA	5
Using the cheaper costs of AVs (due to the absence of labor costs and cheaper maintenance and operating costs of electric vehicles) to operate more vehicles.		0
Maintain cheaper prices for public transit than ride hailing and privately-owned vehicles.		0
Use the money garnered from charging privately-owned vehicles for the use of infrastructure to pay for public transit, switching the status-quo of transportation infrastructure.		0

Prioritizing public transit is a theme found in 13 of the 14 cities, but not all of the ideas for how to do so that are found in the literature review are adopted by the Cities. The Cities made plans to prioritize public transit by improving service and efficiency through the use of AVs, but the methods for doing so are not dependent on the vehicles being autonomous. Rather, cities are using age old transportation goals – more frequent service, better coverage of the City, cheaper costs, and increased ridership – and working to achieve them by using AVs. Mostly, the study cities think this can be accomplished be renewed efforts to improve public transit, which will be helpfully aided by cheaper operating costs. An idea used by many of the Cities but nearly absent

from the literature is the use of shuttles; the Cities view shuttles as the perfect choice for public transit in areas of low ridership to replace larger vehicles, as vehicles for point-to-point public transit (a hybrid of conventional transit and TNC services made possible by automated systems and phone apps), to be linked together as a 'connected' train that can change sizes depending on ridership, and even for areas with high ridership shuttles were chosen to replace larger bus sizes.

Improving public transit through active and multi-modal transportation, including using ride hailing for multi-modal transit or as a new form of public transit, are ideas from the literature used by cities. Incentives for using ride hailing to get to or from transit stops is mostly found as a stated intention, though offering discounted rides to transit stops is mentioned as a possibility. Addressing the inequity of summoning rides through smart phones by planning for mobility hubs or kiosks is also planned for. In the literature the idea of kiosks to summon AVs is targeted for users without access to smart phones, but a few of the Cities take the idea further by including regions of poor cell service so users with the app can have access without data plans or a signal. Another new idea presented with the kiosks is to make them mobility hubs with information regarding transportation options for the City and for the neighborhood along with information and access to social services.

The three ideas that involved money – either the City spending money or receiving it as revenue – are not addressed or used by any of the Cities. As seen in the findings for transportation themes found in city plans for AVs, only three of the Cities have any real notion of how much AVs will change their budgets. Given that the Cities largely don't know how much AV implementation is going to cost them, they might not be ready to think about how much to charge for transit fare or how many autonomous vehicles their budget can afford. Planning for point-to-point services

Idea	Cities that use the idea	Number of Cities
Creating a data-sharing agreement with ride hailing service providers so that information relevant to managing congestion can be shared with the City, so the City can make informed decisions regarding transportation planning.	Atlanta, GA Los Angeles, CA Portland, OR Seattle, WA	4
Asking for anonymized, basic demographic data in the data-sharing agreement so the City can see who is not using the services and question why.	Los Angeles, CA Portland, OR Seattle, WA	3

The operative parameters of point-to-point service is well established, but a few cities are aiming to create stipulations for data sharing with TNC providers so that transportation planning can make better-informed decisions. These ideas for data collection ultimately do not plan how point-to-point services can be used but help in an attempt to use the services efficiently. One of the reasons given by cities to be wary of point-to-point services is increased congestion, so knowing how many vehicles are needed at different times of day or how many trips are shared (and at what level of occupancy) would be helpful to curbing congestion. A reason given for asking for a data sharing agreement is to know who is using point-to-point services. This is a targeted goal named by a few study cities so that the Cities can assess if the services are equitably accessible; if lower-income users are not using the services, then perhaps the prices are too high and a discount for lower-income users would increase ridership. A couple cities

mentioned getting 'suits in seats', the 'suits' being financially-comfortable professionals who are choosing to use public transit or point-to-point services not because it is the cheapest option but because it is more convenient for them than taking a privately-owned car. Using point-to-point services in lieu of routed services in neighborhoods with density too low to support conventional transit is an option given by a few Cities.

Prioritizing ride sharing

Idea	Cities that use the idea	Number of Cities
Financial incentives such as congestion pricing to make ride sharing cheaper than single or low-occupancy vehicles.	Atlanta, GA Los Angeles, CA Portland, OR Seattle, WA	4
Make ride sharing the default for ride hailing services, not an option.		0

A few cities choose to use congestion pricing to promote ride sharing, but none give any indication that ride hailing services will be shared by default – though ride sharing is often explained as superior to single-occupancy rides because it creates less emissions and congestion and that it should be heavily encouraged. Many of the study cities clarify that shared AVs are preferred to single-occupant AVs, but how exactly this is going to be promoted is not always made clear. Congestion pricing is discussed both as a generic idea (such as implementing a congestion pricing system) or a detailed idea (such as describing that a 3-person ride being cheaper than a 2-person ride). Part of the hybrid-transit mode of transportation that cities are using with AVs is ride hailing using shuttles, which the Cities are considering to be both ride sharing and public transit. None of the Cities clarify how a summoned ride that is shared in a 5-seat car is considered ride sharing while a summoned ride that is shared in a 6-seat (or larger) shuttle is considered both ride sharing and public transit.

Aiding first/last-mile connections

Idea	Cities that use the idea	Number of Cities
Promoting ride hailing for use as a first/last-mile connection.	Ann Arbor, MI Atlanta, GA Chamblee, GA Columbus, OH Lincoln, NE SeaTac, WA Seattle, WA	7
Promoting multi-modal transportation.	Atlanta, GA Chamblee, GA Columbus, OH Lincoln, NE Los Angeles, CA Seattle, WA	6

Cities more closely align with the advice for aiding first/last-mile connections by promoting autonomous ride hailing as an option to aid connectivity, and by promoting multi-modal transportation by making a singular trip planning app that can use multiple modes of transportation for a trip and pay for all modes used. Making multi-modal transportation easier through improved infrastructure for active transportation and creating mobility hubs to service multiple modes are also common ways to promote multi-modal transportation, with the secondary purpose of improving first/last-mile connectivity.

Prioritizing active transportation

Idea	Cities that use the idea	Number of Cities
Promoting multi-modal transportation.	Atlanta, GA Chamblee, GA Columbus, OH Lincoln, NE Los Angeles, CA Seattle, WA	6

Many cities made it clear that active transportation is the best form of transportation – Atlanta calls walkability a timeless goal, Portland lists it at the top of the City's hierarchy of mode prioritization – but the only action given that directly relates to autonomous vehicles is improving and promoting multi-modal transportation. To promote walking and biking this is done by improving first/last-mile connectivity, holistic trip planning apps serving active and vehicular modes, and making it easier to transfer between walking and riding. The literature suggests improving pedestrian and bicycling infrastructure and bringing in bike share companies to help prioritize active transportation, but such plans are not usually found in plans for autonomous vehicles. Infrastructure improvements or street redesign plans are more commonly discussed as an entirely separate topic and if found are in documents that do not discuss AVs, thus there is no clear link established between pedestrian and bicycling infrastructure and autonomous vehicles for most of the Cities. City plans are more likely to discuss active transportation in relation to multi-modal transportation and as a concern for first/last-mile connectivity.

Prioritizing multi-modal transportation

Idea	Cities that use the idea	Number of Cities
Creating a trip-planning app that can plan for multiple modes of transportation in one trip, and pay for any fees (such as bus ticket, bike share, and ride hailing) within the app.	Ann Arbor, MI Atlanta, GA Chamblee, GA Columbus, OH Lincoln, NE Los Angeles, CA Palo Alto, CA	7

To aid multi-modal transportation, the use of a universally-supported trip-planning app that can plan for multiple modes (including all mobility services in the City such as bike share, point-to-point ride sharing AVs, and light-rail) and simultaneously pay for all modes used is an idea used by cities to make transferring between modes easier, and to allow more flexibility when planning trips. Users would be able to choose between options such as selecting the quickest route, avoiding peak transit periods, using as much active transportation as possible, avoiding a specific mode of transportation, or using the most environmentally-friendly configuration of modes available. Multi-modal transportation is explained by the study cities as the key to fixing problems with first/last-mile connections. The literature includes concepts such as allowing bikes on transit to aid multi-modal transit, or including bike parking at transit stops, but the Cities did not discuss this. The Cities address multi-modal transportation by planning for mobility hubs, which range in the plans from a kiosk that can pay for bus fare and provide information on the next arrive bus to having a multitude of services available that would also include options such as bike parking, bike share, park-and-ride facilities, a designated drop-off point for TNC services, and access to social services.

Managing sprawl

Idea	Cities that use the idea	Number of Cities
Promoting active transportation.	Atlanta, GA Chamblee, GA Los Angeles, CA Portland, OR Seattle, WA	5
Implementing a Vehicle Miles Traveled tax, to discourage lengthy trips.	Atlanta, GA Los Angeles, CA Portland, OR	3

Just four cities note sprawl as a concern in their plans for AVs, but cities that do not list sprawl as a concern (Chamblee and Seattle) use ideas that the literature proposes to curb sprawl. Palo Alto notes sprawl as a concern but does not use either of the ideas given by the literature as ways to manage it. The two ideas associated with sprawl are also applicable to other goals, so it is possible the study cities are using the ideas without planning to manage sprawl as an outcome, or that the connection between the ideas and sprawl simply isn't clarified in their plans for autonomous vehicles. The literature emphasizes the connection between parking and sprawl but the Cities rarely mention parking, and if parking is mentioned, it is briefly declared that parking demand could be reduced by AVs or that parking revenue would not be able to be relied upon.

Reducing congestion

Idea	Cities that use the idea	Number of Cities
Promoting public transit.	Atlanta, GA Chamblee, GA Columbus, OH Jacksonville, FL Lincoln, NE Los Angeles, CA Nashville, TN Palo Alto, CA Portland, OR Sacramento, CA San Diego, CA SeaTac, WA Seattle, WA	13
Promoting ride sharing, possible tools include charging higher prices for low-occupancy vehicles.	Atlanta, GA Chamblee, GA Los Angeles, CA Nashville, TN Palo Alto, CA Portland, OR Seattle, WA	7
Promoting active transportation.	Atlanta, GA Chamblee, GA Los Angeles, CA Portland, OR Seattle, WA	5
Discouraging zombie cars.	Atlanta, GA Portland, OR Seattle, WA	3
Implementing a Vehicle Miles Traveled tax, to discourage lengthy trips and trips that are short enough to walk.	Atlanta, GA Los Angeles, CA Portland, OR	3

Most of the Cities mention reducing congestion as a goal, and several utilize the ideas given for how to reduce congestion with AVs. The ideas that would be harder to implement – discouraging zombie cars (cars with zero occupancy) and introducing a Vehicle Miles Traveled tax – are the least likely to have cities prepared to use. Reducing congestion is mostly addressed through promoting space-conserving modes of transportation and ride sharing, which cover three of the ideas suggested by the literature. Another method given is the abilities of AVs to drive closer together; this is an explanation given by cities for reducing congestion, but this is not an option that can be acted upon. AVs driving closer together (referred to as platooning) is inevitable because of the technology.

Reducing emissions

Idea	Cities that use the idea	Number of Cities
Using electric vehicles.	Ann Arbor, MI Atlanta, GA Chamblee, GA Columbus, OH Jacksonville, FL Lincoln, NE Los Angeles, CA Nashville, TN Palo Alto, CA Sacramento, CA SeaTac, WA Seattle, WA	12
Incentivizing ride sharing to more efficiently use vehicles.	Atlanta, GA Chamblee, GA Los Angeles, CA Nashville, TN Palo Alto, CA Portland, OR Seattle, WA	7
Increasing ridership for public transit.	Atlanta, GA Chamblee, GA Columbus, OH Lincoln, NE SeaTac, WA	5
Promoting active transportation.	Atlanta, GA Chamblee, GA Los Angeles, CA Portland, OR Seattle, WA	5

Reducing emissions is discussed more abstractly than some of the other goals given by the Cities; it is sometimes listed as a goal but not explained how AVs will help to reduce emissions. If the goal is more thoroughly discussed, using electric vehicles and/or using fewer vehicles are the most common methods given. The study cities do not offer any strategies that are not suggested by the literature.

Improving equity and/or accessibility

Idea	Cities that use the idea	Number of Cities
Installing kiosks at transit stops so rides can be summoned without a smart phone.	Atlanta, GA Columbus, OH Lincoln, NE Los Angeles, CA Seattle, WA	5
Creating a pass for AV systems that can have funds added by cash and providing stations to fill up the pass in commonly accessible public locations (such as grocery stores and libraries).	Atlanta, GA Columbus, OH Lincoln, NE Seattle, WA	4

11 of the 14 cities discuss the potential inequity of autonomous vehicles, mostly because AVs will need smart phone apps to be summoned (phone apps are discussed as a guaranteed concept for point-to-point services, and sometimes for public transit as well) and credit cards to pay for rides. To address this, methods to avoid the necessity of smart phones or credit cards include mobility kiosks and traditionally styled transit passes that will work with AVs. These ideas are being planned for by a few of the Cities. However, three cities mention plans to use an app but do not mention either kiosks or a traditional transit pass. While the literature defines accessibility as having access to services, mostly in reference to smart phone possession or financial feasibility, some of the Cities also include ADA compliance in their definition of accessibility. In these cities, finding shuttles that offer ADA features such as wheelchair ramps is a focus.

Making automated vehicles electric

Idea	Cities that use the idea	Number of Cities
Installing electric charging stations.	Columbus, OH Chamblee, GA Lincoln, NE Los Angeles, CA Palo Alto, CA SeaTac, WA	6
Purchase electric vehicles for all city-owned vehicles.	Seattle, WA	1

Choosing electric AVs for an initial pilot or for the City's public transit fleet does not equate with the idea of making all city-owned vehicles electric, so of the 12 cities that plan to use electric vehicles for the public transportation fleet, only one city clarifies that other city-owned fleets should be electric as well. To support the transition to electric vehicles, about half of the Cities mention installing electric charging stations. Installing charging stations is discussed for city-owned fleets such as public transit, to be distributed throughout the City for the public use, as plans to retrofit parking and storage facilities for AVs, and one city suggests making it a requirement to build an electrical system capable of charging electric vehicles for new developments. No new ideas are included in city plans that are not discussed by the literature.

Idea	Cities that use the idea	Number of Cities
AV-only lanes.	Jacksonville, FL Los Angeles, CA Seattle, WA	3
AVs following specially marked lines within their lane, to help navigate.	Ann Arbor, MI	1

Very few cities have plans for using dedicated lanes by having the autonomous vehicles follow a marked path or by using lanes restricted to AVs. Plans to use AV-only lanes is sometimes linked to periods of peak transit to leverage the efficiency of AVs and to prioritize their use, or in the case of Jacksonville the route is an elevated, single-lane light-rail system. Some cities discuss safety concerns with AVs and question whether the AVs are safe to be in mixed-traffic, but ultimately none of the Cities have plans for separating AVs from other vehicles for safety reasons.

Estimations of the financial cost of AVs for the City budget

The literature does not suggest actionable ideas for cities to implement, so no comparison can be made for how cities are preparing.

Estimations of the financial cost of AVs for users

Idea	Cities that use the idea	Number of Cities
Charge per-mile.	Atlanta, GA Los Angeles, CA Portland, OR Seattle, WA	4
A surcharge for peak travel periods.	Atlanta, GA Los Angeles, CA Portland, OR Seattle, WA	4
Tiered pricing system. An example of a tiered system includes an elevated surcharge for zero-occupant cars, a base surcharge for single-occupant cars, and a reduced surcharge for cars with two or more occupants.	Los Angeles, CA Portland, OR Seattle, WA	3
Charge for parking.	Atlanta, GA Columbus, OH Seattle, WA	3
Charge for curbside usage.	Atlanta, GA Seattle, WA	2
Adding fees to private vehicles to charge equivalently (or more) than ride hailing services.		0

Most cities are likely already charging for parking, but the study cities do not discuss charging for parking in their plans for AVs. Parking fees is not a new concept or one that is necessarily addressed in transportation plans. Parking is more commonly discussed as a reason to transition to AVs because it will be a dwindling source of revenue if AVs don't need to park and also because parking minimums could be removed or adapted given the projected lower demand for parking. The literature suggests charging higher prices for parking to disincentivize it, but the Cities that mention charging for parking do not indicate that prices would be changed in any way. New methods of garnering revenue from AVs is discussed in the form of a tiered congestion pricing system based on occupancy and/or peak travel periods, a Vehicle Miles Traveled tax or fee, and charging for curbside usage (when AVs pick up or drop off passengers) to replace parking fees. Few cities have made plans for how to charge AV riders, possibly because cities don't yet know how much to charge. The literature suggests adding fees to privately-owned vehicles that TNCs are subjected to, to 'change the status quo' and make transportation networks less hospitable for single-occupant, privately-owned vehicles. While cities discuss changing the status quo, adding fees to privately-owned vehicles is not given as a possible solution.

A Discussion of Practices

City Plans Compared to Recommendations from the Literature

The study cities give the same reasons for choosing to prepare for autonomous vehicles as the literature, which indicates consistency between the literature and the Cities in ideology. Improving safety, decreasing congestion, improving air quality, improving mobile equity, and improving first/last-mile connections are commonly given reasons for both the literature and the study cities. While the reasoning and transportation themes to focus on are agreed upon, the Cities diverge from the literature in practice. Broadly speaking, there is more variety in city practices than in the literature. The ideas given in the literature are best suited for city-wide implementation and full saturation of AVs, but most of the plans for the study cities assume a pilot test will take place before plans are finalized. The nature of the pilot tests – which are often confined to a portion of the Cities geographical area or are constrained in another way such as planning for public transit but not privately-owned vehicles – means that some of the ideas from the literature are not easily adopted for action plans that are regarded as temporary.

The plans created by cities explain that most of the reasons for eagerly anticipating AVs can be satisfied by shifting from privately-owned vehicles to public transit, and that using AVs is a fresh twist on an old mission. This is different than the literature, which does place a great emphasis on prioritizing public transit but discusses in greater depth and with more frequency point-to-point services, ride sharing, and promoting active transportation than the study cities do.

Some of the ideas advocated for by the literature are not used by the Cities, possibly because they are more easily discussed conceptually than they are implemented. This is seen in some of the literature ideas that are more detailed in changing transportation behavior or involve funding; generic ideas such as 'promoting public transit' are more frequently used by cities than ideas such as 'implementing a Vehicle Miles Traveled tax or fee'. Promoting public transit does not require any legislative action, but a tax or fee on Vehicle Miles Traveled might need to be voted upon by constituents and would be more difficult to impose on privately-owned vehicles than ride hailing services.

The difference between theory and practice is well-shown in the example of 'promoting ride sharing'. Ride sharing is an idea that is strongly encouraged in the literature, but the study cities are less likely to have concrete ideas for how to promote ride sharing than the literature might anticipate. The Cities that discuss ride sharing agree in theory that it should be promoted but give non-committal answers for how it will be done, or vary in how congestion pricing will be used, or even vary in the exact definition of ride sharing. The literature discusses ride sharing as rides shared with other passengers when using a TNC service, but a few of the study cities discuss public transit as a mode of transportation that is ride sharing. There is some variety in the practices indicated for promoting ride sharing, and also discrepancies in the very definition of it.

Several of the ideas suggested by the literature for achieving transportation Utopia with autonomous vehicles are repeated across the themes identified; for instance, 'promoting public transit' is an idea that is applied to five of the themes asides from its own theme of prioritizing public transit. This kind of overlapping repetition where ideas can serve multiple purposes means

that cities sometimes indirectly address themes that their plans had not mentioned or discussed. A few of the Cities mention goals that fit the themes identify, but do not use any of the ideas suggested by the literature for how to address the themes. Sometimes this is because the Cities created their own ideas for working on the goal, and sometimes it is because the Cities do not explain how exactly they are going to be working on the goal, only that it is a priority.

Preparation Practices

There are evident trends found for how the Cities are preparing for AVs. The type of preparations can be split into two categories. One type includes the Cities preparing city-wide plans (such as Portland and Seattle) that are detailed on many aspects of AV implementation ranging from privately-owned vehicles to city-operated public transit and include policies that could be easily copied by cities seeking inspiration. The other type includes the Cities with piloting plans; these plans are usually for public transit only and cover only a portion of the City's geographical area.

About half of the cities (Atlanta, Chamblee, Columbus, Lincoln, Los Angeles, Portland, SeaTac, and Seattle) address most of the themes outlined by the literature and most could be categorized as having all-encompassing plans for AVs; their plans address how AVs could be used as public transit, ride sharing, and privately-owned vehicles; prioritize improving first/last-mile connections, reducing congestion, and reducing emissions; promote active and multi-modal transportation; and express concern and/or ideas for making AVs accessible to all and provide equitable transportation services. These city plans have policies or action items that can be used to create measurements of success.

With the exception of Chamblee and Lincoln, the cities that address most of the transportation themes have plans that are city-wide. Chamblee and Lincoln address most of the themes identified in the literature but describe piloting projects for public transit, not plans applicable to TNC companies or privately-owned vehicles.

The pattern of cities creating a piloting project is usually strongly tailored to the City and its needs. Using a piloting test for public transit is not an idea found in the literature, though the Cities with piloting projects follow similar formats. The basic procedure described by most of the study cities creating piloting plans is to find a region that is underserved or has measurable needs and to use AVs to improve service, through a new public transit route, autonomous ride hailing services, or using AVs to improve first/last-mile connections to get to public transit. If not using an area that is underserved by public transit, then using AVs for a well-established public transit system is another option, as this would create a comparison that could be monitored by transportation planners to see how the City would be able to use AVs and how the benefits could be leveraged.

In the cases of Jacksonville and Lincoln, these action plans are seen in the replacement or creation of public transit routes, such as Jacksonville replacing the monorail trains on a route with autonomous shuttles to see how well AVs perform compared to expectations and how Lincoln is creating a new transit route in a downtown region with high density. The City of Jacksonville discusses how replacing the monorail with autonomous shuttles will create a comparison study of how well (or if) the AVs improve service, but the City of Lincoln takes a

different viewpoint and recommends creating a new route, not replacing one, so as to not replicate efforts but instead spread the reach of the transit system.

The cities with piloting projects usually know dedicated region(s) or routes of deployment, and sometimes know if they are using dedicated lanes (because the dedicated lane is the route being replaced). After the pilot project is able to show measurable outcomes (such as increased ridership or shorter headway times), the plan often explains intentions to expand the service to the rest of the City and amend the plan now that the City is better informed of the capabilities of automated systems. Cities following this format include Ann Arbor, Atlanta, Chamblee, Columbus, Jacksonville, Lincoln, Sacramento, San Diego, and SeaTac. Atlanta's plan is an example of being both a piloting project and a city-wide agenda; the plan describes both a piloting project (with an identified region of deployment) and what actions will be taken to spread AVs throughout the City after the successful implementation and study of measurable outcomes of the piloting project.

The only cities to know how much AV programs will cost the city to implement and operate are cities who have also identified dedication regions or routes of deployment; this is because these cities plans' (Ann Arbor, Chamblee, Jacksonville, and Lincoln) have specified the operational parameters and cost of an initial trial run. Chamblee knows exactly where AVs will be used for the pilot project of replacing the vehicles on a bus route with AVs, and the City has researched what vehicles are suited for the task and how much it would cost to purchase, lease, or have a third-party contract in order to conduct the trial run. Jacksonville methodology for estimating cost is similar to Chamblee; Jacksonville knows the routes, how much the shuttles will cost, and has estimated construction costs for updating the routes and operating costs. The price estimates from cities that discuss costs in detail are very close, and the Cities recommend leasing AVs because it is the cheapest option and includes help from the manufacturing company in overseeing operations, maintenance, and sometimes includes on-board attendants while also affording a great amount of authority to the Cities.

Of the study cities with plans encompassing the majority of the themes; Atlanta, Chamblee, Lincoln, Los Angeles, SeaTac, and Seattle used consulting agencies (or in the case of Los Angeles, gave a fellowship) for help preparing the plans. The study cities that address fewer themes or do not have city-wide plans were less likely to have hired outside help.

City Plans to Emulate
Of the two general types of preparations – city-wide policies and targeted pilot projects – Seattle and Chamblee stand out as exemplary cases.

For inspiration in creating city-wide policies, Seattle's New Mobility Playbook contains five actionable 'plays' for different methods of implementing AVs, each of which details in depth action plans to apply the plays. Policies for a wide variety of considerations (found in Appendix C) include: standardizing autonomous behavior, equity and accessibility, pilots and partnerships, infrastructure and street design, pricing mechanisms, and land use and building design. The only transportation themes that Seattle's New Mobility Playbook does not address is choosing a vehicle brand and estimating the cost for the City to transition to automated vehicles.

For an example of how to create an exploratory pilot project to address specific transportation challenges, Chamblee's Self-Driving Shuttle Feasibility Study and Concept Plan explains in detail what the goals of the project are, how Chamblee chose the region of the City to focus on, how goals were chosen, how vehicles were chosen, how stakeholders and the public were involved and what their input was, and precisely how the project is intending to produce results and improve first/last-mile connectivity to boost public transit.

Future Research

In the future, this study could be expanded to include more cities as they produce plans for AVs, and to update the assessment of currently identified cities as their plans change. At the time of this project, several of the study cities are in the process of adopting the transportation plans for autonomous vehicles, and the majority of the study cities do not have any AVs in operation. As these plans are implemented, observation will produce ideas for improvement, mistakes will be realized and corrected, and policies will be amended or added to. Some of the study cities are brief in describing their plans for AVs, which will not remain true as more concrete information about AVs is published and more cities can serve as case studies for inspiration. The small number of 14 cities in this study will multiply to greater numbers and be capable of showing more trends in how cities are preparing for autonomous vehicles, such as a potential correlation of policies chosen for cities of similar population size or development density, or for cities with minimal public transit systems compared to cities with extensive public transit systems. The current plans are split between city-wide plans and piloting projects, but once AVs have well-known characteristics piloting projects will no longer be appropriate. Current plans for AVs focus heavily on promoting public transit, possibly because it is easier to envision how automated systems could change public transit operations compared to privately-owned vehicles, which the literature has less consistent predictions for. Current city plans are also unlikely to include actionable policies or measurable goals (exceptions being Los Angeles, Portland, and Seattle), a sign of hesitant, newly-formed plans. Overall, cities will need to be firmer in how goals will be achieved, instead of merely identifying them.

The capabilities of AVs will improve with time, which will increase the possibilities for how AVs will be able to be directed and planned for. As AVs transition from engineered testing to public streets and it becomes easier to study the effects of AVs on transportation behavior and city development, the messages in the literature may change. While the literature is currently speculative of how AVs will change transportation and thus delivers recommendations that can at times feel vague, within the coming years substantiated research will replace assumption. For instance, will the often-repeated estimation that parking demand will be reduced by 90% be realized, or is the forecast critically inaccurate? Gaps in the literature such as estimated costs for municipal budgets, purchasing costs for privately-owned vehicles, user costs for automated TNC services, and how cities will replace the lost revenue of gas taxes and parking fees will be answered and will influence the decisions cities make as they craft their transportation policies.

Conclusion

In studying how cities in the US are preparing for autonomous vehicles, it is clear that there are consistent motivations given by the literature and by the study cities for transitioning to autonomous vehicles. AVs are seen as an improvement to vehicular travel that could cure transportation challenges such as congestion and first/last-mile connections, equity concerns, and improve air quality and safety.

The study cities address the themes identified in the literature to varying levels of completion, some themes are not addressed by even half of the Cities, sometimes the themes are acknowledged as a clearly-stated goal without accompanying action plans, sometimes the Cities use ideas suggested by the literature, and sometimes the Cities use ideas of the Cities own creation to respond to transportation challenges. Of the ideas suggested by the literature, the study cities are less likely to use the ideas if they are specific to an objective rather than a more generic task. Of the 32 ideas assembled from the literature, 11 are not used by any of the study cities. Ideas that address multiple themes, such as promoting public transit or ride sharing, are more likely to be used than ideas that are particular to one purpose or more politically difficult, such as introducing new ways to charge privately-owned cars for their use. This insinuates that the preparations for AVs are more easily discussed than applied, which according to the Utopia vs. Dystopia deliberation in the literature, might mean that the benefits of autonomous vehicles will not meet their full potential.

The congruity for how cities are using the ideas given by the literature and focusing on the themes for achieving transportation utopia suggests that cities are well aware of, or at least in agreement with, the literature for how AVs should be used and how AVs could be advantageous to transportation and city development. The few cities in the US that are preparing for autonomous vehicles collectively represent methods that the literature would deem as proficient, but not necessarily ambitious. To be excellent in the viewpoint of the literature, the Cities would need to answer the harder challenges such as how much the new modes of transportation will cost users and do more to discourage sprawl and privately-owned vehicles. Much of the preparations can be classified presently as experimental pilot projects, though some of the difficulties with planning for emerging technologies will be better answered as AVs start to be used in more cities.

References

1 Levin, Sam, and Mark Harris. "The Road Ahead: Self-driving Cars on the Brink of a Revolution in California." The Guardian. March 17, 2017. Accessed 2017. https://www.theguardian.com/technology/2017/mar/17/self-driving-cars-california-regulation-google-uber-tesla.

2 Hern, Alex. "Uber Is '5,000 times Worse than Google's Waymo at Self-driving Cars'." The Guardian. April 04, 2017. https://www.theguardian.com/technology/2017/apr/04/uber-google-waymo-self-driving-cars.

3 Randazzo, Ryan. "Arizona Getting Ahead of Autonomous Vehicle Industry by Stepping aside." Azcentral. June 26, 2017. https://www.azcentral.com/story/money/business/tech/2017/06/23/arizona-getting-ahead-autonomous-vehicle-industry-stepping-aside-waymo-uber-intel-chevy-bolt/405436001/.

4 Gibbs, Samuel. "Waymo Ditches Futuristic Self-driving Bubble Car for ... a Minivan." The Guardian. June 13, 2017. Accessed 2017. https://www.theguardian.com/technology/2017/jun/13/waymo-self-driving-car-replaces-firefly-bubble-design-adapted-chrysler-alphabet.

5 Hicks, Nancy. "Nebraska Tested Driverless Car Technology 60 Years Ago." JournalStar.com. September 13, 2017. Accessed 2018. http://journalstar.com/news/local/govt-and-politics/nebraska-tested-driverless-car-technology-years-ago/article_a702fab9-cac3-5a6e-a95c-9b597fdab078.html.

6 Chapin, Tim, Lindsay Stevens, Jeremy Crute, Jordan Crandall, Anne Rokyta, and Alexandria Washington. "Envisioning Florida's Future: Transportation and Land Use ..." April 2016. Accessed July 2017. http://www.bing.com/cr?IG=980AD86414004C5F8CEA222BD4F653B8&CID=087EB0ACFBAD6A0630DFBA5AFAAB6BDD&rd=1&h=gr-raNdlZ2zemGKOO1UotVA-94azKDDPRhssX3wCyMM&v=1&r=http%3a%2f%2fwww.automatedfl.com%2fwp-content%2fuploads%2f2015%2f06%2fEnvisioning-Floridas-Future-Final-Report-BDV30-TWO-934-10.pdf&p=DevEx,5062.1.

7 "Bloomberg Aspen Initiative on Cities and Autonomous Vehicles." About / Global Atlas of AVs in Cities. Accessed 2018. https://avsincities.bloomberg.org/.

8 "Home." Mcity. 2015. Accessed 2018. https://mcity.umich.edu/.

9 "Number of U.S. Cities, Towns, Villages by Population Size 2015 | Statistic," Statista, , accessed June 2018, https://www.statista.com/statistics/241695/number-of-us-cities-towns-villages-by-population-size/.

10 Jaffe, Eric. "Why Aren't America's Cities Ready for Driverless Cars?" CityLab. December 08, 2015. Accessed 2017. https://www.citylab.com/solutions/2015/12/why-arent-urban-planners-ready-for-driverless-cars/419346/.

11 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017. Accessed 2017. https://altaplanning.com/resources/preparing-for-new-mobility/.

12 Plumer, Brad, Ezra Klein, David Roberts, Dylan Matthews, Matthew Yglesias, and Timothy B. Lee. "Cars Take up Way Too Much Space in Cities. New Technology Could Change That. | The New New Economy." Vox. Accessed 2017. https://www.vox.com/a/new-economy-future/cars-cities-technologies.

13 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance."

14 "The Commissioner." American Planning Association. Accessed 2017. https://www.planning.org/planning/2016/dec/thecommissioner/#driverless.

15 Bowers, Alison, and Nico Larco. "Residential Preference." March 2017. Accessed 2017. https://static1.squarespace.com/static/59ea2e51e5dd5ba9f8646cdc/t/5a3177e38165f58447aee9e7/1513191396529/Residential Preference - Urb Next - SCI - Bowers - Larco - 2017.pdf.

16 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles." August 2016. https://static1.squarespace.com/static/57c864609f74567457be9b71/t/57c9059b9de4bb1598eeee49/1472793280502/Transportation Technology Strategy_2016.pdf.

17 Plumer, Brad, Ezra Klein, David Roberts, Dylan Matthews, Matthew Yglesias, and Timothy B. Lee. "Cars Take up Way Too Much Space in Cities. New Technology Could Change That. | The New New Economy." Vox. Accessed 2017.

18 Wollsgrove, Ceri. "Advanced Vehicle Technologies, Autonomous Vehicles and Cycling." Accessed 2017.

19 Chapin, Tim, Lindsay Stevens, Jeremy Crute, Jordan Crandall, Anne Rokyta, and Alexandria Washington. "Envisioning Florida's Future: Transportation and Land Use ..." April 2016.

20 "Autonomous Vehicles." American Planning Association. Accessed 2017. https://www.planning.org/knowledgebase/autonomousvehicles/.

50

21 Henderson, Jason, and Jason Spencer. "Autonomous Vehicles and Commercial Real Estate." June 2016. Accessed August 2017. http://scholarship.sha.cornell.edu/crer/vol14/iss1/14.

22 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance." August 2017. Accessed 2017. https://urbanismnext.uoregon.edu/files/2017/07/Impacts-of-AV-Ecommerce-on-Local-Govt-Budget-and-Finance-SCI-08-2017-2n8wgfg.pdf.

23 ibid

24 Chapin, Tim, Lindsay Stevens, Jeremy Crute, Jordan Crandall, Anne Rokyta, and Alexandria Washington. "Envisioning Florida's Future: Transportation and Land Use ..." April 2016.

25 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies. April 2, 2017. Accessed 2017. https://www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDFreleaseMay3rev2.pdf.

26 Henderson, Jason, and Jason Spencer. "Autonomous Vehicles and Commercial Real Estate."

27 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017.

28 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies. April 2, 2017. Accessed 2017.

29 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017.

30 Henderson, Jason, and Jason Spencer. "Autonomous Vehicles and Commercial Real Estate."

31 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies. April 2, 2017. Accessed 2017.

32 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance." August 2017.

33 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017.

34 Sam Schwartz, HR&A, and Arcadis. "Driverless Future: A Policy Roadmap for City Leaders." Driverless Future: A Policy Roadmap for City Leaders. 2017. Accessed 2017. http://driverlessfuture.webflow.io/.

35 Guerra, Erick. "When Autonomous Cars Take to the Road." American Planning Association. May 2015. Accessed 2018. https://www.planning.org/planning/2015/may/autonomouscars.htm.

36 ibid

37 "Autonomous Vehicles." American Planning Association. Accessed 2017.

38 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance." August 2017.

39 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017.

40 Rice, Annibel, and Adie Tomer. "How Will Autonomous Vehicles Transform the Built Environment?" Brookings. February 09, 2018. Accessed 2018. https://www.brookings.edu/blog/the-avenue/2017/10/16/how-will-autonomous-vehicles-transform-the-built-environment/.

41 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017.

42 Bliss, Laura, and CityLab. "In Cities, Uber and Lyft Mean More Cars, Trips, and Miles." CityLab. October 13, 2017. https://www.citylab.com/transportation/2017/10/the-ride-hailing-effect-more-cars-more-trips-more-miles/542592/.

43 Rice, Annibel, and Adie Tomer. "How Will Autonomous Vehicles Transform the Built Environment?" Brookings. February 09, 2018.

44 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies. April 2, 2017. Accessed 2017.

45 "INRIX Connected & Automated Vehicle Consumer Survey." INRIX Economic Cost of Parking Pain Report. Accessed 2017. http://www2.inrix.com/research-cav.

46 Plumer, Brad, Ezra Klein, David Roberts, Dylan Matthews, Matthew Yglesias, and Timothy B. Lee. "Cars Take up Way Too Much Space in Cities. New Technology Could Change That. | The New New Economy."

47 Plumer, Brad, Ezra Klein, David Roberts, Dylan Matthews, Matthew Yglesias, and Timothy B. Lee. "Cars Take up Way Too Much Space in Cities. New Technology Could Change That. | The New New Economy."

48 Walker, Jarrett. "Basics: Walking Distance to Transit." Human Transit. January 22, 2016. Accessed 2018. http://humantransit.org/2011/04/basics-walking-distance-to-transit.html.

49 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."

50 "Shared and Self-driving Cars: A Game Changer in Real ..." 2017. Accessed 2018. https://www.bing.com/cr?IG=B20FCD9B62AC4712BE7E77AB2FEC01D0&CID=2A9128F723BF69C01BB524FC22426890&rd=1&h=HJltWKMqJfqtXYK1DVv5HqmHTug0xN18rsrBQ8ndQeI&v=1&r=https://www2.deloitte.com/nl/nl/pages/real-estate/articles/shared-and-self-driving-cars-a-game-changer-in-real-estate-and-area-development.html&p=DevEx.LB.1,5037.1.

51 "Autonomous Vehicles." American Planning Association. Accessed 2017.

52 ibid

53 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017

54 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies. April 2, 2017. Accessed 2017.

55 Tim Burns, "Swapping Cars for Bikes, Not Diesel for Electric, Is the Best Route to Clean Air," The Guardian, July 31, 2017, sec. Environment, http://www.theguardian.com/environment/bike-blog/2017/jul/31/swapping-cars-for-bikes-not-diesel-for-electric-is-the-best-route-to-clean-air.

56 Chapin, Tim, Lindsay Stevens, Jeremy Crute, Jordan Crandall, Anne Rokyta, and Alexandria Washington. "Envisioning Florida's Future: Transportation and Land Use ..."

57 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies.

58 Marshall, Aarian. "Uber and Lyft Haven't Revolutionized the American City-Yet." Wired. October 14, 2017. https://www.wired.com/story/uber-and-lyft-havent-revolutionized-cities/?mbid=BottomRelatedStories.

59 "Autonomous Vehicles." American Planning Association. Accessed 2017.

60 "Autonomous Vehicles." American Planning Association. Accessed 2017.

61 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017

62 Wollsgrove, Ceri. "Advanced Vehicle Technologies, Autonomous Vehicles and Cycling." Accessed 2017.

63 "Autonomous Vehicles." American Planning Association. Accessed 2017.

64 ibid

65 Wollsgrove, Ceri. "Advanced Vehicle Technologies, Autonomous Vehicles and Cycling." Accessed 2017.

66 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017

67 Rice, Annibel, and Adie Tomer. "How Will Autonomous Vehicles Transform the Built Environment?" Brookings. February 09, 2018.

68 Benjamin Schneider, "Don't Let Autonomous Vehicles Revive Car-Centric Planning," CityLab, accessed August 6, 2017, https://www.citylab.com/transportation/2017/07/will-autonomous-vehicles-lead-to-a-resurgence-of-auto-centric-infrastructure/534804/.

69 Millard-Ball, Adam. "Pedestrians, Autonomous Vehicles and Cities." October 27, 2016. Accessed 2017. https://www.bing.com/cr?IG=0C44E36E6EC24426B9995D531F17C2D6&CID=04F8DE99DCF369613CCED29EDD0E68ED&rd=1&h=pqUXfJchM8gM2apvXDqvhHhyHG8JIUok17VRo8tnnWQ&v=1&r=https://people.ucsc.edu/~adammb/publications/Millard-Ball_2017_Autonomous_vehicles_pedestrians_cities_preprint.pdf&p=DevEx.LB.1,5065.1.

70 Lewis, Paul, Gregory Rogers, and Stanford Turner. "Beyond Speculation: Automated Vehicles and Public Policy An Action Plan for Federal, State, and Local Policymakers." Accessed 2018. https://www.enotrans.org/wp-content/uploads/2017/04/AV_FINAL-1.pdf.

71 Millard-Ball, Adam. "Pedestrians, Autonomous Vehicles and Cities." October 27, 2016.

72 Chapin, Tim, Lindsay Stevens, Jeremy Crute, Jordan Crandall, Anne Rokyta, and Alexandria Washington. "Envisioning Florida's Future: Transportation and Land Use ..."

73 Henderson, Jason, and Jason Spencer. "Autonomous Vehicles and Commercial Real Estate."

74 Nico Larco, "AVs and Streets - A Guide to Potential Impacts | Urbanism Next," accessed August 6, 2017, https://urbanismnext.uoregon.edu/2017/07/21/avs-and-streets-a-guide-to-potential-impacts/

75 Bliss, Laura, and CityLab. "In Cities, Uber and Lyft Mean More Cars, Trips, and Miles."

76 "NACTO Policy Statement on Automated Vehicles." Nacto.org. June 2016. Accessed 2018. https://nacto.org/wp-content/uploads/2016/06/NACTO-Policy-Automated-Vehicles-201606.pdf.

77 "Autonomous Vehicles." American Planning Association. Accessed 2017.

78 Millard-Ball, Adam. "Pedestrians, Autonomous Vehicles and Cities." October 27, 2016.

79 "AVs and Streets – A Guide to Potential Impacts." Urbanism Next. July 21, 2017. Accessed 2017. https://urbanismnext.uoregon.edu/2017/07/21/avs-and-streets-a-guide-to-potential-impacts/.

80 Lewis, Paul, Gregory Rogers, and Stanford Turner. "Beyond Speculation: Automated Vehicles and Public Policy An Action Plan for Federal, State, and Local Policymakers."

81 "Emissions from Hybrid and Plug-In Electric Vehicles." Alternative Fuels Data Center: Hydrogen Fueling Station Locations. June 13, 2018. Accessed June 2018. https://www.afdc.energy.gov/vehicles/electric_emissions.php.

82 "NACTO Policy Statement on Automated Vehicles." Nacto.org. June 2016.

83 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies.

84 "Autonomous Vehicles." American Planning Association. Accessed 2017.

85 Millard-Ball, Adam. "Pedestrians, Autonomous Vehicles and Cities." October 27, 2016.

86 "Mobile Fact Sheet." Pew Research Center: Internet, Science & Tech. February 05, 2018. Accessed 2018. http://www.pewinternet.org/fact-sheet/mobile/.

87 Skowronski, Jeanine. "Survey: More Millennials Say 'No' to Credit Cards." Bankrate. December 19, 2017. Accessed 2018. https://www.bankrate.com/finance/credit-cards/more-millennials-say-no-to-credit-cards-1.aspx.

88 "Preparing for New Mobility: Writing Effective Resolutions." Alta Planning Design. October 13, 2017.

89 Sam Schwartz, HR&A, and Arcadis. "Driverless Future: A Policy Roadmap for City Leaders." Driverless Future: A Policy Roadmap for City Leaders. 2017.

90 Lampton, Christopher. "Will Electric Cars Require More Maintenance?" HowStuffWorks. December 06, 2011. Accessed 2017. http://auto.howstuffworks.com/will-electric-cars-require-more-maintenance.htm.

91 Lampton, Christopher. "Will Electric Cars Require More Maintenance?"

92 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance."

93 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance."

94 Patil, Ajaykumar. Safety Aspects of Bicyclists in a Connected Vehicle Environment. University of Texas, Department of Civil Engineering. May 2016. Accessed 2017. Https://uta-ir.tdl.org/uta-ir/bitstream/handle/10106/25831/PATIL-THESIS-2016.pdf?Sequence=1&isallowed=y.

95 Chapin, Tim, Lindsay Stevens, Jeremy Crute, Jordan Crandall, Anne Rokyta, and Alexandria Washington. "Envisioning Florida's Future: Transportation and Land Use ..."

96 Patil, Ajaykumar. Safety Aspects of Bicyclists in a Connected Vehicle Environment. University of Texas, Department of Civil Engineering. May 2016.

97 "World's First Autonomous Train Released." Modern Cities. August 1, 2017. Accessed 2017. https://www.moderncities.com/article/2017-aug-worlds-first-automonous-train-released.

98 Schneider, Benjamin. "Don't Let Autonomous Vehicles Revive Car-Centric Planning." CityLab. July 27, 2017. Accessed 2017. https://www.citylab.com/transportation/2017/07/will-autonomous-vehicles-lead-to-a-resurgence-of-auto-centric-infrastructure/534804/?utm_source=SFTwitter.

99 Lampton, Christopher. "Will Electric Cars Require More Maintenance?"

100 Crabtree, George, Elizabeth Kocs, and Bryan Tillman. "Where Is Transportation Going? - Northwestern University." June 16, 2017. Accessed 2017. https://www.europhysicsnews.org/articles/epn/pdf/2017/03/epn2017483p21.pdf.

101 Plumer, Brad, Ezra Klein, David Roberts, Dylan Matthews, Matthew Yglesias, and Timothy B. Lee. "Cars Take up Way Too Much Space in Cities. New Technology Could Change That. | The New New Economy."

102 Crabtree, George, Elizabeth Kocs, and Bryan Tillman. "Where Is Transportation Going? - Northwestern University."

103 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance."

104 McGrane, Clare. "Americans Waste $73 Billion per Year Looking for a Parking Spot, New INRIX Study Finds." GeekWire. July 13, 2017. Accessed 2017. https://www.geekwire.com/2017/inrix-study-find-americans-waste-73-billion-per-year-looking-parking-spot/.

105 Henderson, Peter. "Some Uber and Lyft riders are giving up their own cars: Reuters/Ipsos poll."

106 "Will autonomous cars change the role and value of public transportation?" The Transport Politic. October 20, 2016. http://www.thetransportpolitic.com/2015/06/23/will-autonomous-cars-change-the-role-and-value-of-public-transportation/.

107 "Taming the Autonomous Vehicle: A Primer for Cities." Bloomberg Philanthropies.

108 Rice, Annibel, and Adie Tomer. "How Will Autonomous Vehicles Transform the Built Environment?" Brookings. February 09, 2018.

109 "First Mile-Last Mile, Intermodalism, and Making Public Transit More Attractive." Planetizen - Urban Planning News, Jobs, and Education. Accessed 2017. https://www.planetizen.com/node/93909/first-mile-last-mile-intermodalism-and-making-public-transit-more-attractive.

110 Rice, Annibel, and Adie Tomer. "How Will Autonomous Vehicles Transform the Built Environment?" Brookings. February 09, 2018.

111 "The Commissioner." American Planning Association. Accessed 2017.

112 McGrane, Clare. "Americans Waste $73 Billion per Year Looking for a Parking Spot, New INRIX Study Finds."

113 Clark, Benjamin Y., Nico Larco, and Roberta F. Mann. "The Impacts of Autonomous Vehicles and E-Commerce on Local Government Budgeting and Finance."

114 Sam Schwartz, HR&A, and Arcadis. "Driverless Future: A Policy Roadmap for City Leaders." Driverless Future: A Policy Roadmap for City Leaders. 2017.

115 "Atlanta's Transportation Plan: New Mobility and Technology." 2017. Accessed 2018. https://transportationplanatl.blob.core.usgovcloudapi.net/transportationplanatlsite/New_Mobility_and_Technology.pdf.

116 "Smart Columbus Detailed Overview." July 22, 2016. Accessed 2018.
    https://www.columbus.gov/WorkArea/DownloadAsset.aspx?id=2147489293.
117 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
118 "Lincoln AV/CV Microtransit Study." HDR. March 28, 2018. Accessed 2018.
    https://www.hdrinc.com/portfolio/lincoln-avcv-microtransit-study.
119 "Lincoln Multimodal Technology Vision: A Guide for the Future of Mobility." February 2018. Accessed 2018.
    http://lincoln.ne.gov/city/pworks/startran/micro-av/pdf/lincoln-vision-2018.pdf.
120 "Transportation System Plan: Proposed Draft." August 18, 2017. Accessed 2018.
    https://www.portlandoregon.gov/transportation/article/651817.
121 "The New Mobility Playbook." September 2017. Accessed 2018.
    https://newmobilityseattle.info/storage/app/media/Documents/newmobilityplaybookfurtheractionsappendices.pdf.
122 "Atlanta's Transportation Plan: New Mobility and Technology." 2017.
123 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
124 "Moving the Music City: Nashville & Davidson County's 2017-2020 Transportation Action Agenda."
125 "What Is Shared Mobility?" Shared Use Mobility Center. Accessed 2018. http://sharedusemobilitycenter.org/what-is-shared-mobility/.
126 "Atlanta's Transportation Plan: New Mobility and Technology." 2017.
127 "Moving the Music City: Nashville & Davidson County's 2017-2020 Transportation Action Agenda."
128 "Transportation System Plan: Proposed Draft." August 18, 2017.
129 "The New Mobility Playbook." September 2017.
130 Jenkins, Kate. "New App Reinvents University Bus System to Be More like Uber." The Michigan Daily. Accessed 2018. https://www.michigandaily.com/section/research/new-app-helps-turns-university-bus-system-demand-service.
131 "Atlanta's Transportation Plan: New Mobility and Technology." 2017.
132 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
133 "Smart Columbus Detailed Overview." July 22, 2016.
134 "The New Mobility Playbook." September 2017.
135 "Atlanta's Transportation Plan: New Mobility and Technology." 2017.
136 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
137 "Transportation System Plan: Proposed Draft." August 18, 2017.
138 "The New Mobility Playbook." September 2017.
139 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
140 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
141 "The New Mobility Playbook." September 2017.
142 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
143 "City of Palo Alto Comprehensive Plan 2030." November 13, 2017. Accessed 2018.
    https://www.cityofpaloalto.org/civicax/filebank/documents/62915.
144 "Transportation System Plan: Proposed Draft." August 18, 2017.
145 "Atlanta's Transportation Plan: New Mobility and Technology." 2017.
146 "Smart Columbus Detailed Overview." July 22, 2016.
147 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
148 "Transportation System Plan: Proposed Draft." August 18, 2017.
149 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
150 "Lincoln Multimodal Technology Vision: A Guide for the Future of Mobility."
151 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
152 "City of Palo Alto Comprehensive Plan 2030." November 2017.
153 "Transportation System Plan: Proposed Draft." August 18, 2017.
154 Appleton, William. "Memorandum to the Transportation & Public Works Committee: Action Plan Development for Autonomous Vehicles." 2017. Accessed 2018.
155 "Atlanta's Transportation Plan." Vhb, Nelson Nygaard, Arcadis, CityFi, Contente Consulting, Perez Planning Design, and Vision Engineering and Planning. 2017. Accessed 2018.
    https://transportationplanatl.blob.core.usgovcloudapi.net/transportationplanatlsite/ATPPlan.pdf.
156 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
157 "Smart Columbus Detailed Overview." July 22, 2016.
158 "Lincoln Multimodal Technology Vision: A Guide for the Future of Mobility."
159 "City of Palo Alto Comprehensive Plan 2030." November 2017.
160 "Transportation System Plan: Proposed Draft." August 18, 2017.

161 "The New Mobility Playbook." September 2017.
162 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
163 Bauerlein, David. "JTA Opens Test Track to Future for Self-driving Transit Shuttles." The Florida Times.
    December 19, 2017. Accessed 2018. http://www.jacksonville.com/news/metro/2017-12-19/jta-opens-test-track-
    future-self-driving-transit-shuttles.
164 Hand, Ashley Z. "Urban Mobility in a Digital Age: A Transportation Technology Strategy for Los Angeles."
165 "Moving the Music City: Nashville & Davidson County's 2017-2020 Transportation Action Agenda."
166 "City of Palo Alto Comprehensive Plan 2030." November 2017.
167 "Home." Mcity. 2015. Accessed 2018.
168 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
169 Appleton, William. "Memorandum to the Transportation & Public Works Committee: Action Plan Development for
    Autonomous Vehicles." 2017.
170 "The New Mobility Playbook." September 2017.
171 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
172 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
173 "Jacksonville, US / Global Atlas of AVs in Cities." About / Global Atlas of AVs in Cities. Accessed 2018.
    https://avsincities.bloomberg.org/global-atlas/americas/us/jacksonville-us.
174 "Lincoln Multimodal Technology Vision: A Guide for the Future of Mobility."
175 "The New Mobility Playbook." September 2017.
176 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
177 Appleton, William. "Memorandum to the Transportation & Public Works Committee: Action Plan Development for
    Autonomous Vehicles." 2017.
178 "Transporting Jacksonville Into the Future." U2C System - Jacksonville Transportation Authority l. Accessed 2018.
    https://u2c.jtafla.com/.
179 Jenkins, Kate. "New App Reinvents University Bus System to Be More like Uber." The Michigan Daily. Accessed
    2018.
180 "Home." Mcity. 2015. Accessed 2018.
181 "Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan." Stantec, Inc. March 2018.
182 "Smart Columbus Detailed Overview." July 22, 2016.
183 "Lincoln Multimodal Technology Vision: A Guide for the Future of Mobility."
184 "Sacramento State Planning for Self-driving Electric Shuttle." Association for Unmanned Vehicle Systems
    International. December 18, 2017.
185 "Chula Vista, California." Wikipedia. June 05, 2018. Accessed 2018.
    https://en.wikipedia.org/wiki/Chula_Vista,_California.
186"San Diego, US / Global Atlas of AVs in Cities." About / Global Atlas of AVs in Cities. Accessed 2018.
    https://avsincities.bloomberg.org/global-atlas/americas/us/san-diego-us.
187 Appleton, William. "Memorandum to the Transportation & Public Works Committee: Action Plan Development for
    Autonomous Vehicles." 2017.