Preparing for an Autonomous Future

Transportation Planning for Autonomous Vehicles in the Puget Sound Region

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Abstract

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Autonomous vehicles (AVs) are already on the road in test scenarios in multiple cities. This technology will result in dramatic changes for existing transportation systems and land use patterns, disrupting today's planning practices. This study uses existing research about predicted implications of autonomous vehicles to build a criteria for evaluating existing comprehensive plans and transportation plans for municipalities in the Puget Sound Region. The results of this plan evaluation were then used to create interview questions for planners and policymakers to explore why plans do or do not take AVs and technology change into account. The results of this study demonstrate that most municipal planning documents do not mention or include thorough discussion of autonomous vehicles and their effects, and that public officials face significant uncertainties in how to best plan for autonomous vehicles despite being aware of the changes taking place and their potential impacts.

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Introduction

Autonomous vehicles (AVs) are coming. Newly-manufactured vehicles today already have highly-automated features, such as lane correction, assisted braking and parking, and other autonomous controls that help to cut down on collisions and improve the driving experience. Fully autonomous vehicles are already on the road in many states through testing permits and closely-monitored programs, and semi-autonomous vehicles with some of the aforementioned assistance features are already commonplace and helping to reduce collisions on our roadways.

With many AV developers indicating that fully autonomous vehicles could enter the market by 2020, researchers predict full-scale and widespread adoption of autonomous vehicles, whether through direct ownership or shared systems, by 2040 and 2050. This will undoubtedly transform existing travel patterns, with research indicating a dramatic increase in vehicle miles traveled, fewer vehicles making far more trips each day, and eventually vehicles made smaller and lighter because of the decreased risk of collisions. Indeed, the built environment could change dramatically with travel patterns changing land uses, infrastructure not needing to carry as much load or withstand fiery collisions, and the potential for repurposing land in what's predicted to be abandoned parking structures in central business districts. Through vehicle-to-vehicle or vehicle-to-infrastructure communications, autonomous vehicles will be able to improve throughput and optimize travel times, making existing roadways more efficient and less prone to the congestion caused by the predicted increase in vehicle miles traveled. However, algorithmic travel patterns can only increase efficiency by so much; cars each take up more space per person than transit vehicles or bicycles.

Autonomous vehicles show such tremendous public health and economic promises for the decades to come. By cutting out human errors in driving, autonomous vehicles have the potential to save thousands of lives, reduce energy consumption, reduce congestion and its associated costs, and improve accessibility for those who are unable to drive. While shared autonomous vehicles may reduce car ownership rates, not all people are on board with using autonomous vehicles – those who currently own and operate their own vehicles, wealthier people and older populations are less likely to choose shared autonomous vehicles.

The implications of AVs aren't entirely positive—autonomous vehicles have the potential to reduce traffic collisions and improve access, but only if they are economically feasible for the entire population. Thousands of jobs depend on driving people and goods around, including accessible and stable lower and middle class jobs, such as truck driving, taxi driving, transit operators and the mechanics and other positions supporting them. Further, while connecting all vehicles to each other and to the infrastructure they use may result in increased efficiency, it also creates a cybersecurity nightmare for information technology officials tasked with keeping people, and their data, safe.

Planners and public officials have already created and adopted transportation infrastructure plans and policies for decades into the future, when autonomous vehicles are predicted to overtake today's non-autonomous cars. In addition, a handful of cities in the United States voted on and passed major transportation investment packages in 2016, including Atlanta, Los Angeles, Denver and Seattle. Over the next few decades in the Puget Sound area nearly $54 billion dollars will be invested in light rail and transit expansion as a part of the Sound Transit 3 ballot measure.

Given the concurrency of autonomous vehicle implementation, long range planning, and recent transit investments, it's important to look at how planners are taking into account this disruptive technological change in order to ensure that today's investments serve tomorrow's needs.

Because of the Puget Sound's status as an international technology hub, its widespread adoption of comprehensive planning practices due to the state's Growth Management Act, and its recent votes to expand transit and transportation infrastructure and service, the region makes a suitable candidate for studying *how* planners are integrating technology change into comprehensive and transportation planning documents, and *why* they are, or aren't, considering autonomous vehicles in said documents.

Motivations and background

Autonomous vehicles may be exciting and sexy, but the policies governing their adoption and impacts typically aren't. There is extensive research taking place *right now* about the implementation of and ramifications to be caused by autonomous vehicles in our near future. There are significant gaps when it comes to how that knowledge is being addressed and incorporated in meaningful ways. Often associated with disruption, technology changes at a rapid pace and its influence today cannot be overstated. As indicated earlier, autonomous vehicles have a lot of promise and opportunity when it comes to reducing traffic deaths and collisions, potentially helping cities to achieve Vision Zero goals. They could also help increase transportation access for those who are currently unable to drive. However, our society will only realize benefits like these if we implement autonomous vehicles in an equitable way by planning for their arrival and mitigating their potential negative impacts on our communities.

Today the Puget Sound region is investing $54 billion into the Sound Transit 3 expansion, an effort to relieve congestion on crowded and fully-built-out roadways and provide another, more sustainable, frequent and easy option for passenger travel around our region. However, Link Light Rail, despite its recent build date, doesn't include driverless trains like many other, older systems have. Amazon, Microsoft and other tech companies call our region home and some are developing autonomous vehicle systems, yet our cities, transit agencies, counties and regional government may not be planning for their arrival. Our region is stronger when we look forward at what's facing us and make a plan for how we will harness the opportunities this new technology provides, rather than letting it shape us as it sees fit.

It's for this reason that I want to investigate how municipalities have prepared, or currently are preparing, for a future with autonomous vehicles. Planning documents typically have a lifespan of 20-30 years. For example, does the Puget Sound Regional Council's Transportation 2040 plan include autonomous vehicles in its vision? Studies predict that our roadways could have full implementation of autonomous vehicles by 2050. Are AVs missing from the plan? And what about vehicle sharing systems? I want to know what is there, and what's missing. Further, how do interim updates and amendments to these long-range planning documents incorporate technology changes? This question can be answered by taking a hard look at plans and their updates, and comparing them to existing research about what's predicted to happen.

This would be a pretty simple question to answer on its own, but I want dive into the motivations of planners and their attitudes toward technological change. If autonomous vehicles are missing from planning documents, then why is that the case? Is it a matter of timelines and amendment processes? Are they unaware of the research and the implications? Or do they not believe the research?

I care about the future of our region, and I want to make our ability to plan in the face of fast paced technological change stronger. I believe that starts by taking a critical look at what we're doing now, learning more about why things are the way they are, identifying areas of improvement, and most importantly, acting on those opportunities.

Hypothesis

I expect to find that our existing planning documents do not adequately address these changes, although some may talk about connectivity and change in a high-level or nebulous way. Planners are already overloaded with projects and work focused on the next five to 10 years, and it is difficult to make concrete predictions about what will happen beyond that time frame, especially when it comes to technology.

Research implications

The results of this study demonstrate how prepared transit agencies and municipalities are for a future with fully autonomous vehicles. The results will also demonstrate opportunities for planners in the Puget Sound region to improve their understanding of autonomous vehicles and their potential impacts, and roadblocks that get in the way of planners incorporating complex technology changes into their plans. By better understanding where the field is, planners can change planning processes in the future to address identified gaps.

This research exposes gaps and flaws in our existing planning processes. It requires planners to lean into vulnerabilities, which is difficult to do, especially for municipal agencies constantly under public pressure and scrutiny. Because of these vulnerabilities, I understand the hesitancy planners may have in going on-the-record in interviews. In order to allow planners to discuss sensitive topics with full candor, results from interviews with planners have been kept anonymized in this research paper.

Literature review

How we got here

Driverless transportation isn't new—the SkyTrains in Vancouver, Canada use automatic train operation technology, as do trams in the Seattle-Tacoma International and Denver International airports. In fact, SeaTac's tram has been running on its own without human drivers since 1964. However, these systems all run on fixed tracks free from traffic, blockages or other variables a vehicle might encounter in a typical trip. Since the first DARPA challenge in 2004, robotics researchers have made tremendous progress in computer vision, simultaneous localization and mapping algorithms, neural networks, and vehicle-to-vehicle and vehicle-to-infrastructure communication systems. Because of these technological advances, autonomous vehicles have gone from a dream to reality in just over a decade.

The ability for a vehicle to fully drive itself and avoid collisions is not far off. In fact, most tech companies and vehicle manufacturers hope to bring their autonomous vehicles to market by 2020 (Fagnant and Kockelman 2015). This is a relatively short timeline for a major technological change. Researchers are already looking at the potential social ramifications of AVs (Folsom 2011). While it may be a few years before AVs are featured in car commercials or at a nearby dealership, vehicles manufactured today and over the last few years already have highly-automated features, such as lane correction, assisted braking and parking, and other autonomous controls that help to cut down on collisions and improve the driving experience. The average lifespan of a vehicle on the road in the United States today is 16 years (Bento 2016), which means if vehicle manufacturers hold to their timelines in bringing AVs to market, a significant share of vehicles on the road in 2030 or 2040 could be autonomous. Fully autonomous vehicles are already on the road in many states through testing permits and closely-monitored pilot programs. Examples of this include Waymo's pilot program in the Phoenix, Arizona metropolitan area, and Navya's driverless bus service in Las Vegas, Nevada.

The Society of Automotive Engineers (SAE) and the U.S. Department of Transportation (USDOT) have defined six levels of autonomous vehicles, from Level 0 with human drivers controlling all aspects of driving, to Level 5 full automation where a vehicle could drive itself around without any human assistance or intervention; vehicles with levels 2 and 3 automation are already in the marketplace and on roadways today (National Highway Traffic Safety Administration 2018).

Figure 12.1 // SAE + USDOT levels of automation

SAE Level 0	No automation	Human driver controls all aspects of driving unassisted by any warning, enhancement or intervention systems.
SAE Level 1	Driver assistance	Some steering or acceleration/deceleration assistance, but all driving controlled ultimately by a human
SAE Level 2	Partial automation	One or more driving assistance systems, including steering *and* acceleration/deceleration, but all remaining driving tasks controlled by a human
SAE Level 3	Conditional automation	An automated driving system controls all aspects of a dynamic driving task (such as parallel parking) but the human driver is there to respond to requests to intervene
SAE Level 4	High automation	Nearly fully automated, but can request for a human driver to intervene. However, vehicle can continue driving itself even without requested human intervention.
SAE Level 5	Full automation	An automated driving system controls all aspects of driving with no assistance from a human driver.

So, autonomous vehicles are already on the roads, and they're predicted to proliferate over the coming decades. Because of this, it's important for planners to consider the implications of autonomous vehicles, how technology adoption may take place, and how they can help to shape a future with AVs in order to fully realize the benefits, and mitigate any concerns or potential negative consequences.

Predicted implications of autonomous vehicles

Autonomous vehicles show such tremendous promise for the decades to come. By cutting out human errors in driving, autonomous vehicles have the potential to save thousands of lives, reduce energy consumption, reduce congestion and its associated costs, and improve accessibility for those who are unable to drive. They will truly disrupt existing travel patterns, which will have huge implications not only on existing transportation systems, but how cities operate, including land use and development decisions, public health considerations, emissions and sustainability.

Anderson et al (2014) dive into a number of predicted implications of AVs in their 2014 magnum opus for the RAND Corporation, a research and development think tank. This piece serves as foundational research for many of the studies looking at more detailed or specific implications and outcomes that will be triggered by AVs. The authors begin with what's known today: the externalities of driving, including economic and social costs such as congestion, collisions, noise and pollution. Each of these externalities may be associated with even more detailed costs, such as property damage, healthcare, legal costs, infrastructure costs and more.

A year following, Fagnant and Kockelman (July 2015) brought together dozens of studies in a conversation about implications of autonomous vehicles and general policy recommendations that legislators should consider. This work is also considered foundational, and is quoted extensively in many of the studies looking at specific implications of autonomous vehicle implementation.

Safety and liability

Anderson et al (2014) looks at collision rates over the last few decades, today, and predictions made by the Insurance Institute for Highway Safety, a nonprofit funded by auto insurers working to reduce the number of collisions. These predictions have to do with known technology such as forward collision warning systems, lane departure warnings, blind spot assistance and adaptive headlights, and how these systems are expected to decrease collision and fatality rates into the future. Many of these features are associated with SAE Level 1 automation. The study then extrapolates these figures into a future with increased automation at SAE Levels 2 through 5.

Folsom (2011) also provides foundational research about the effects of autonomous vehicles. This research explores the social ramifications of autonomous vehicles. This paper was published in a journal from the Institute of Electrical and Electronics Engineers (IEEE), an organization “dedicated to the advancement of technology”. His paper explores how full deployment of autonomous vehicles will impact social variables such as health, economy, accessibility, energy consumption and more. Planners and policymakers typically collect metrics associated with these social variables as a part of urban planning and public administration efforts. For example, Folsom (2011) highlights traffic collisions and traffic-related deaths in the 2000s, and how autonomous vehicles have the potential to reduce traffic deaths to zero. This certainly will impact cities with existing Vision Zero programs, as well as saving on healthcare costs, vehicle repair costs, congestion (time) costs and infrastructure repair costs caused by collisions.

Cities often include goals for reducing traffic collisions and deaths in their comprehensive plans and transportation plans. With autonomous vehicles promising change in the human cost of vehicle travel, these plans will need to incorporate goals of increasing AV mode share if jurisdictions hope to realize collision reduction benefits.

Similarly, while driverless cars have enormous potential to improve on human errors in driving, they bring their own safety risks to the table. Human error currently accounts for 94% of all traffic collisions (Favaro et al 2017)(National Highway Traffic Safety Administration 2015). A series of sensors looking in all directions could be better than our eyes and ears, but currently pilot programs of autonomous vehicles have had worse collision rates than conventional vehicles (Favaro et al 2017). In March 2018 an autonomous Uber vehicle struck and killed Elaine Herzberg, a pedestrian crossing a road at night in Tempe, Arizona. While technology will continue to improve, and many assume that autonomous vehicles will become better drivers than humans, they still may not be perfect. This opens up a host of safety and liability issues for vehicle manufacturers, software developers, public agencies, and the people who use driverless cars.

Economy and unemployment

Autonomous vehicles present the opportunity to make driving more efficient by getting rid of human error, and that's achieved by getting rid of human drivers. While this has the potential to be a boon to transportation safety, it also means putting professional drivers out of business. Not only would truck drivers and transit operators lose their jobs, so would those people that depend on traditional vehicles and collisions caused by human error, such as auto body shops and possibly even insurance companies (Anderson et al 2014). Transit operators are often unionized, while taxi drivers are often immigrants (Anderson et al 2014), and well-paid union positions and jobs for immigrants are often hard to find. Autonomous vehicle technology could make operating transportation systems much cheaper, but also contribute to increased unemployment and economic disruption.

Accessibility

Anderson et al (2014) looks at how SAE Levels 4 and 5 automation could allow for greater mobility for those who are currently unable to drive, such as those with vision impairment, people with disabilities, the elderly and children. They look at existing studies about transportation accessibility, and point out that autonomous vehicle access could equate to more independence and greater access to essential services. However, these benefits are only realized when autonomous vehicles are also *practically* accessible to these populations, meaning that users have the money, bank account, credit card, and/or smartphone necessary to access the vehicle. This does not consider the economic feasibility and business models of AVs as there is not research available about predicted pricing structures for either privately-owned or shared autonomous vehicles. There may be additional cultural barriers, such as knowledge about how to use the service or language barriers, that could hinder AV access for marginalized populations.

These increased accessibility benefits are not without consequence. If a family can send a car full of kids to school without a parent, they can also send a car away to run miscellaneous errands without a driver. Shared autonomous vehicles could cruise around densely populated areas completely empty while scouting for their next passengers. These zero-occupancy vehicle movements have the potential to increase vehicle miles traveled and contribute to congestion and emissions.

Vehicle miles traveled and congestion

With more people able to access vehicles, and people sending empty vehicles on errands, there will be more trips made overall. This has significant implications for vehicle miles traveled (VMT) and congestion. Anderson et al (2014) build up foundational research in this area by looking at the predicted increase in vehicle miles traveled, greater lane throughput through algorithmic travel patterns, and reduced delays caused by fewer (perhaps nonexistent) collisions. They do this by examining today's opportunity costs of driving a car, that is, the time, energy and money it takes to make a car trip as opposed to the same trip using a different mode. Today's drivers must stay alert and behind the wheel, while AVs mean that drivers transition into passengers, and those passengers can get ready for work, watch TV or read a book while commuting, reducing the opportunity cost of traveling by car. This foundational paper also mentions how AVs with vehicle-to-vehicle communication technology could "buddy-up", resulting in lines of AVs traveling at high speeds only inches apart from each other, accelerating and braking in unison. These "platooning" behaviors mean that one lane of roadway carrying 1,500 cars per hour today could carry far more more per hour with AVs.

Other studies use Anderson et al's (2014) research to explore exactly how much VMT could increase, and how many autonomous vehicles would be needed to meet trip demand in a shared AV scenario. One of the most cited studies in this endeavor comes from Fagnant, Kockelman and Bansal (2015) in a case study looking at Austin, Texas. Fagnant and Kockelman have multiple studies on autonomous vehicle implications, and are well regarded in the field for their groundbreaking research and unique way of exploring what may happen in the future. With Bansal, their Austin study finds that each shared autonomous vehicle (SAV) could replace up to nine non-autonomous vehicles, but that a shared system would increase VMT because of the reasons outlined by Anderson et al. They found that VMT could increase by as much as 10%. The study also compared shared autonomous vehicles to existing taxicab movements, and found that SAVs will remain occupied for a larger percent of their total in-service time, and can better position themselves to become occupied quickly.

But Fagnant, Kockelman and Bansal (2015) weren't the only ones to build on the VMT findings from Anderson et al. Boesch et al (2016) conducted a similar experiment, but this time looking at Zurich, Switzerland. Their study found that one SAV has the potential to replace up to 10 non-autonomous vehicles, and found that this number can vary depending on the wait times deemed acceptable by potential passengers. For example, one SAV can replace 10 non-AVs when 95% of passengers will wait for up to 10 minutes for their ride to pick them up, but one SAV can only replace four non-AVs when 95% of passengers will only wait for up to five minutes.

This study also takes the Fagnant, Kockelman and Bansal (2015) study further by looking at a "day in the life" of a shared autonomous vehicle—what exactly it will spend its day doing. Boesch et al (2016) found that an SAV would spend 28% of its day driving customers around, 4% waiting for customers to get in the car, and 64% of its day waiting to be hailed by passengers. While it may seem like a waste to have a car spending nearly two-thirds of its day waiting around, the study also points out that vehicles in Switzerland today are only used productively for 3% of the day. Spending 28% of its time active is a significant improvement over 3%.

Boesch et al (2016) point out that this number could change depending on how a network of shared autonomous vehicles are programmed to redistribute themselves, which is exactly what Zhang et al (2015), Martinez et al (2017), and Gora and Rub (2016) look at in their studies. These studies find that vehicles could reposition themselves closer to where trip demand might be (greater density of people) but that this would have implications in terms of (a) the land available to park the vehicle while it's waiting for passengers, (b) increased vehicle miles traveled AVs would create while roaming around in their quest for the most ideal position to find another customer, and (c) longer wait times for people in less-dense neighborhoods.

Planners must be proactive, and not reactive, to the VMT and congestion implications autonomous vehicles might have. This involves a delicate balance between increasing transportation access, realizing the safety benefits of full implementation, and limiting the negative externalities created by people making more trips. Policymakers must look at how the implications of AVs will impact their existing plans and goals. Beaudoin et al (2015) notes in their paper that the most effective means for reducing vehicle miles traveled is to force drivers to "internalize the full marginal social cost of their travel" – planners must weigh the benefits of cheaper autonomous vehicles with those costs.

Land use and parking

Transportation and land use are intrinsically tied together. Variations in land use are the reason why people need to move from place to place. Autonomous vehicles will bring about big changes when it comes to transportation trip making behaviors and parking. Increased efficiency and throughput will result in shorter duration trips for the same distance traveled as today, incentivizing people to use autonomous vehicles to save time and money. However, these improved trip times, particularly if trips cost a flat rate (membership fee), as opposed to a rate based on distance, may incentivize travelers taking longer trips. This would further increase VMT and negate any efficiency gains because of induced demand.

As previously noted, each shared autonomous vehicle could replace around 10 of today's non-autonomous vehicles. That could mean people choosing to forego car ownership, instead choosing to buy into transportation service membership schemes. Anderson et al (2014) found that the average cost of car ownership today comes out to $5,695 annually. But the math is interesting; today, if a person owns a car, the more they drive that car in a year, then the less their trips cost on a per-mile basis. This is because the cost of car ownership is generally flat, not accounting for gas. In a way, this incentivizes taking more trips. Switching to a shared vehicle system would likely mean being charged a per-mile rate, which would help passengers to realize the full costs of their trip. This is unlike today, where drivers do not realize the full costs of driving because of negative externalities they create, such as congestion or polluting emissions.

Additionally, the time costs of commuting decrease in an autonomous vehicle because passengers can use their time on activities other than driving. Anderson et al (2014) found that decreased commute costs, both in terms of time and money, may increase commuter willingness to have longer commute, causing people to move further away from downtown and contributing to sprawl. Without planning controls such as urban growth boundaries, autonomous vehicles could lead to dispersed and low-density land use patterns. This holds true with bid-rent theories and central place theories popularized by Alonso (1964) and others over the last century. As Anderson et al (2014) notes: “While AVs would not alter the underlying nature of trading off land values with transportation costs, they could have a major effect on the computation of the latter.”

Lari et al (2015) back this study up, discussing a Volvo-made video about increased productivity and the implications for land use planning. Because of decreased commute costs, people may choose to live farther away from urban centers, which could contribute to urban sprawl. Further, sprawl often increases costs to governments of providing services to those living in rural areas, including paving roads, electrical and utility services.

While it may seem contradictory, some studies about autonomous vehicles and land use patterns suggest that metropolitan areas may increase density in their urban cores as a result of autonomous vehicles. However, it’s possible that we see both increased density in urban areas, as well as sprawl in suburbs and exurbs. Shoup’s 2005 book *The High Cost of Free Parking* notes that a typical car is parked 95% of the time. If that figure can be reduced to around 60% because of autonomous vehicles, then there’s a significantly decreased need for parking. Currently 30% of each major city’s central business district is dedicated to parking on average. Under an autonomous vehicle scenario, it’s likely that much of this CBD parking could be redeveloped for other uses.

Further, autonomous vehicles will have different kind of parking requirements than today’s vehicles. As noted by Zhang et al (2015), not only do we need fewer parking areas because of fewer cars making more trips, but autonomous vehicles can park just millimeters away from each other because of their more precise, algorithmic control, and because they have no reason to open their doors when parked as the vehicles would travel to potential passengers to pick them up. However, this will change street design as vehicles shift from parking to loading and unloading passengers at the front door of their destination. Finally, Zhang et al (2015) also notes that allowing empty vehicles to cruise or prowl for passengers will decrease demand for parking, but it will increase vehicle miles traveled. Thus we see that VMT and parking demand are intricately related variables in planning for AVs.

Because AVs change how humans interact with the world around them, policymakers should be proactive in implementing policies and land-use codes that influence the built environment. Without planning interventions these dramatic land use changes may take place uncontrolled, with lasting repercussions on the people and places that make up a city. For example, existing parking minimums may need to change as parking ownership rates and developments shift as this new technology is deployed, and programs funded by parking revenue may need to look for other funding sources or face the chopping block.

Mode choice and infrastructure

Brownell and Kornhauser (2014) offer the most-cited and foundational research when it comes to autonomous vehicles and mode choice behaviors. Their paper explores mode choices, and develops a criteria for evaluating what a transportation mode must provide in order to be competitive with drive-alone vehicles. These criteria include:

- Efficacy in reducing congestion
- Safety improvements over today's human-operated vehicles
- Environmental impact
- Economic feasibility
- Comfort and convenience

From there, the study looks at two different pickup models for autonomous vehicles: pick up zones or stations v. on-demand pickups. It uses the identified criteria to explore economic viability and competitiveness with existing modes given existing travel demand.

While Brownell and Kornhauser's (2014) work provides a valuable foundation, it was published a few years ago, and predates some of the technological advances of late, including ridehailing services. With autonomous vehicles and shared autonomous vehicles starting as test programs today on a limited scale, it's not too early to think about how these new modes will change existing transportation mode shares. Similarly, as cities, counties and states track mode share figures, they should begin tracking new modes such as ride hailing services and autonomous vehicles.

More research has been published in the last year about ride hailing services such as Uber and Lyft, or carsharing services such as Car2Go and Zipcar, which are fairly good proxies for shared autonomous vehicles. However, two of the largest studies have conflicting results about how these newcomer transportation services influence transit mode shares. One study from Clewlow and Mishra

(2017) shows that ride hailing apps such as Uber and Lyft result in a 6% reduction in transit trips and a 3% reduction in bus trips, while a 2016 study from the Feigon et al, funded by the American Public Transportation Association, shows that people who use those same services are more likely to use public transit and own fewer cars. It goes even further: one study identifies why people choose ridesharing services over transit, while the other identifies how ride hailing services complement transit.

The Clewlow and Mishra (2017) study looked at a myriad of variables related to mode choice decision making and travel behaviors, including how often customers/passengers use ridehailing services, user age, reasons for using ridehailing over other modes, ranking other modes for various trip types, and vehicle ownership rates. The findings show that ridehailing users use the service to avoid parking and drunk driving, and that they use ridehailing services over transit because they find transit too slow, too infrequent, unreliable, or unavailable at the desired times. These findings are consistent with other studies related to transportation demand management and shifting mode share away from driving alone to transit.

Many cities, towns, counties, transit agencies, and regional governing bodies have invested significantly in existing transportation systems, including decades-long and very expensive rail expansion projects. Planners must understand how technology changes will influence mode shares, and research what they can do to make these projects more resilient to coming change.

Sustainability

Autonomous vehicles present a significant opportunity to reduce emissions and promote sustainability efforts through a number of means, and many of these complement aforementioned studies and discussions. For example, VMT, vehicle type (ie: electric v. non-electric) and emissions are all linked together. Some of these opportunities include:

- Fleet size/number of vehicles
- Composition of vehicles (lighter, more recyclable materials)
- Electric vehicles and emissions
- Infrastructure composition (lighter, more recyclable materials)
- Efficiencies through algorithmic travel behavior (drafting, inductive charging)
- Land use, density, smart growth

As Folsom (2011) discusses in his paper detailing social ramifications of autonomous vehicles, full AV implementation could “reduce urban congestion, sprawl and impervious surfaces since fewer freeway lanes and parking lots would be required. Wide scale acceptance could reduce U.S. oil consumption by 16% and eliminate 146,000 metric tons of carbon daily.” These environmental impacts also play into the goals established by cities and regions through their comprehensive planning processes. However, as noted above, other studies have noted the potential for increased sprawl because of AVs.

In the past, increased vehicle miles traveled has meant more carbon emissions, energy used and congestion, but autonomous vehicles likely won't have the same pollution impacts that today's vehicles have had. Anderson et al (2014) again lays the groundwork here: Some 80 percent of autonomous vehicles under development today use an electric or hybrid powertrain. But electric vehicles are not a panacea—if the electricity used to charge said vehicles comes from polluting sources such as coal, then polluting emissions will continue to rise as VMT increases. Additionally, electric autonomous vehicles are not a given; planners and policymakers must actively encourage their adoption and provide the infrastructure necessary to support them. Many jurisdictions, particularly in the Puget Sound region, have climate action plans accompanying their comprehensive plans outlining sustainability goals and target emissions metrics, including electric vehicle adoption.

Further, autonomous vehicles will have efficiency advantages over non-AVs: (a) autonomous vehicles operating in an entirely AV environment won't need to be as heavy as today's vehicles because of the significant decrease in collisions by removing human error from driving; (b) autonomous vehicles will result in further travelling efficiencies through algorithmic travel improvements, such as "platooning" vehicles on highway lanes, which results in significant energy savings due to drafting at close distances; and finally (c) autonomous vehicles will use optimized control to reduce and smooth acceleration and braking, improving energy performance.

If municipalities hope to meet their climate action plan and sustainability goals, they must be able to plan for and regulate autonomous vehicles. They present an enormous opportunity to cut transportation emissions, which often account for a majority or plurality of the emissions from any given community.

Technology adoption

Data security + information technology

There are many factors that influence how widespread technology adoption will be, and over what period of time. Some of these factors include information technology, security, liability and legal ramifications. These variables have less to do with traditional transportation and land use planning, although they may overlap with strategic and infrastructure planning. Autonomous vehicles and the connected devices that support them, such as intelligent transportation systems, vehicle-to-vehicle and vehicle-to-infrastructure technology, will generate massive amounts of data that will need to be managed by both private industry and jurisdictions. This high-value data will also presents cybersecurity and privacy risks. Governments will need to have policies in place to manage connected assets, data, and the risks presented by this new technology (United States 2014). Additionally, this proliferation of connected devices also brings up privacy concerns, such as how long data is stored and by whom, or what legal rights the passenger has to access vehicle data, or even if law enforcement can access and use transportation data (Anderson et al 2014). Data security, information technology and privacy issues are interconnected, and are an important aspect of a connected vehicle system that must be addressed.

Sentiment analysis

While autonomous vehicles may result in achieving significant safety and sustainability goals, or may clog up our streets with increased VMT, one thing we can say for certain is that these changes won't occur if people aren't willing to use autonomous vehicles. There are four studies in this area, all published within the last two years, so while there certainly overlaps and consistencies, they don't build on each other.

One study, from Krueger et al (2016), conducted a survey among Australian residents of major metropolitan areas collecting sociodemographic information, transportation and mobility preferences, and a series of hypothetical questions about which mode they would choose for a specific trip and why. The study found that travel time, waiting time and fares were significant factors in whether someone would choose a shared autonomous vehicle service and/or dynamic ridesharing (being matched up with other users taking similar trips). It found that those who almost exclusively drive in vehicles alone today are those most resistant to using shared autonomous vehicles and using dynamic ridesharing services. The study also found that young populations are more likely to adopt these new technologies quickly.

A study from Haboucha et al (2017) the following year were in line with the sentiment analysis from Kruger et al (2016). This study investigated user attitudes toward owning and operating a traditional vehicle, owning an autonomous vehicle, or participating in a shared autonomous vehicle system. A number of other factors were also included in the survey, which was distributed in North America and Israel. Those factors included individuals' attitudes toward technology, environmental concern, enjoy driving, public transit attitude, and pro-AV sentiments, as well as demographic characteristics.

This larger and more recent study found that nearly half of survey-takers prefer owning and operating a traditional vehicle. Younger, more educated people, and those who spend more time in vehicles are most open to using shared autonomous vehicles, similar to the results from Krueger et al (2016). However, an interesting point came out of the study—25% of people would not be willing to use shared autonomous vehicles even if they were completely free. Having to run errands, store items in the vehicle, or having children increased the likelihood of preferring traditional vehicles.

These two studies could help influence how jurisdictions implement policies or adopt campaigns to promote autonomous vehicle use among various communities. As co-existence of autonomous and traditional vehicles will be difficult, these campaigns could help usher in a future of full AV deployment, thus fully realizing the potential gains in energy efficiency and safety.

Similarly, a study from Yap et al (2016) also looked at user sentiment towards AVs, this time focusing on using AVs as a first-and-last mile connection to and from train trips compared to bicycling and walking. This study was unique in that it considered AVs as a distinct option separate from SAVs. The study found that second to driving alone, people preferred autonomous vehicles over active transportation modes. This study also identified a concern about user attitudes toward autonomous vehicles: users don't realize the time cost savings that autonomous vehicles afford them—they view time costs in commuting about the same whether they're in an AV or driving themselves.

Finally, a study in Atlanta, Georgia from Lu et al (2017) conducted a sentiment analysis on data from an autonomous vehicle survey carried out by the city in 2015. Through this analysis, researchers found that residents are very concerned that autonomous vehicles may be a threat to public transportation investments. Other concerns included liability and safety concerns, policy incentives for autonomous vehicle use, and cybersecurity concerns.

The current state of policy

As of late 2017 half of all states have either passed legislation or issued executive orders related to autonomous vehicle use. However, these legislative or executive actions are often vague and simply encouraging autonomous vehicle testing as an economic boon to the state. If AVs and SAVs are to be integrated into the transportation system, then these policies must be carried down to the regional and local levels through planning processes. When implemented locally AVs and SAVs can be considered as a part of an integrated transportation system, and their effects on land use planning, infrastructure planning and capital budgeting processes fully realized and mitigated.

As Anderson et al (2014) point out in their three chapters dedicated to public policies, standards and regulations, "the history of technology in general—and transportation in particular—is littered with promising ideas that never achieved widespread adoption". With many already calling for immediate adoption of autonomous vehicles because of the unnecessary traffic deaths that will occur will implementation is delayed, it's important that jurisdictions shape implementation so that those benefits are fully realized, shared equitably, and negative consequences are ameliorated or avoided altogether.

Anderson et al (2014) highlight a few public policy interventions that jurisdictions might consider, including regulation of sensor technology, safeguarding against risks of market failure, and creating more stringent rules for roadway signage and markings.

Interestingly, some practices they highlight also include *avoiding* regulation out of fear that it would hinder development of the technology, including safety testing at the state and local level. Instead, the researchers argue that safety regulators should create working groups coordinating with firms developing the technology so that they can better understand the risks and issues, and develop regulations that would be more appropriate for a more mature technology to be implemented later. Fagnant and Kockelman (July 2015) build on this in their study investigating policy recommendations related to autonomous vehicles. While open-ended, they recommend jurisdictions sort out issues related to vehicle costs, certification, litigation and liability, security, privacy, and market penetration.

While the recommendations from these studies do explore a litany of issues, they have more to do with short-term implementation than longer-term consequences of how autonomous vehicles will shape communities. With planning documents highlighting visions and policies 20-30 years in the future, and autonomous vehicles trending towards market penetration within that time horizon, it's important to examine how technology change and autonomous vehicles are integrated into planning documents at the local and regional level, and why they have or have not been considered in those documents up until now.

Planning rationality

Finally, evaluating planning documents for whether they include autonomous vehicles would not be a worthwhile endeavor unless planning for technology change is an effective means for shaping or influencing change. This means looking at the rationale for planning, as well as efficacy and outcomes of earlier plans regarding previous technological changes.

Evaluating plans for their efficacy in including previous technological changes is difficult. There is not much available research about earlier plans and how they accommodated automobiles in a time of horse-powered vehicles, or how transportations plans from 2000 to 2010 accounted for up-and-coming carsharing services, such as Zipcar and car2go. At the other end of the spectrum, there are countless newspaper and magazine articles discussing new transportation technologies that surely had the potential to change society as we know it, such as the Segway. Planning for technological change is a tricky endeavor, one that requires balancing the known with the unknown. This relates to a planning framework published in the Journal of the American Planning Association in 1984 related to planning, technology and economic growth. This framework, while focused on technological advancements particular to economic planning, discusses how planners must (1) research the conditions or environment in which the new technology will operate; (2) research the impacts the new technology will have; (3) draft policies related to the research findings; and finally (4) evaluate those policies using case studies, or by taking them through step-by-step to their logical outcomes (Wim et al. 1984).

One rationale for planning, published in the Journal of the American Planning Association in 1992, is relevant to autonomous vehicles in that it describes planning as a mechanism for correcting market failures and political failures. This article discusses how planning corrects for failures including externalities, non-appropriability, large numbers, and imperfect information (Sager 1992). This certainly relates to autonomous vehicles and their aforementioned effects, such as the negative externalities of congestion, or unequal access caused by certain populations having imperfect information. Sager argues that planning is an action: standing for the most vulnerable in a society, and ensuring “an optimal production of public goods.” In this sense, transportation planning for autonomous vehicles is an act of mitigating the potential consequences this new technology could bring, and ensuring an optimal transportation system.

Methodology

My research relies on the many predictions and assumptions made in existing studies about a future where autonomous vehicles, and likely shared autonomous vehicle systems, are widespread and have largely replaced conventional human-driven vehicles that we have today. Given this, there are no existing data sets about autonomous vehicle use as it relates to transit; the situation hasn't occurred yet and thus can't be studied directly. However, there are peer-reviewed studies that have made predictions about changes in:

- Vehicle miles traveled (VMT), lane throughput and congestion;
- Vehicle use, trip making behaviors and mode share;
- Land use and parking; and
- Transportation accessibility.

There is not a lot of data about autonomous vehicle use yet because AVs aren't widely adopted, so it's difficult to conduct a quantitative study about the impact autonomous vehicles will have on existing transportation systems and infrastructure; there are simply too many unknowns and variables at play. Given this constraint, I want to understand what municipalities and transit agencies are doing to incorporate predicted technology changes, including autonomous vehicles and shared autonomous vehicle systems, into their planning documents. Further, this research evaluates what exactly they are and are not planning for, and why they are planning (or not planning) for specific areas of our autonomous vehicle future.

Research Design

This is a qualitative study mirroring the design of an explanatory sequential mixed methods study. This format has allowed me to take a critical look at existing planning documents to see what is and isn't included. I then interview planning personnel to examine why their plans either include or exclude autonomous vehicles and their effects. It begins with phase one, a qualitative analysis of comprehensive and transportation planning documents from each jurisdiction. More detail about the analysis criteria can be found below in *phase one*. Phase two involves interviewing planners, policymakers and other transportation-related public officials who involved with the transportation and comprehensive planning process from each of the identified jurisdictions. More details on the interview process can be found below in *phase two*.

I would consider this research fully qualitative and not quantitative because, while I am taking measurements of what plans do and do not contain, this document analysis and grading uses ordinal-level data to categorize and rank plans, and isn't useful for meaningful quantitative analysis on the plans themselves.

Study area / scope

This study is focused on the Puget Sound region because of its history and practice of comprehensive planning, its status as a tech sector hub, and because of the researcher's familiarity with transportation planning in this region as a student at the University of Washington. Larger studies could, and a few have, compared and contrasted cities, regions and states (DuPuis 2016)(Guerra 2016). Those studies, while interesting, would prove too large a scope for a thesis project and would be more appropriate for a dissertation. This study focuses on the metropolitan planning organization (MPO) the Puget Sound Regional Council; the regional transit authority, Sound Transit; the three largest counties in the region, King, Pierce and Snohomish, and their respective transit agencies; and the two largest cities in each of the aforementioned counties: Seattle, Bellevue, Tacoma, Lakewood, Everett and Marysville. Larger municipalities have more resources to devote to planning, and their planning efforts will affect more people over the coming decades. These cities also include the region's largest tech employers, as denser urban areas have the most promise for implementation of AV or shared AV systems (Anderson et al 2014). Choosing the two largest cities (by population) of each county, the counties themselves, and the regional planning and transit agencies provides a good snapshot of planning in the Puget Sound region from a large, international city (Seattle) to bustling suburbs like Lakewood, and more exurban towns such as Marysville. Counties typically run transit agencies in our region, and I am particularly interested in the effects of autonomous vehicles on transit systems given their potential to both help and harm transit ridership.

Transit agencies	City governments	Other governments
- Sound Transit - King County Metro Transit - Pierce Transit - Community Transit	- City of Seattle - City of Bellevue - City of Tacoma - City of Lakewood - City of Everett - City of Marysville	- King County - Snohomish County - Pierce County - Puget Sound Regional Council

Phase One: Plan Analysis

Documents analyzed

The first phase is akin to survey research, conducting an analysis of comprehensive planning and transportation planning documents for municipalities and transit agencies within my study area. Plan documents included those listed below, and all documents were found on the jurisdiction's website.

Regional

Puget Sound Regional Council

- Vision 2040
- Transportation 2040

Central Puget Sound Regional Transit Authority (Sound Transit)

- Sound Transit 3: The Regional Transit System Plan
- Sound Transit Long Range Plan

Counties

King County

- King County Comprehensive Plan
- Metro Connects Long Range Plan

Snohomish County

- Snohomish County Comprehensive Plan
- Community Transit Long Range Plan

Pierce County

- Pierce County Comprehensive Plan
- Pierce Transit Long Range Plan

Cities

Seattle

- Seattle 2035 Comprehensive Plan
- Move Seattle (Seattle Department of Transportation 10-year plan)
- Seattle Department of Transportation (SDOT) New Mobility Playbook

Bellevue

- Bellevue Comprehensive Plan

Tacoma

- One Tacoma (Comprehensive Plan)
- Tacoma Transportation Master Plan

Lakewood

- City of Lakewood Comprehensive Plan

Everett

- Everett Comprehensive Plan

Marysville

- Marysville Comprehensive Plan 2015
- 2017 - 2022 Six Year Transportation Plan

Plan analysis criteria

The analysis criteria covers 28 questions based on the findings identified in the *literature review* above. These questions cover everything from when the plan was created and how often it is updated, to specifics like, “does the plan consider both the potential for increases and decreases in vehicle miles traveled brought about by autonomous vehicles?” Here I will go through the 28-point plan analysis criteria, and provide commentary about the value and intent of each question.

Plan Background

1. When was the plan originally created?
2. When was the plan last updated?
3. How often is the plan updated?
4. How far out does the plan project (number of years)?
5. How far out does the plan project (year it projects to)?

The intent of the plan background section is to find out more about how planning works in the jurisdiction. Knowing when the plan was last updated, and how often it’s updated, can provide valuable insight about why a plan may not address autonomous vehicles. We live in a period of rapid technological change, so a plan that’s just a few years old may completely overlook recent innovations. Similarly, knowing how far out a plan projects is valuable in that it shows us what’s missing. Plans projecting out to 2035 or 2040 include a time period when researchers predict autonomous vehicles will have a fairly substantial market share, so those plans may need to consider more AV effects than those plans only covering the next two or three years. This section also tells us about the functionality of planning departments in a jurisdiction—if a plan is supposed to be updated biennially, but the latest plan is three years old, then we know that (a) updates are currently underway, or (b) the jurisdiction is having difficulty staying on top of its planning mandates.

Technology

6. Does the plan mention autonomous vehicles at all?
7. Does the plan consider transportation network companies or services?

The intent of the technology questions is to gauge whether the jurisdiction considers new technologies such as autonomous vehicles or transportation on-demand services in their plan at all. This is a valuable primer before the AV effects questions listed below, because if a jurisdiction does not address these points sufficiently, then continuing on with the AV effects analysis is not a valuable endeavor. For example, if a jurisdiction does not mention autonomous vehicles at all, then it will not consider the potential for VMT increases brought about by autonomous vehicles. Essentially, this section determines whether to continue with plan analysis or not.

The questions in this section are fairly simple. “Are autonomous vehicles mentioned?” is a fairly easy question, and documents either contain this subject matter or they don’t. Question six is also a litmus test for whether a plan should be analyzed for AV effects. If the plan mentions AVs or has a full-on discussion of AVs, thus scoring two or three points on question six (see *grading* for more information on scoring and points), then it can be graded on how it tackles AV effects. If a plan does not mention autonomous vehicles, or only refers to "technology change" in a general sense (ie: receives one point or no points), then it will not be graded on how it addresses AV effects as this question determines that it hasn't addressed AVs at all.

As a follow-up, I've included a question about transportation network companies or transportation technology services. Some plans may have been left strategically open-ended until more technological advances have been made on autonomous vehicles. To that end, question seven looks at widespread technologies in-use today (transportation network companies, such as Uber and Lyft) as a test of how nimble planners are at including recent technological changes in their plans. Research has also identified TNCs as a potential proxy for shared autonomous vehicle services, so this question is relevant to planning for autonomous vehicles.

AV Effects

8. Does the plan consider both the potential for increases and decreases in vehicle miles traveled brought about by autonomous vehicles?
9. Does the plan consider implications of VMT increases? (ie: congestion, emissions)
10. Does the plan consider zero-occupancy vehicle movements? (vehicles with no passengers, vehicle self-repositioning movements, etc.)
11. Does the plan consider equity concerns regarding autonomous vehicles?
12. Does the plan consider land use changes due to autonomous vehicles (ie: increased urbanization, repurposing of urban land (particularly parking), and increased rural and exurban development
13. Does the plan consider urban form/urban design changes, such as pick-up and drop-off zones necessary to accommodate AVs?
14. Does the plan consider economic implications of automation? (ie: jobs lost currently in the transportation sector, such as transit drivers, mechanics, etc.)
15. Does the plan consider decreased costs due to automation?
16. Does the plan consider changes in revenue sources due to automation, or secondary implications of automation? (ie: fewer traffic and parking violations, gas tax v. mileage tax)
17. Does the jurisdiction have a pilot program in place related to autonomous vehicle technologies (ie: level 1-2 automation of tasks, partnerships with TNCs, etc.)
18. Does the jurisdiction plan for both fully-autonomous vehicles, semi-autonomous vehicles, and a period in which autonomous and non-autonomous vehicles mix?
19. Does the plan consider other infrastructure changes necessary to accommodate autonomous vehicles? (ie: standardized lane markings, signs, electric vehicle charging, etc.)
20. Does the plan take into account increased demand for communications infrastructure caused by autonomous vehicles? (ie: intelligent transportation systems, vehicle-to-vehicle (V2V) and/or vehicle-to-infrastructure (V2I) communications systems, cell towers, fiber, etc.)
21. Does the plan consider adoption of autonomous vehicle technology in municipally-owned fleets? (ie: transit vehicles, emergency vehicles, other city-owned vehicles)
22. Does the plan consider AVs/SAVs and their potential to either harm or help transit ridership?
23. Does the plan outline or include discussion of regulating autonomous vehicles?

24. Does the jurisdiction outline a certification or licensing process for autonomous vehicles?

The questions in the AV effects section mirror the research findings outlined in the literature review. The intent of this section is to look at how jurisdictions are planning for the predicted effects of autonomous vehicles. Only plans that scored two or three points on question six in the technology section were analyzed using the questions in the AV effects section. See *grading* for more information about points and scoring.

Questions eight, nine and 10 deal with congestion and vehicle miles traveled. As noted in the literature review, studies show the potential for autonomous vehicles to increase VMT because of increased access to transportation services among people who are currently unable to drive, particularly youth and the elderly. Autonomous vehicles make it easy to summon a ride and potentially eliminate some of the time costs associated with driving (although those time costs could be replaced with monetary costs, depending on the business structure). This ease of use and cost reduction could further increase VMT. Today, increased VMT means more congestion and polluting emissions, among other negative externalities associated with driving. (Anderson et al 2014)

Question 11 is related to the previous three, dealing with accessibility of new transportation systems in an equitable way. While autonomous vehicles have the potential to increase the public's access to transportation services, not everyone has the money, credit card or smartphone necessary to use the service. Additionally, there may be other barriers to using the service, such as a lack of awareness among historically disadvantaged communities, AVs not operating in lower income or more racially diverse neighborhoods, or AVs not meeting the needs of parents with small children. If communities hope to realize the full safety and throughput benefits of autonomous vehicles, planners must ensure AVs are equitably accessible for the entire community, not just the privileged.

Questions 12 and 13 relate to urban form and land use. Multiple studies speculate that autonomous vehicles could lead to increased rural and exurban development as they reduce commute costs (Anderson et al 2014) (Alonso 1964). Urban areas could also see changes as parking undergoes redevelopment, and right of ways change to accommodate more passengers being picked up and dropped off curbside. In Washington, planners must consider land use changes, including reducing sprawl and concentrating urban development, under the 1990 Growth Management Act (Washington Growth Management Act). Therefore, these questions get to the heart of the issue, whether planners are taking autonomous vehicles into account for future land use and urban form changes.

Questions 14, 15 and 16 reference the expected economic implications of driverless vehicles. With increased VMT a major theme from existing research, and many existing AV pilot projects using electric vehicles, jurisdictions should be prepared for reductions in gas tax revenues, as well as revenues from traffic and parking tickets. Further, autonomous vehicles will inherently replace regular drivers, including professional drivers such as transit operators. Autonomous vehicles have the potential to make public transportation systems cheaper by cutting out manual labor, but also could decimate revenue sources funding currently funding those systems. These questions look at how prepared jurisdictions are for changes to their budgets and economies due to driverless cars.

Questions 17 and 18 elucidate near-term ramifications of autonomous vehicles by asking what jurisdictions are currently doing (ie: pilot projects) and what they've done to prepare for a mix of autonomous and non-autonomous vehicles on the same roadways. In June 2017, Governor Jay Inslee issued an executive order encouraging testing and pilot programs of autonomous vehicles on Washington's roadways (Exec. Order 2017). This question looks at how local jurisdictions have carried out that executive order and responded to technology changes already taking place.

Questions 19 and 20 look at the infrastructure changes necessary to accommodate driverless cars, including changes in the public right of way such as paint and signage, but also technological advances supporting the right of way, such as intelligent transportation systems, vehicle-to-vehicle and vehicle-to-infrastructure communication technology. Comprehensive plans and transportation plans typically set priorities and goals for government agencies, which in turn influences capital allocation for projects during budgeting processes. Infrastructure changes due to autonomous vehicles should be identified in transportation plans in order to receive funding during the lifetime of said plan.

Question 21 relates to budgeting and infrastructure as they relate to a government agency's own fleet vehicles. Typically governments own a fleet of vehicles for their regular operations, and transit agencies obviously own a fleet of transit vehicles. Upgrading fleet vehicles to autonomous technology could improve safety outcomes, and save costs through slower vehicle turnover, but it also could increase near-term costs while the new technology remains expensive.

Question 22 looks at autonomous vehicles as both a potential threat and boon to transit service. This question is concerned with what planners have done to prepare public transportation systems from being replaced by autonomous vehicle services, particularly shared autonomous vehicle systems, and what they've done to ensure these new services provide a first-and-last mile connection to existing transit.

Finally, questions 23 and 24 have to do with regulations, liability and autonomous vehicles. Safety is a major concern for autonomous vehicles, and questions remain open-ended about who is responsible in the case of a collision. Some studies suggested regulations and government oversight as a way forward, particularly in protecting the public against negative impacts such as increased VMT and rural development (Anderson et al 2014).

Other

25. Does the plan consider data management, information technology, privacy and security matters?
26. Does the plan mandate adoption of new technologies associated with increased safety? (ie: collision warning systems, forward collision and lane departure warnings, blind spot assistance, and adaptive headlights)
27. Does the plan consider electric vehicles?
28. Does the plan consider utility infrastructure needs to support electric vehicles? (ie: charging stations, increased power sources/supply, etc.)

The questions in this section include topics related to autonomous vehicles, but not considered a direct effect or byproduct of AVs. These topics may apply to autonomous vehicles, but may also standalone. All plans in this study faced the four questions of this section, regardless of how they performed in the technology section.

The first question in this section, question 25, relates to IT and data security. In an increasingly digitized society, officials must be mindful of privacy and data security concerns brought about by connected devices. These connected devices, sometimes collectively referred to as the "internet of things" can collect personal information. A good example of this might be RFID transit fare media, such as the Puget Sound region's ORCA card. Computer scientists have demonstrated how easy it is to collect the most recent trip data from ORCA cards using an near-field communication capable smartphone. Autonomous vehicles will bring even more data about transportation patterns and behaviors, and about the passengers using the new service. Jurisdictions including data management, information technology, privacy and security in their planning documents today are more likely to be prepared for the next level of big data tomorrow.

Question 26 relates to specific components of autonomous vehicle technology, many of which are already included in modern vehicles in the marketplace today. A car manufactured in the last few years likely includes blind spot, rear bumper, or even lane departure warning systems. If municipalities hope to achieve the safety benefits touted by autonomous vehicle manufacturers, they could begin improving safety on their roadways by encouraging or mandating adoption of these new technologies today.

Finally, the last two questions of the plan analysis criteria deal with electric vehicles. Many municipalities have sustainability goals included in their planning efforts, and may have separate climate action plans to supplement comprehensive plans. One tool in reducing emissions caused by transportation travel is increasing use of electric vehicles. If autonomous vehicles are brought to market in the coming decade, as private manufacturers have promised, then there's a large opportunity to reduce pollutant emissions by ensuring autonomous vehicles are also electric vehicles. If cities, counties and regions already include electric vehicles in their transportation planning efforts, then it's not a stretch to apply those goals and policies to autonomous vehicles regardless of whether AVs are included in the same plan. Similarly, planners must also take into account planning for utilities when planning for electric autonomous vehicles. Electric vehicles will need charging stations, for example. Additionally, while electric vehicles promise some emissions savings over today's combustion-engine vehicles, those savings can be multiplied by ensuring the electricity sources for a municipality are also sustainable. In the Pacific Northwest electricity is largely hydroelectric, but that may not be the case elsewhere.

Grading

All plans were graded on the above criteria, as previously discussed, and each question was assigned points based on how thorough planners had been in considering the issue. This four-tiered structure allowed for more nuance than a simple yes-and-no grading scheme.

3 points

Plans were awarded three points for a question if the issue was fully considered, including pros and cons and some discussion of the topic. It is clear that planners and policymakers gave some thought to what impacts autonomous vehicles might have on their jurisdiction.

2 points

Plans were awarded two points for a question if the issue was mentioned, but remained brief and did not demonstrate nuance or complex consideration of autonomous vehicles and/or their impacts.

1 point

Plans were only awarded one point for a question if they addressed the issue in an open-ended way, potentially allowing for future updates to address autonomous vehicles as the technology becomes more established.

0 points

Plans were not awarded any points if they did not consider the issue.

If a plan did not receive one, two or three points in the technology section, then it was not analyzed for the questions listed under AV effects. Similarly, plans that addressed an issue in AV effects that did not relate the issue to autonomous vehicles received no points. For example, if a plan included discussion of intelligent transportation systems, but did not relate it back to autonomous vehicles, then it received no points for question 20. This thesis is concerned with planning for autonomous vehicles, so the grading system is specific to that issue.

Phase Two: Interviewing Planners

For the second phase of my explanatory sequential qualitative study, I contacted planning staff in the aforementioned jurisdictions to set up interviews about their transportation planning process. The interview focused on autonomous vehicles and technology change, and how those topics either came to be incorporated into the agency's planning documents, or neglected to be included. From these interviews I learned about (a) what prompts a jurisdiction or transit agency to incorporate technology change and autonomous vehicles into its planning documents, and (b) what issues prevent a jurisdiction or transit agency from incorporating these topics into their planning documents. This mimics qualitative grounded theory research in its approach, hoping to derive theories or larger explanations of phenomena out of the views of study participants.

Contacting planners

I began reaching out to planners from each of the 11 jurisdictions starting with those listed as contacts on the same webpage where the comprehensive plan or transportation plan could be found. Initial contacts were made via email and included a brief introduction to the study and study goals, and an invitation to participate. Frequently those initial contacts forwarded me to their colleagues who they felt would be a better fit or could provide more input relevant to this study. Planners were promised anonymity so that they could speak candidly about pressures, hurdles and constraints facing their jurisdiction.

In the end, I was able to interview 11 planners over the phone or via video conference, and two planners via email, from seven of the jurisdictions. Some jurisdictions had multiple participants in the study with different backgrounds on their municipality's planning process, which proved valuable. For example, one jurisdiction's interview included an analyst, a planner, a capital budgeting specialist, and an operations manager. While this methodology may have resulted in oversampling some jurisdictions and their issues, I found that often issues were more specific to the person's role in planning. Interviews covered governments both urban and rural, and of various sizes and levels. As alluded to above, interviews included more than just planners, which provided well-rounded input on the planning process. Indeed, autonomous vehicles will result in significant changes for transportation engineers, operations and maintenance workers, budgeting processes and, of course, planners. Interviews ranged from 15 to 45 minutes and were conducted in April and May of 2018.

Interview questions

I carefully crafted open-ended questions to help facilitate longer, explanatory answers and discussions about planning for autonomous vehicles in that jurisdiction. All of these questions were asked in every interview. Some interviews included additional and/or follow-up questions to provide more detail.

Interview questions

- Tell me about your role working on planning efforts for <jurisdiction>.
- What has <jurisdiction> done to prepare for autonomous vehicles?
- What impacts do you think autonomous vehicles will have on <jurisdiction>?
- What do you think are the biggest barriers in planning for autonomous vehicles?
- Where do you find out about AVs and different studies going on?
- Do you have any additional thoughts on the effect of autonomous vehicles on transportation planning?

The intent of these interviews was to find out more about what cities, counties and regional agencies are doing to prepare for a future with autonomous vehicles, and what roadblocks are getting in their way. To that end, these questions start out by finding out more about the planner's background and involvement with planning in their jurisdiction. After that I proceeded to questions about autonomous vehicles. While I had already conducted plan analysis, I asked the subject what their jurisdiction had done to prepare for autonomous vehicles in an effort to capture programs, policies or discussions not covered by the plan. Similar to the process for analyzing plans, I then transitioned into the effects of autonomous vehicles on their jurisdiction. Planners are concerned with the future, so this question allowed me to get a better sense of what planners knew about autonomous vehicles and their potential effects in their jurisdiction. The next question may not seem related, but it provided a natural transition from AV effects to the difficulties in planning for those effects: "what do you think are the biggest barriers in planning for autonomous vehicles?" The open-endedness of this question allowed for a good discussion of existing constraints in transportation planning in their jurisdiction, but also allowed for opinion and commentary about AV effects, uncertainties and potential issues. The next question reflected my curiosity about how information relating to fast-paced technological change makes its way to governments and planners—I asked about where they find information about AVs and related studies. The answers to this question allowed me to identify strengths and weaknesses in information sharing, and opportunities for improved communication in the future. Finally, I ended by asking for additional thoughts about autonomous vehicles and transportation planning overall. This allowed interviewees to provide thoughts or comments that didn't match the other questions

Finding themes

After I had conducted all of the interviews, I went back through my notes and began to identify key themes or similarities between the different interviews. I came up with a variety of tags to generalize answers given to each question, then tallied up those tags to identify popular themes throughout the interviews. For example, multiple interviewees in the question about biggest barriers identified funding or resource constraints. Therefore, “funding/resource constraints” became a tag, which was found in four of the interviews, and became a common theme.

Results

Plan analysis

Individual plan scores

Figure 36.1 // Individual Plan Scores

Jurisdiction	Plan	Year adopted	Points	Score on #6
Seattle	New Mobility Playbook	2017	57	3
Everett	Everett Comprehensive Plan	2017	22	3
King County	Metro Connects Long Range Plan	2016	17	2
Tacoma	Transportation Master Plan	2015	16	3
Bellevue	Bellevue Comprehensive Plan	2017	11	2
Seattle	Seattle Comprehensive Plan	2017	11	2
Sound Transit	Sound Transit 3	2016	8	2
Pierce County	Pierce Transit Long Range Plan	2016	8	2
Seattle	Move Seattle (SDOT 10 year plan)	2015	7	2
King County	King County Comprehensive Plan	2016	7	0
Puget Sound Regional Council	Vision 2040	2014	4	1
Tacoma	Tacoma Comprehensive Plan	2015	3	1
Puget Sound Regional Council	Transportation 2040	2014	2	1
Sound Transit	Sound Transit Long Range Plan	2014	2	1
Snohomish County	Snohomish County Comprehensive Plan	2016	1	0
Marysville	Marysville Comprehensive Plan	2015	1	0
Snohomish County	Community Transit Long Range Plan	2011	0	0
Pierce County	Pierce County Comprehensive Plan	2015	0	0
Lakewood	Lakewood Comprehensive Plan	2014	0	0

>> Full results, including points assigned for each question, comments and quotes, can be found in *Appendix C*.

The highest-ranking plan was Seattle's *New Mobility Playbook* with 57 points. The highest possible score was 69. The lowest-ranking plans were Snohomish County's *Community Transit Long Range Plan*, the *Pierce County Comprehensive Plan*, and the *Lakewood Comprehensive Plan*, all tied for zero points. The average plan score was 9.3, and the median plan score was 7. If the *New Mobility Playbook* is left off as an outlier (it more than doubles the next closest score) the average plan score becomes 6.6, while the median becomes 5.5. All plans created or updated in 2017 scored at least double digits. Only a few plans from 2015 and 2016 scored in the top third of all plans. All plans created or updated in 2014 or earlier placed in the bottom half of the rankings.

On question six, the fundamental question of whether or not plans consider or mention autonomous vehicles:

- Three plans received 3 points (fully considers);
- Six plans received 2 points (mentions);
- Four plans received 1 point (mentions technology change, but not AVs specifically); and
- Six plans received a score of zero (no mentions of AVs or technology change).

As expected by the scoring design, all plans receiving low scores on question six were in the bottom half of the full rankings. Interestingly, the *King County Comprehensive Plan* received a score of zero for question six (ie: it did not mention AVs or technology change) but received a total score of seven. It achieved this through thorough consideration of electric vehicles, utilities and IT policy.

Scores by jurisdiction

It's also possible to look at scores by each municipality. In order to do this, I added up the top score for each question regardless of plan. For example, King County received a score of 20 despite the *King County Comprehensive Plan* scoring seven, and the *Metro Connects Long Range Plan* scoring 17. On some questions the comprehensive plan scores higher, and on other questions the long range plan has the higher score. This scoring scheme rewards the jurisdiction for having a response to each question, whereas the previous scoring scheme required all of those responses to be in the same plan.

Figure 37.1 // Scores by jurisdiction

Combined Scores	**Score**	**2017 Population**
Seattle	57	713,700
Everett	22	109,800
King County	20	2,153,700
Tacoma	16	208,100
Bellevue	11	140,700
Sound Transit	8	3,802,500
Pierce County	8	859,400
PSRC	5	4,066,800
Snohomish County	1	789,400
Marysville	1	65,900
Lakewood	0	59,280

However, this new scoring scheme does not change the standings. King County was able to pick up a few points due to its comprehensive plan covering a few items the *Metro Connect Long Range Plan* did not, but it did not change the overall standings. In all other cases the highest-scoring plan from any given jurisdiction also scored the highest on every question for that jurisdiction.

To add another dimension to these results, I added in estimated 2017 population figures from Washington's Office of Financial Management (State of Washington, 2017), which is tasked with creating official growth estimates, we can see that the largest city had the best scores, and the smallest cities had the lowest scores. However, this pattern does not hold true for mid-size cities, with Everett outscoring Bellevue and Tacoma, despite being smaller than both of those cities. If we rank counties, we see the population-scoring correlation hold true, with King County receiving top marks, followed by Pierce County and then Snohomish County. Population doesn't fit well if we look at all of the jurisdictions as the largest government, the Puget Sound Regional Council, scored quite poorly.

Interviews

What's been accomplished

When asked what their jurisdiction had one to prepare for autonomous vehicles that may not be included in a planning document, planners were eager to showcase their work. I logged 19 separate answers to this question from 13 interviewees.

- First-and-last mile connections between transit and transportation network companies - 4

Multiple interviewees expressed that today's transportation network companies (TNCs) such as Uber and Lyft are precursors to shared autonomous vehicle systems. To that end, four jurisdictions have begun partnerships with TNCs providing first-and-last mile connections to transit service.

- Infrastructure technology - 3

Three interviewees indicated their jurisdiction had worked on intelligent transportation system, vehicle-to-vehicle, vehicle-to-infrastructure, or fiber installations that helped to ready their city, county or the entire region for autonomous vehicles

- Incorporating AV level 1-2 technology - 2

Two interviewees indicated their jurisdiction had begun incorporating lower levels of autonomous vehicle technology, typically into its fleet of transit or operations vehicles.

- Monitoring research - 2

Two interviewees claimed their jurisdiction was actively monitoring and researching the topic.

- Working on plan update, which will include AVs - 2

Representatives from two separate jurisdictions said they were currently updating their plans, and that new plans released later this year would incorporate autonomous vehicles.

- Changing planning process - 2

Two jurisdictions were working on processes to update their plans more frequently, or to make their planning processes “more nimble”.

Finally, interviewees had a number of one-off answers that did not build on any common themes. One interviewee felt strongly that their jurisdiction’s work in changing parking regulations was a step toward preparing for autonomous vehicles. Another jurisdiction had draft policies before its council for adoption. One jurisdiction hoped to get a better handle on both pushing data out to private companies and researchers, and pull more data in from TNCs and autonomous vehicle developers. Lastly, one interviewee indicated their city, county or regional entity was actively lobbying the state and federal government to clarify AV rules without preempting local authority.

Perceived impacts

When asked how autonomous vehicles would impact their municipality, interviewers had a wide range of answers. A few themes emerged that mirrored the literature review section of this research paper.

- Land use changes and sprawl - 5

Five interviewees suggested that autonomous vehicles would result in increased suburban, exurban or rural development in their jurisdiction that would need to be mitigated for. Multiple of these five brought up the region’s urban growth boundary as an important tool for protecting against this behavior. Two interviewees worried about what autonomous vehicles might mean for the region’s “urban centers” development and land use planning.

- Safety implications - 5

Safety was a major topic of concern for interviewees. Many cited the recent collision in Arizona where an autonomous Uber vehicle struck and killed a pedestrian. Others cited the popular ethical dilemma, the trolley problem. With autonomous vehicles, this has often taken the form of: “if the vehicle must kill someone, does it kill the passenger, or the person outside of the vehicle?”

Interviewees also brought up liability issues under the umbrella of safety. Some worried about whether or not their jurisdiction would be liable for collisions if it implemented AV technologies that later failed.

- Congestion and vehicle miles traveled impacts - 4

Multiple interviewees brought up the issue of increased congestion due to autonomous vehicles. Many were aware of zero occupancy vehicle movements as an issue contributing to this. A few felt that any efficiencies gained in throughput due to autonomous vehicles would later balance out with more congestion because of increased demand. Many considered this issue in conjunction with the next issue.

- Equity and access - 3

Interviewees were aware of the complex and nuanced issues relating to equity and access to autonomous vehicles. All recognized the potential for increased access for populations that are currently not able to drive or face barriers to driving, such as children, the elderly, or those with certain disabilities. Interviewees also realized the potential for autonomous vehicles to exacerbate inequalities related to transportation access, particularly among historically disadvantaged communities.

- Budget impacts - 2

Two interviewees expressed concern about the financial burdens autonomous vehicles might place on their already constrained municipal budgets. One interviewee explained it would be difficult to prioritize existing operations and maintenance budgets over new connected infrastructure supporting autonomous vehicles.

- Data management - 2

Two interviewees weren’t sure how their jurisdictions would cope with both giving and receiving massive amounts of data that could be associated with autonomous vehicles. One interviewee expressed concerns about sharing out municipally-owned data to private companies, while another wasn’t certain whether their municipality had the capability of collecting, analyzing, ensuring the security of, and acting on the large amounts of data that could come their way.

Finally, interviewees listed some forecasted impacts that were not echoed in other interviews. These included autonomous vehicles and their effects on parking, pick-up and drop-off areas, pollution from brakes and oil, privatization of public assets, signal timing changes, erosion of transit ridership, and changes to mode shares and how mode shares are currently measured.

Barriers to planning for AVs

When asked about what barriers they currently face in planning for autonomous vehicles, interviewees were open and honest about not only issues in their own departments, but issues they had with the technology or the companies developing it. Their answers fit into fairly cohesive themes, with fewer one-off answers than the other interview questions.

- Uncertainty - 12

Out of 13 interviews, 12 expressed uncertainty about the future of autonomous vehicles. This theme of uncertainty could be divided into subthemes: (1) uncertainty about what infrastructure will municipalities need to provide to make AVs a reality, and how much it will cost; (2) uncertainty about the timeline—when AVs will become available, when they will become widespread; and (3) uncertainty about whether autonomous vehicles will be owned like cars today, or operate in a shared system similar to TNCs.

Because there is so much uncertainty about the nature of autonomous vehicles and their impacts on governments, the follow-up question about where interviewees learn about autonomous vehicles proved illuminating (see *information sources* below).

- Funding and resource constraints - 5

This answer echoes one of the popular answer themes from the question about forecasted impacts. However, in this case, interviewees more often commented about the constraints and pressures they already face in a rapidly growing region, often facing a lack of staffing or time to accomplish standard work, let alone take on the additional task of accommodating a new technology. Two interviewees specifically highlighted autonomous vehicles as additional work, or extra work, on top of their existing work.

- Technology isn't there yet / safety concerns - 4

Four interviewees stated that the technology for autonomous vehicles was not yet safe or operational. These interviewees often stated that they would plan for them later, when the technology was more proven. Interestingly, some of the interviewees stating that the technology was not yet complete were the same interviewees stating they had incorporated level 1 and level 2 AV technologies into their jurisdiction's fleet vehicles.

- Legal / liability issues - 4

Four interviewees believe that issues related to liability would need to be worked out in the court system or through legislation at higher levels of government before their jurisdiction could proceed with planning for autonomous vehicles.

- Private sector moving faster than the public sector - 4

This answer certainly related to the topic of uncertainty, but I felt it was a theme in its own right. Four interviewees explained how private industry, typically the ones developing autonomous vehicle technology, can move much faster than public agencies. This disparity results in government trying to play "catch-up" to find out (1) what's going on in technology development, and (b) how can and should government be involved. If a company can try one technology, then try another new technology the next month, it results in government not knowing what to do. This theme seems indicative of not only uncertainty, but communications issues between industry and government, and an issue with slow bureaucracy that's unable to act nimbly.

- Data management and security - 2

Concerns about data management and security came up as a barrier to planning for autonomous vehicles. This issue related to the theme of lacking resources or funding, but interviewees focused on agreements between governments and technology or telecom firms, managing connected assets, securing private data, and using data to inform decision making processes.

There was only one answer that did not fit into these larger themes: automation would have significant impacts on the jurisdiction's workforce, potentially resulting in significant layoffs in a union environment.

Information sources

Interviewees were very enthusiastic to share what they already knew about autonomous vehicles, and where they had learned about them. Answers spanned both the sources of information, as well as the most effective media used for reaching out to planners and their colleagues.

Sources

- Trade associations - 12

While not immediately clear after conducting the interviews, it became clear that trade associations were the largest source of information about autonomous vehicles after generalizing and tabulating the results. Interviewees identified seven different trade groups as a source of information. Often these trade groups were specific to the position or work this person does. Major trade associations identified include the American Association of Motor Vehicle Administrators, the American Planning

Association, the American Public Transportation Association, the American Public Works Association, the Institute of Transportation Engineers, Smart Cities, and the Transportation Research Board.

- Higher levels of government - 10

Another popular answer to this question was higher levels of government. However, similar to trade associations, interviewees identified a number of different groups, including the Washington State Department of Transportation, the Washington State Transit Insurance Pool, the federal government (including the U.S. Department of Transportation, the Federal Transit Administration, and the Federal Highway Administration), and the Puget Sound Regional Council. The Puget Sound Regional Council also came up frequently when asked for additional commentary (see *other thoughts* below).

- Peer networking - 6

While not as popular as trade associations or regional, state or federal government agencies, interviewees indicated that their peers were a helpful source of information about autonomous vehicles. Two interviewees specifically stated they looked to Seattle, the largest city in the region and one with robust transportation planning practices, for their expertise in planning for technology change.

- Private industry - 3

Only three interviewees identified private industry, including tech companies and autonomous vehicle developers, as sources of information about autonomous vehicles. In all three cases, interviewees had been approached by private industry rather than the jurisdiction seeking out more information.

Finally, one interviewee indicated they received some information from transportation and land use advocacy groups, naming the northwest’s Sightline Institute specifically.

Media

Interviewees identified six media that were effective in educating them about autonomous vehicles. The top medium mirrored the top answer for sources: industry conferences. Interviewees named the Transportation Research Board’s annual meeting and the American Planning Association's yearly conference, and one interviewee included the Railvolution conference. All other media were mentioned twice in interviews. Other media included email lists, committees (both being a part of committees and attending committee meetings), magazines and industry publications, webinars, and panel discussions, forums or events.

Other thoughts

It was difficult to draw major themes from the question about other thoughts because interviewees had such varied backgrounds and experience with autonomous vehicles. However, four themes did pop up, as well as dozens of one-off comments.

- Waiting for the Puget Sound Regional Council to take the lead - 3

Multiple interviewees indicated they were waiting on an update to the metropolitan planning organization's plan to include autonomous vehicles. They also indicated that autonomous vehicles would operate between jurisdictions, so they felt a regional or statewide solution would make more sense from a regulatory standpoint rather than patchwork of varying regulations from city to city, or county to county.

- Planners must be proactive and not reactive - 2

Two interviewees discussed how planners must take the lead in preparing for a future with autonomous vehicles. One cited the rise of vehicles in the 20th century to the detriment of existing streetcar systems. These interviewees were pragmatic, realizing the potential for AVs to help improve safety and transportation access, but also the potential to exacerbate congestion and equity issues. One included that government must actively work with private industry on autonomous vehicles, rather than letting autonomous vehicles change infrastructure needs and transportation systems without government input.

- Don't treat AVs as a panacea for today's transportation problems - 2

These interviewees worried that many people treat autonomous vehicles as a cure-all for the problems in today's transportation systems. They cautioned that AVs do have their pitfalls, and that governments need to be mindful of mitigating those issues rather than leaving them unchecked.

- Data management, analysis and security - 2

This issue came up when asked about potential impacts of AVs, hurdles getting in the way of planning for AVs, and now other thoughts related to planning and AVs. Interviewees highlighted the amount of data that would be collected by autonomous vehicles, and the potential to use that data for better planning transportation systems. These interviewees also highlighted data management practices that may need to change within their governments to prevent any privacy or security issues.

Finally, this question resulted in a number of one-off comments that weren't reflected in other interviews. These included:

- AV impacts on access or paratransit services
- Planning processes must be more nimble
- AVs could provide valuable first-and-last mile connections
- Most issues related to AVs have both pros and cons
- AVs could disrupt current growth and development approach
- Planners need to be prepared for unintended consequences
- Be prepared for cultural shifts in transportation attitudes
- AVs could dramatically change street designs
- Must plan for platforms and not individual services
- Rural roads present different challenges for smart infrastructure
- Long range plans must be more cognizant of technology change
- AVs could help with transit operator recruitment issues
- Moral and ethical dilemmas brought about by AVs
- Planners will need more technical skills
- AVs could mean significant changes to large vanpool systems

Conclusions + reflections

Plan performance

A majority of plans did not adequately discuss or prepare for a future with autonomous vehicles. Only nine of the 19 plans even mentioned autonomous vehicles. However, when combined to look at jurisdictions overall instead of individual planning documents, seven of the 11 jurisdictions mention autonomous vehicles in one of their planning documents.

No plan received a perfect score. Even Seattle's New Mobility Playbook, a plan entirely devoted to autonomous vehicles and technology change in the transportation sector, missed a few things identified in research related to autonomous vehicles. The most difficult questions all fell in the **AV effects** section, which makes sense as only nine out of 19 plans were able to complete that section. The remaining plans did not consider autonomous vehicles at all, and thus were not analyzed on how well they planned for the effects of autonomous vehicles. The following questions often resulted in zero or only one point awarded for most plans. Planners should better address these issues in future plan updates in order to better prepare their transportation systems for autonomous vehicles and their effects.

- Certification or licensing process for AVs.
- Infrastructure improvements to accommodate AVs (lane markings, signs, EV charging, etc.)
- Communications infrastructure improvements for AVs (ITS, V2V, V2I, cell towers, etc.)
- AVs/SAVs harm or help transit ridership
- Regulation of AVs
- Changes to revenue sources (gas tax, parking tickets, etc.)
- Economic implications (jobs lost, unemployment, etc.)
- Equity
- Urban form/design changes (pick-up and drop-off, etc.)

Plans performed best on the questions about mentioning autonomous vehicles, incorporating technology change generally, and planning for electric vehicles. This is promising because it demonstrates that planners are beginning to incorporate technology change into their planning documents, even if they haven't considered the effects of those technologies in their documents yet.

Size divide

Larger cities tended to perform better than more suburban cities. The smallest cities in the scope of this project, Marysville and Lakewood, had the lowest scores. Research indicates that autonomous vehicles will likely first come to dense urban areas, so it isn't a surprise that lower population suburbs may not have this technology change on their radar. However, Marysville and Lakewood are the second largest cities in Snohomish and Pierce counties, respectively, and they are not immune to the changes predicted to take place over the coming decades.

More frequent updates

Plans that were updated most recently included better coverage of the issue. Many plans described their update cycle in the plans themselves. The median plan was last updated in 2015, and the median plan's update cycle is every two years. Therefore, plans are due for updates within the next year if those updates aren't already currently underway, which could improve coverage of autonomous vehicles as a planning issue. In fact, interviewees explained that updates were currently pending in multiple jurisdictions.

While more recently updated plans have higher scores, it is likely difficult for some jurisdictions to provide regular updates to their plans given the resource constraints identified in quite a few interviews.

Interview insights

Regional leadership

Interviewees claimed they looked to higher levels of government, such as the Puget Sound Regional Council, for guidance on this issue. However, PSRC's two plans scored poorly in the plan analysis. Interviewees also indicated that committees, panels, webinars and emails from PSRC helped their jurisdiction in its planning processes. The metropolitan planning organization has the power to influence local governments, and should therefore be on the forefront of recommending approaches to planning for autonomous vehicles and technology change.

Similarly, interviewees looked to their peers, and especially Seattle, for leadership in planning for autonomous vehicles. This is good news because Seattle's *New Mobility Playbook* does an excellent job preparing the city for the potential benefits of autonomous vehicles will pointing out and preparing policies to mitigate the potential consequences of AVs. Because committees, meetings and working groups were popular learning methods, governments should seek to build better relationships and plan events with governments like Seattle and Everett, who are clearly leading the pack when it comes to planning for a future with autonomous vehicles.

Regional leadership is particularly important if we look at the most anticipated impacts of autonomous vehicles identified by planners in these interviews. Interviewees were most concerned about land use and sprawl, a regional issue currently managed by the Puget Sound Regional Council, and safety concerns, which are often regulated at the state and federal level.

Private industry partnerships

Uncertainty was a huge roadblock in planning for autonomous vehicles, yet interviewees indicated that private industry is not a large source of information about autonomous vehicle technology. Similarly, only four plans mentioned autonomous vehicle pilot programs. It seems like governments could demystify the uncertainty by developing relationships with firms working on autonomous vehicle development. These relationships needn't be pilot programs, but regular communication, committees or working groups could help the public sector to better prepare for changes being thrust upon it by the private sector.

Trade associations

Interviewees indicated that their information about autonomous vehicles largely comes from trade associations. This is valuable because trade associations provide a large experience pool for colleagues to share information and network. However, trade associations could play an even larger role by inviting autonomous vehicle developers into the fold for conferences, events and webinars as a way to better disseminate information about the technologies under development and their potential impacts.

In relation to previous studies

The two existing studies closest to this study are Guerra's 2016 evaluation of the United States' 25-largest metropolitan planning organizations in how they plan for autonomous vehicles, and the National League of Cities' 2015 evaluation of transportation plans for the United States' 50 most populous cities.

The NLC study found that most plans project out to between 2030 and 2040 on average, similar findings to this study. It finds that only 6% of plans "consider the potential effect of driverless technology" (DuPuis et al. 2015). The publication about this study does not include information about its methodology. It does include quotes from transportation planners in major cities discussing uncertainty and the need for planners to move more quickly and partner with private industry, (DuPuis et al. 2015) all key themes identified in my research focused on the Puget Sound region.

Guerra's study aligns even closer with this one, both evaluating metropolitan planning organization documents and following up with planners from those MPOs. Those interviews found that uncertainty, "too far removed" timelines and impacts, and AVs being just one of many large technological changes were the strongest reasons planners had for not including AVs in their plans (Guerra 2016). Two of these three themes are mirrored in my research. Further, Guerra only identified one plan from an MPO that even mentioned autonomous vehicles, but found that planners were doing more to research AVs than what had been included in their plans. These findings are a bit more dire than those found in this research, where at least nine of 19 plans mentioned AVs, but these results are not in conflict given that (a) Guerra's research is now two years old, and (b) that the two plans from the one MPO in my study's scope (Vision 2040 and Transportation 2040, from the Puget Sound Regional Council) neglect to even mention autonomous vehicles. This suggests that cities or counties may be more nimble in responding to technological change, and warrants further research in this area.

Reflection

This research provided valuable insight into what Puget Sound governments are doing to prepare for autonomous vehicles, but I think the most interesting aspects of this project covered what governments aren't doing, and the roadblocks getting in their way. Providing anonymity allowed interviewees to speak candidly about the issues they face in planning, but made it so that a jurisdiction's plan analysis scores could not be compared to interview notes because of the potential for backlash or repercussions against an individual speaking about their jurisdiction's weaknesses publicly.

Ideally more professionals would participate in the interview process. While I was able to interview a wide variety of people, I was not able to interview a person from each jurisdiction. Having input from planners, engineers, budgeting and finance, and facilities and operations departments was incredibly useful, and it would be valuable to have representatives from all of those departments for every jurisdiction within the scope of this research project.

While this project focused on what governments are doing, I think a supplemental component could have interviewed autonomous vehicle developers and those "in industry" to learn more about their perspective on what governments are (and aren't) doing to prepare. This research project only captured the public sector's view on AVs, and the private industry could provide more perspective on the issue.

Finally, changing the scope of the project to include state agencies could better show what the region is doing to prepare as many interviewees indicated they work with state agencies particularly on issues related to safety and regulation. There are studies that have already examined what the largest cities and metropolitan planning organizations in the country are doing to prepare for autonomous vehicles (DuPuis 2016)(Guerra 2016), so for that reason I believe that including smaller cities and counties in the scope of this project provided valuable new insight.

Appendix A
Glossary of terms

Autonomous Vehicles (AVs). Also sometimes called self-driving cars or driverless cars.

Carsharing. A system where multiple people use one vehicle at different times, often through reserving through an app. Popular carsharing services include Zipcar, Car2go and ReachNow.

DARPA. A common acronym used for the Defense Advanced Research Projects Agency, a division of the United States Department of Defense. The agency regularly hosts robotics challenges to help advance certain technologies. DARPA challenges between 2004 and the present have largely centered on autonomously operated robots, including vehicles.

Electric Vehicles (EVs). Vehicles using electricity instead of gasoline for power. Electric vehicles can be autonomous or non-autonomous.

Metropolitan Planning Organization (MPO). A regional planning body. For the Seattle area this is the Puget Sound Regional Council, covering King, Pierce, Snohomish and Kitsap counties.

Puget Sound region. The metropolitan area centered around Washington's Puget Sound. Includes Seattle, Tacoma and other cities. Some definitions include King, Pierce, Snohomish and Kitsap counties, while others only include King, Pierce and Snohomish.

Puget Sound Regional Council (PSRC). Often referred to by its acronym. The region's metropolitan planning organization.

Semi Autonomous Vehicles. Vehicles that are considered to have levels one, two, three or sometimes four of automated controls according to the standards put out by the Society of Automotive Engineers. This includes things like driver blind spot assistance or lane correction.

Shared Autonomous Vehicles (SAVs). Autonomous vehicles shared between various users.

Society of Automotive Engineers (SAE). Put together standards to classify various levels of automation ranking from zero (non-autonomous) to five (fully autonomous).

Transportation Network Companies (TNCs). Also sometimes called ridehailing services or ridesharing applications. It's a generic term for companies providing on-demand app-based transportation services, such as Uber and Lyft.

Vehicle Miles Traveled (VMT). A measure of transportation demand. VMT measures the amount of miles traveled for all vehicles in a certain area during a certain time period, typically one year. For example, one might refer to all of the VMT for the Puget Sound region over the last year, and compare it to previous years.

Vision Zero. A common program for city, county and state departments of transportation to adopt. Involves setting a goal of zero traffic deaths and fatalities and finding approaches to achieve that goal.

Appendix B
Plan analysis criteria

Jurisdiction, plan name

Plan Background

1. When was the plan originally created?
2. When was the plan last updated?
3. How often is the plan updated?
4. How far out does the plan project (number of years)?
5. How far out does the plan project (year it projects to)?

Technology

6. Does the plan mention autonomous vehicles at all?
7. Does the plan consider both shared autonomous vehicle and non-shared autonomous vehicle schemes?
8. Does the plan consider transportation network companies or services?

Effects

9. Does the plan consider both the potential for increases and decreases in vehicle miles traveled brought about by autonomous vehicles?
10. Does the plan consider implications of VMT increases? (ie: congestion, emissions)
11. Does the plan consider zero-occupancy vehicle movements? (no passengers, repositioning movements, etc.)
12. Does the plan consider land use changes due to autonomous vehicles (ie: increased urbanization, repurposing of urban land (particularly parking), and increased rural and exurban development
13. Does the plan consider urban form/urban design changes, such as pick-up and drop-off zones necessary to accommodate AVs?
14. Does the plan consider economic implications of automation? (ie: jobs lost currently in the transportation sector, such as transit drivers, mechanics, etc.)
15. Does the plan consider decreased costs (ie: transit labor) due to automation?
16. Does the plan consider changes in revenue sources due to automation, or secondary implications of automation? (ie: fewer traffic and parking violations, gas tax v. mileage tax)
17. Does the jurisdiction have any test or pilot programs in place related to autonomous vehicle technologies (ie: level 1-2 automation of tasks, partnerships with TNCs, etc.)

18. Does the jurisdiction plan for both fully-autonomous vehicles, semi-autonomous vehicles, and a period in which autonomous and non-autonomous vehicles mix?
19. Do infrastructure plans take into account increased demand for communications infrastructure? (ie: intelligent transportation systems, v2v, v2i, cell towers, fiber, etc.)
20. Does the plan consider data management, information technology, privacy and security matters?
21. Does the plan consider other infrastructure changes necessary to accommodate autonomous vehicles? (ie: standardized lane markings, signs, electric vehicle charging, etc.)
22. Does the plan mandate adoption of new technologies associated with increased safety? (ie: collision warning systems, forward collision and lane departure warnings, blind spot assistance, and adaptive headlights)
23. Does the plan consider equity concerns regarding autonomous vehicles?
24. Does the plan consider adoption of autonomous vehicle technology in municipally-owned fleets? (ie: transit vehicles, emergency vehicles, other city-owned vehicles)
25. Does the plan consider AVs/SAVs and their potential to either harm or help transit ridership?
26. Does the plan consider electric vehicles?
27. Does the plan consider utility infrastructure needs to support electric autonomous vehicles? (ie: charging stations, increased power sources/supply, etc.)
28. Does the plan outline or include discussion of regulating autonomous vehicles?
29. Does the jurisdiction outline a certification or licensing process for autonomous vehicles?

Appendix C
Results spreadsheet

Plans

	PSRC	PSRC	Sound Transit	Sound Transit	King County	King County	Seattle	Seattle	Seattle	Bellevue	Snohomish County	Snohomish County	Everett	Marysville	Pierce County	Pierce County	Tacoma	Tacoma	Lakewood
Plan name(s)	Vision 2040	Transportation 2040	Sound Transit 3	Sound Transit Long Range Plan	King County Comprehensive Plan	Metro Connects Long Range Plan	Seattle Comprehensive Plan	Move Seattle (Transportation/SDOT Plan)	New Mobility Playbook	Bellevue Comprehensive Plan	Snohomish County Comprehensive Plan	Community Transit Long Range Plan	Everett Comprehensive Plan	Marysville Comprehensive Plan	Pierce County Comprehensive Plan	Pierce Transit Long Range Plan	Tacoma Comprehensive Plan	Tacoma Transportation Master Plan	Lakewood Comprehensive Plan
First adopted	2008	2010	2016	1996	2016	2016	2015	2015	2017	2015	2010	2010	2015	2015	2015	2015	2015	2015	2000
Last updated	2014	2014	2016	2014	2016	2016	2017	2015	2017	2017	2016	2011	2017	2015	2015	2016	2015	2015	2014
How long between major updates (years)	-	4	-	-	4	6	1	-	0.5	1	-	1	-	-	2	4	-	-	-
How far out does it project	30	30	24	-	20	10/25	20	10	1.5 - 5 years	20	20	20	20	20	20	25	25	25	30
When does it project to?	2040	2040	2040	-	-	2025/2040	2035	2025	March 2019 to 2022	2035	2030	2030	2035	2035	2035	2040	2040	2040	2030
Does the plan include autonomous vehicles at all?	1	1	2	1	0	2	2	2	3	2	0	0	3	0	0	2	1	3	0
Describe	"The transportation policies call for reducing pollution through cleaner cars, buses, and trucks, cleaner fuels, and fewer vehicle miles traveled. Future mobility needs must consider alternatives to fossil fuels, new transportation technologies, and more alternatives to driving alone"	"We must make the most of our existing transportation system. This requires managing our assets 24 hours a day, seven days a week as efficiently as possible. It also includes the deployment of the most efficient technologies to provide information to the traveling public and to operators so they can make informed, smart transportation choices."	Includes one line about leveraging "future transportation technologies such as driverless cars to complement and expand the reach of high-capacity transit" and implementing other technologies to find efficiencies and save costs.	Talks about technology innovation, change and flexibility as key to improving service into the future. This includes first-and-last mile connections, cost savings and convenience.	Describes new transportation technologies but only as it relates to carbon emissions (ie: electric vehicles) and does not leave it open ended to other types of new transportation technologies	Mentions automated vehicles and automated buses, but does not consider implementation or effects, or include any discussion of the technology.	Includes shared mobility and access to new technology. Calls out carsharing and "new technologies" in an open ended way, and that "and driverless vehicles will change the way people move through Seattle".	Mentions a pilot project of an automated transit vehicle, but otherwise mostly talks about TNCs and apps. Does leave very open ended with references to new technology and changes that are hard to predict	This document is entirely about autonomous vehicles and technology change in transportation, the effects these changes may have, and different strategies for shaping that change.	TR-38. "Monitor and implement as appropriate, emerging technologies related to autonomous vehicles and other transportation technologies that are intended to improve mobility, safety, efficiency and people-moving capacity on existing and planned transportation facilities."	Does not mention new transportation technologies or AVs.	Describes new transportation technologies but only as it relates to carbon emissions (ie: electric vehicles) and does not leave it open ended to other types of new transportation technologies	Considers effects of autonomous vehicles and new transportation technologies, specifically mentioning potential for both increases and decreases in vehicle-miles traveled due to increased access, as well as emissions implications of new technologies. Leaves open ended and calls for further research as technologies become more developed	Does not mention new transportation technologies or AVs.	Does not mention new transportation technologies or AVs.	Includes a paragraph talking about rise of autonomous vehicles and potential for use on transit, but does not consider the implications of adopting this new technology, and leaves it open-ended: "autonomous vehicles have the potential to create new opportunities for growth in transit services in ways which cannot presently be imagined."	"Employ emerging technology to enhance transportation system efficiency" and "Tacoma recognizes that transportation needs and travel choices may change over time as new alternatives become available"	Addresses semi-autonomous vehicles (levels 1, 2 and 3) and their potential for interim adoption, considers VMT, access and liability issues. Discusses pros and cons, and leaves open ended for further research when more information is available.	Does not mention new transportation technologies or AVs.
TNCs/other tech transportation services	0	0	2	1	0	0	3	3	3	3	0	0	0	0	0	1	1	1	0
Describe	Does not address	Does not address	Refers to mobility on-demand services as a potential for first-and-last mile connections to transit service	Highlights potential for opportunities to develop and run shuttle and/or circulator systems that would expand the scope of transit station service areas.	Does not address	Does not address	Referred to as shared mobility services. Addressed in multiple areas.	Talks about TNCs and apps, and references other new technologies and changes.	This document is entirely focused on autonomous vehicles, shared mobility services, their pros and cons.	Refers to implementing emerging technologies to improve mobility, safety and efficiency.	Does not address	Does not address	Considers semi-autonomous features (lane correction, blind spot recognition, etc.) and electric vehicles, but not TNCs or other transportation services.	Does not address	Does not address	Talks about a zonal transportation service that could operate like Uber or Lyft in providing increased access in rural areas to transit stops. Does not consider actual TNCs operating in Pierce County today.	Mentions bikeshare, but does not mention TNCs or other more popular tech transportation services	Mentions carsharing service Zipcar, but does not mention TNCs or other more popular tech transportation services	Does not address
Increases/decreases in VMT	-	-	0	-	-	0	0	0	3	0	-	-	3	-	-	0	-	3	-
Describe	-	-	Addresses VMT decreases from increased transit service. Does not address VMT through lens of AVs.	-	-	Does not address	Does not address VMT changes caused by AVs	Does not address	Considers the potential for increases and decreases, and the effects caused by changes to VMT	Does not address	-	-	Discusses how AVs have the potential to both increase and decrease VMT depending on the business models used and the regulations put in place.	-	-	Identifies decreasing vmt as a plan goal, but does not tie it in with AVs.	-	Mentions that new populations will have access to transportation services with AVs, and that there may be more vehicles on the road, but that AVs create efficiencies. Says future of VMT with AVs is unknown at this time and/or may go down.	-
Implications of VMT increases (congestion, emissions)	-	-	0	-	-	0	0	0	3	0	-	-	3	-	-	0	-	0	-
Describe	-	-	Addresses VMT decreases from increased transit service. Does not address VMT through lens of AVs.	-	-	Does not address	Discusses VMT and relationship to emissions and congestion, but does not relate to AVs	Does not address	Considers the potential for increases and decreases, and the effects caused by changes to VMT	Does not address	-	-	Discusses increases of VMT and the ties to congestion and emissions.	-	-	Identifies decreasing vmt as key to improving sustainability, but does not tie it in with AVs.	-	Does not address	-
Zero occupancy vehicle movements	-	-	0	-	-	0	0	0	3	0	-	-	3	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	Does not address	Does not address	Considers zero occupancy vehicle movements and how they contribute to VMT/congestion, considers policies to mitigate this.	Does not address	-	-	Includes language about people sending their vehicles on errands without anyone inside when discussing VMT and AVs.	-	-	Does not address	-	Does not address	-
Equity	-	-	0	-	-	0	0	0	3	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Addresses equity but not within context of AVs	Covers race and social equity extensively, but not within the context of AVs	Addresses geographic equity, but not within the context of autonomous vehicles	Has an entire section devoted to equity concerns related to autonomous vehicles, and ways to mitigate those concerns.	Addresses equity but not within context of AVs	-	-	Does include some brief language in economic section about disadvantaged communities, but doesn't talk about transportation equity, or equity within the context of AVs.	-	-	Does not address	-	Has equity and access goals for its transportation system, does not tie it in with AVs	-
Land use changes (urbanization, rural development)	-	-	0	-	-	0	0	0	3	0	-	-	3	-	-	0	-	3	-
Describe	-	-	Does not address	-	-	Does not address	Addresses land use but not within context of AVs	Does not address	Considers changes to land use in urban areas caused by repurposing parking and infill development. Does not consider sprawl or rural development caused by AVs specifically, but does call for AVs to carry out the City's land use goals.	Addresses land use but not within context of AVs	-	-	[because of autonomous vehicles] "the City should monitor shifts in demographics, where people are choosing to live and the availability of alternative forms of transportation to ensure that its infrastructure is accommodating changing needs, in whatever form that is.	-	-	Has section on transit-supportive land use, but doesn't tie in with AVs and their effects on land use.	-	[because of autonomous vehicles] "the City should monitor shifts in demographics, where people are choosing to live and the availability of alternative forms of transportation to ensure that its infrastructure is accommodating changing needs." (looks like Tacoma and Everett have significant overlap/sharing in their plans)	-
Urban form/design changes (pick-up and drop-off, etc.)	-	-	0	-	-	1	0	0	3	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Mentions access to transit within context of transportation network companies (TNCs) and carsharing.	Does not address	Addresses urban form and street design, and even some vehicle loading and unloading, but not within the context of TNCs or autonomous vehicles	Includes a specific policy to expand pick-up/drop-off zones city wide	Addresses load/unload areas for carpools and vanpools, but not for AVs	-	-	Does not address	-	-	Addresses transit friendly street designs, but does not include AVs.	-	Does not address	-
Economic implications (jobs lost, unemployment, etc.)	-	-	0	-	-	0	0	0	3	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	Does not address	Does not address	Addresses the potential for job loss through automating certain positions.	Does not address	-	-	Does not address	-	-	Does not address	-	Does not address	-
Decreased costs due to automation (labor costs, etc.)	-	-	1	-	-	1	0	0	2	0	-	-	0	-	-	1	-	0	-
Describe	-	-	"Invest in technologies or services that can meet the agency's sustainability goals and/or reduce long-term operating costs."	-	-	"Pilot and start new service models to reduce costs and improve service quality." within context of technology change.	Does not address	Does not address	Mentions decreased operational costs for wheelchair-assisted taxi program.	Does not address	-	-	Does not address	-	-	Identifies TNC-style community vans as potential cost savers for transit service in rural areas	-	Does not address	-
Changes to revenue sources (gas tax, parking tickets, etc.)	-	-	0	-	-	0	0	0	3	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	Does not address	Does not address	Considers revenue losses due to loss of gas taxes, commercial parking taxes and other parking fees. Looks at other revenue sources in appendix (draft policy framework).	Does not address	-	-	Does not address	-	-	Does not address	-	Does not address	-
Pilot programs (AVs, TNCs, level 1-2 automation, etc.)	-	-	0	-	-	2	0	2	3	0	-	-	0	-	-	2	-	0	-
Describe	-	-	Does not address	-	-	"Pilot new and innovative services and technology applications. Advances in real-time, on-demand transit may enable us to serve low-density areas more effectively, providing connections to local activity centers and to regional and local fixed-route transit. Changes in the way we get around could include ridesharing options, on-demand van service, use of automated vehicles, traffic management innovations, and other advances in technology yet to come."	Does not address	Calls for Metro and other transit providers to pilot automated transit vehicles	Calls for pilot projects, specifically partnering with King County Metro and Sound Transit, to test first-and-last mile connections, microtransit. It also calls for pilots for expanding load zones, wheelchair accessible taxi programs, and data analysis positions.	Does not address	-	-	Calls for the city to foster adoption of electric vehicles, but doesn't mention any projects underway or promote pilots for AV technology	-	-	Identifies TNC-style community vans for rural area transit service, transportation on-demand services, as potential pilot programs.	-	Does not address	-
Plan for fully AV roadways, and period with AVs and non-AVs mixed?	-	-	0	-	-	0	0	0	3	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	Does not address	calls for Metro and other transit providers to pilot automated transit vehicles	Appendix addresses this - calls for allowing mix of all levels of autonomous vehicles on Seattle streets	Does not address	-	-	Does not address	-	-	Does not address	-	Does not address	-
Infrastructure improvements to accommodate AVs (lane markings, signs, EV charging, etc.)	-	-	0	-	-	0	0	0	2	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	Establishes flex zones for prioritizing curb space on roadways, but does not tie these improved load/unload zones to AVs (mostly talks about commercial load/unload)	Much of it is a capital improvement plan, but the improvements are not specific to, preparing for, or mitigating autonomous vehicle effects	Addresses electric vehicle charging, but does not address lane markings, signs, or other physical infrastructure that may be necessary for AV operations.	Talks about infrastructure improvements to promote transit, biking and walking but does not include AVs. Refers to upgrading and maintaining existing infrastructure to support new tech economy, but does not mention AVs.	-	-	Does not address	-	-	Does not address	-	Does not address	-
Communications infrastructure improvements for AVs (ITS, V2V, V2I, cell towers, etc.)	-	-	0	-	-	0	0	0	3	0	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	Discusses ITS and fiber optic networks and other information and communication infrastructure, but does not tie into technology change in transportation or AVs.	Does not address	Specifically addresses data infrastructure, including V2V, V2I and communications needs.	Does include intelligent transportation systems and cell towers, but not within lens of AVs.	-	-	Does not address	-	-	Does not address	-	Includes ITS in quite a few places, but does not tie in with future technology development or AVs	-
AV technology in municipality fleets	-	-	1	-	-	3	0	0	0	0	-	-	0	-	-	0	-	0	-

Plans

	PSRC	PSRC	Sound Transit	Sound Transit	King County	King County	Seattle	Seattle	Seattle	Bellevue
Plan name(s)	Vision 2040	Transportation 2040	Sound Transit 3	Sound Transit Long Range Plan	King County Comprehensive Plan	Metro Connects Long Range Plan	Seattle Comprehensive Plan	Move Seattle (Transportation/SDOT Plan)	New Mobility Playbook	Bellevue Comprehensive Plan
Describe	-	-	"Evaluate and implement other technologies to improve rider experience and/or save operating costs"	-	-	Calls for incorporating AV technology into transit vehicles including object recognition technology.	Does not address	Does not address	Does not address	Does not address
AVs/SAVs harm or help transit ridership	-	-	0	-	-	0	0	0	3	0
Describe	-	-	Does not address	-	-	Does not address	Does not address	Does not address	Discusses the ways AVs could both erode ridership base for public transit, as well as provide a useful first/last mile connection helping transit	Does not address
Regulation of AVs	-	-	0	-	-	0	0	0	3	0
Describe	-	-	Does not address	-	-	Does not address	Does not address	Does not address	Appendix C offers a draft policy framework with a series of regulations identified	Does not address
Certification or licensing process for AVs	-	-	0	-	-	0	0	0	1	0
Describe	-	-	Does not address	-	-	Does not address	Does not address	Does not address	Assigns responsibility for licensing to state government	Does not address
Data management, IT, privacy and security	0	0	0	0	1	3	0	0	3	0
Describe	Does not address	Does not address	Does not address	Does not address	States that King County will "continue to explore improvements to system design, contracting, data collection and analysis;" - so very open ended, not referring to specific data management and IT issues in any detail	"Better integrate data into our planning and customer service work. Create systems that better manage the information we give customers and the feedback we receive from them, and improve internal data collection and reporting."	Describes fiber and other information and communication infrastructure the city owns, but does not consider management or expansion of it. Talks about data driven planning, but does not consider data management practices.	Discusses increasing use of data to drive planning and decision making, does not mention data management, IT, privacy or security	Includes multiple discussions of data management, information infrastructure, privacy and security. Calls for anonymizing personally identifiable data collected by AVs.	Does not address
Mandate/encourage adoption of safety affiliated technologies (collision warning systems, lane departure, etc.)	0	0	1	0	0	2	0	0	1	2
Describe	Does not address	Does not address	Creates a fund to implement new technologies in transit service, including autonomous and other technologies. Does not mandate, nor does the plan discuss specific technologies or how they'll be implemented.	Does not address	Does not address	Includes technological safety upgrades in the future fleet section, including pedestrian warning sounds and license plate recognition technology, which would both use computer vision	Does not address	Does not address	Acknowledges safety benefits created by new technologies, remains neutral on encouraging adoption.	Encourages city to "monitor and implement as appropriate, emerging technologies related to autonomous vehicles and other transportation technologies that are intended to improve mobility, safety, efficiency and people-moving capacity"
Electric vehicles	0	1	0	0	3	3	3	0	3	3
Describe	Does not address	"Recognize that improvements to vehicles and fuels will play a crucial role in reducing emissions. PSRC has undertaken research with the Department of Ecology on the potential technological advances that may be likely in our region by the year 2040."	Does not address	Does not address	Has a thorough discussion of converting government vehicles (fleet), vanpool and transit vehicles to electric.	Calls for increasing electrification of an already partially electric fleet (trolley buses using electrical overhead wiring) through expansion of trolley system and adopting electric bus technology.	Contains policy promoting adoption of electric vehicles	Encourages SDOT to partner with Metro for battery bus pilot project, but does not mention EVs anywhere in the plan.	Appendix (draft policy frameworks) mandates that all AVs must be EVs	"Promote the use of alternative fuels such as electricity and compressed natural gas and evaluate the use of such fuels for the city's vehicles."
Utility infrastructure needs to support electric vehicles	3	0	1	0	3	0	3	0	0	1
Describe	Anticipates further electricity demand and discusses strategies for developing other sustainable electrical sources	Does not address	"Work to maximize energy efficiency and make the agency's electricity use carbon-neutral via onsite renewable energy projects and other strategies."	Does not address	Full discussion of different electricity sources and priorities in the future	Does not address	Includes language recognizing electrical resource constraints specifically due to increases in electric vehicles. Discusses strategies for increasing electrical sources. Also discusses expansion of EV charging stations.	Does not address	Does not address	Predicts increased need for electrical service and identifies strategies with Puget Sound Energy to work on that. Doesn't call out EVs specifically, but refers generally to new technologies.
Score	**4**	**2**	**8**	**2**	**7**	**17**	**11**	**7**	**57**	**11**
Combined score for jurisdiction	*5*		*8*		*20*		*57*			*11*

	Snohomish County	Snohomish County	Everett	Marysville	Pierce County	Pierce County	Tacoma	Tacoma	Lakewood
Plan name(s)	Snohomish County Comprehensive Plan	Community Transit Long Range Plan	Everett Comprehensive Plan	Marysville Comprehensive Plan	Pierce County Comprehensive Plan	Pierce Transit Long Range Plan	Tacoma Comprehensive Plan	Tacoma Transportation Master Plan	Lakewood Comprehensive Plan
Describe	-	-	Talks about certain technologies that are already available and in use in vehicles on Everett's roadways, but does not mention the city's own fleets.	-	-	Does not address	-	Does not address	-
AVs/SAVs harm or help transit ridership	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	-	Does not address	-
Regulation of AVs	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	-	Does not address	-
Certification or licensing process for AVs	-	-	0	-	-	0	-	0	-
Describe	-	-	Does not address	-	-	Does not address	-	Does not address	-
Data management, IT, privacy and security	0	0	0	0	0	0	0	0	0
Describe	Does not address	Does not address	Calls for creation of multiple databases for various purposes, but does not discuss data management, security, privacy or other IT management related concerns.	Does not address	Does not address	Does not address	Does not address	Does not address	Does not address
Mandate/encourage adoption of safety affiliated technologies (collision warning systems, lane departure, etc.)	0	0	1	0	0	0	0	0	0
Describe	Does not address	Does not address	Talks about "braking assistance, lane guidance, and blind-spot recognition" technologies, then later refers to encouraging the adoption of certain technologies that make driving more efficient and safer	Does not address	Does not address	Does not address	Does not address	Talks about "braking assistance, lane guidance, and blind-spot recognition" technologies, but doesn't talk about encouraging adoption of these technologies	Does not address
Electric vehicles	0	0	3	0	0	2	0	3	0
Describe	Does not address	Does not address	Supports increase in use of electric vehicles, discussed throughout transportation section of plan	Does not address	Does not address	Mentions "exploring" electric and hybrid vehicles for its vanpool fleet, as well as applying for a grant to test six electric buses in its fleet	Does not address	"Encourage and promote the use of EVs as they are developed in all automobile, truck, and commercial vehicle classes"	Does not address
Utility infrastructure needs to support electric vehicles	1	0	3	1	0	0	1	3	0
Describe	Predicts increased need for electrical service and identifies strategies with the electric utility (non-county operated) to work on that. Attributes growth in need to population growth, not technology or innovation. Does call for re-evaluating anticipated service levels every few years.	Does not address	Supports increasing infrastructure to acommodate EVs, such as easing land use restrictions and providing encouragement to build more EV charging stations	Eases land use/zoning requirements to make it easier to build electric vehicle charging stations	Does not address	Does not address	Predicts increased need for electrical service and identifies strategies with the electric utility (non-county operated) to work on that. Attributes growth in need to population growth, not technology or innovation. Does call for re-evaluating anticipated service levels after 2020	"Provide for a broad range of charging opportunities at public and private parking venues throughout the City, including minimum standards for new developments that provide parking facilities."	Does not address
Score	**1**	**0**	**22**	**1**	**0**	**8**	**3**	**16**	**0**
Combined score for jurisdiction	*1*		*22*	*1*	*8*		*16*		*0*

Jurisdiction	Plan	Year adopted	Points	Score on #6
Seattle	New Mobility Playbook	2017	57	3
Everett	Everett Comprehensive Plan	2017	22	3
King County	Metro Connects Long Range Plan	2016	17	2
Tacoma	Transportation Master Plan	2015	16	3
Bellevue	Bellevue Comprehensive Plan	2017	11	2
Seattle	Seattle Comprehensive Plan	2017	11	2
Sound Transit	Sound Transit 3	2016	8	2
Pierce County	Pierce Transit Long Range Plan	2016	8	2
Seattle	Move Seattle (SDOT 10 year plan)	2015	7	2
King County	King County Comprehensive Plan	2016	7	0
Puget Sound Regional Council	Vision 2040	2014	4	1
Tacoma	Tacoma Comprehensive Plan	2015	3	1
Puget Sound Regional Council	Transportation 2040	2014	2	1
Sound Transit	Sound Transit Long Range Plan	2014	2	1
Snohomish County	Snohomish County Comprehensive Plan	2016	1	0
Marysville	Marysville Comprehensive Plan	2015	1	0
Snohomish County	Community Transit Long Range Plan	2011	0	0
Pierce County	Pierce County Comprehensive Plan	2015	0	0
Lakewood	Lakewood Comprehensive Plan	2014	0	0

Combined Scores	Score	Population #	#6
Seattle	57	713,700	3
Everett	22	109,800	3
King County	20	2,153,700	2
Tacoma	16	208,100	3
Bellevue	11	140,700	2
Sound Transit	8	3,802,500	2
Pierce County	8	859,400	2

Appendix D
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