VISION 2050

Technology

Briefing Paper

May 2019

Puget Sound Regional Council

Funding for this document provided in part by member jurisdictions, grants from U.S. Department of Transportation, Federal Transit Administration, Federal Highway Administration and Washington State Department of Transportation. PSRC fully complies with Title VI of the Civil Rights Act of 1964 and related statutes and regulations in all programs and activities. For more information, or to obtain a Title VI Complaint Form, see https://www.psrc.org/title-vi or call 206-587-4819. Sign language, and communication material in alternative formats, can be arranged given sufficient notice by calling 206-464-7090, TTY Relay 711.

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Introduction

In recent years, potentially transformative technologies have captured the imagination of the public, elected officials, and planners alike. With increasing shared mobility options, the rise of e-commerce, continued growth in vehicle electrification and the emergence of connected and automated vehicles, the future could look quite different from the past.

These transportation technologies span a wide spectrum in terms of their deployment timelines, maturity levels, and anticipated benefits, as well as potential risks. Existing technologies, including electric vehicles (EVs) and shared mobility services such as Car2Go, Lime, Lyft, and Uber, are providing new mobility options for travelers in an increasing number of cities. The availability of these alternatives provides some understanding of their benefits and challenges, but there are still unknowns in terms of their growth, long-term impacts on travel choices, and integration with other technologies such as automated vehicles.

Emerging technologies such as connected and automated vehicles (CAVs) have advanced significantly in the last few years, but many unknowns remain. CAV technology hit a key milestone with the recent launch of a limited commercial self-driving taxi service in Phoenix, Arizona.[1] While this represents a significant development, the technology is still not widely deployed and technical, safety, cost challenges remain. A thorough understanding of impacts is not yet feasible.

The technology spectrum will continue to evolve as more transportation services and tools are deployed and new ones are introduced. A key challenge for planners is to integrate these technologies into the planning framework and ensure that outcomes are in line with stated policy goals. Rather than focusing on the technology specifics, it is important to understand the cross-cutting nature of potential changes and develop flexible and proactive guidance that helps support local and regional goals.

[1] Laris, M. (2018, December 5). Waymo launches nation's first commercial self-driving taxi service in Arizona. Retrieved from https://www.washingtonpost.com/local/trafficandcommuting/waymo-launches-nations-first-commercial-self-driving-taxi-service-in-arizona/2018/12/04/8a8cd58a-f7ba-11e8-8c9a-860ce2a8148f_story.html?utm_term=.1d62868c7f2f

As part of the VISION 2050 update, this briefing paper focuses on the intersection of emerging transportation technologies and land use. VISION 2050 is the long-term strategy for sustaining a healthy environment, thriving communities, and a strong economy as the region grows. VISION 2050 is anticipated to be adopted by the Puget Sound Regional Council's General Assembly in 2020 and will be complemented by policies and strategies to be developed by local jurisdictions to guide growth and development within their respective boundaries.

Highlighted in this briefing paper are considerations relevant for regional and local stakeholders within this context of land use, growth management, and the changing nature of transportation technology. The topics in this paper are focused specifically on the interaction between technology and land use/growth decisions and are not meant to be an exhaustive list. This paper builds on prior work in the Regional Transportation Plan and will feed into the development of PSRC's larger work program to plan for emerging transportation technologies in a comprehensive manner, and help the region prepare for the associated changes on the land use and transportation system.

The following section provides a brief overview of electric vehicles, shared mobility options, and connected and automated vehicles. These technologies were selected based on the current state of development, deployment status, expected overlap between them, and relevance to the conversation on growth and land use planning. More detailed information on these technologies is provided in the Regional Transportation Plan. There are other technologies that are emerging in the transportation landscape, including unmanned aerial vehicles and drone deliveries, which have started receiving attention. PSRC will continue to monitor these emerging transportation technologies and incorporate them into the planning framework as applicable.

Electric Vehicles

Photo Credit: WA Department of Commerce

Electric vehicles (EVs) refer to a family of vehicles powered by electric motors, particularly those charged by plugging directly into the electric grid, as well as hybrid electric vehicles, which employ a mix of batteries and gasoline as energy sources. In the last few years, the share of EVs in the global market has steadily increased and this trend is expected to continue for all types of vehicles from bicycles to passenger cars, freight, and public transport vehicles.[2,3] The growth in EVs has been particularly robust on the West Coast, in part due to government policies, financial incentives, subsidies, and investments in public charging infrastructure.[4]

Many vehicle manufacturers are also shifting resources into EVs to meet global climate change goals and standards set by governments regarding vehicle emissions of carbon dioxide and other pollutants. EV prices are forecasted to decline as automakers benefit from increased investment and economies of scale for larger volume vehicle production. Increasing affordability, combined with government policies, incentives, and informational campaigns, could make EVs increasingly popular, but local conditions such as the ability to quickly and reliably access a standardized network of charging stations will be critical to widespread EV adoption.

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[2] Bloomberg New Energy Finance (2018). Electric Vehicle Outlook 2018. Retrieved from https://about.bnef.com/electric-vehicle-outlook/#toc-download

[3] Energy Insights (2017, September). New reality: electric trucks and their implications on energy demand. Retrieved from http://www.mckinseyenergyinsights.com/insights/new-reality-electric-trucks-and-their-implications-on-energy-demand/

[4] Lutsey, N., Slowik, P., & Jin, L. (2016). Sustaining electric vehicle market growth in US cities. International Council on Clean Transportation. Retrieved from https://www.theicct.org/sites/default/files/publications/US%20Cities%20EV%20mkt%20growth_ICCT_white-paper_vF_October2016.pdf

Shared Mobility

Shared mobility refers to transportation vehicles and services that are shared among users. This includes:

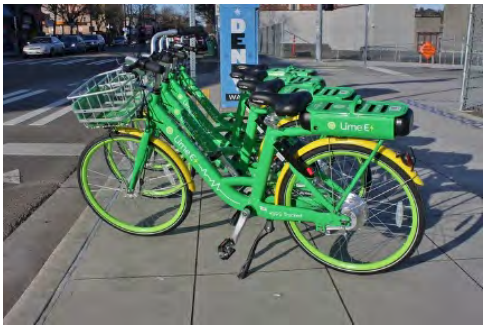

Photo Credit: Bruce Englehardt, 2018

- Ride-hailing (Lyft, ReachNow, Uber), also called transportation networking companies (TNCs), for single-trip car rides picked up and dropped off by a driver
- Vehicle sharing (Car2Go/ReachNow, Jump, Lime, Turo, Zipcar) for short-term, single-trip bicycle, car, or scooter rides operated by the user
- Ridesharing (LyftLine, UberPool, King County Metro Vanpool) for people with similar origins/destinations to share car rides
- On-demand micro-transit (Via), which is commuter-focused and typically uses ad-hoc pickup/drop-off points, generally within limited service zones

Photo Credit: PSRC, 2019

Ride-hailing services have grown in popularity in the central Puget Sound region, taking advantage of smartphone technology. Though the base services are essentially no different than taxis, smartphone access has allowed travelers to estimate trip costs in advance, monitor pick-up times, and track trips and experiences. With around 31 million trips provided in the Seattle area in 2018, ride-hailing has far eclipsed traditional taxis, which provided 5.2 million trips at their peak in 2012 and have been declining since.[5] Vehicle sharing and ridesharing services have been successful in the central Puget Sound region as well. Seattle became the first U.S.

Photo Credit: PSRC

[5] Seattle Times (2018, November 5) How popular are Uber and Lyft in Seattle? Ridership numbers kept secret until recently give us a clue. Retrieved from https://www.seattletimes.com/seattle-news/transportation/how-popular-are-uber-and-lyft-in-seattle-ridership-numbers-kept-secret-until-recently-give-us-a-clue/

city with over 2 million trips on Lime bikes[6] and remains one of the largest Car2Go markets in the U.S. Transit agencies in the region such as King County Metro and Pierce Transit are actively partnering with shared mobility service providers to address first/last-mile connections to transit hubs in the region and provide more options for travelers to get around.[7,8,9]

Technological changes through smartphone capabilities have contributed to the growth of shared mobility services. Further advances in technology, especially in terms of vehicle automation, could lower trip costs as primary labor costs for drivers are reduced.[10] This may increase the popularity of shared mobility services such as TNCs, depending on competition and performance of other modes.

Connected and Automated Vehicles

Photo Credit: Dllu, 2017

Connected and automated vehicles (CAVs) involve the application of technology to operate a system of vehicles without direct human control. Self-driving represents the "automated" part, while the "connected" component assumes that vehicles would communicate with other road users such as bicyclists and pedestrians, other vehicles, and infrastructure such as signals and roadway sensors to coordinate safe and efficient movements. Separately, these two components have distinct characteristics and present different opportunities and challenges. However, many experts and the U.S.

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[6] Lime Year-End Report 2018. Retrieved from https://www.li.me/hubfs/Lime_Year-End%20Report_2018.pdf

[7] King County Department of Transportation (2018, January 17). Metro partners with ReachNow and Car2go to offer car share parking at Northgate Transit Center. Retrieved from https://www.kingcounty.gov/depts/transportation/news/2018/20180117-Northgate-car-share-parking.aspx

[8] King County Metro (2018). Retrieved from https://kingcounty.gov/depts/transportation/metro/programs-projects/innovation-technology/innovative-mobility/first-last-mile/ride2.aspx

[9] Pierce Transit (2018). Limited Access Connections. Retrieved from https://www.piercetransit.org/limited-access-connections/

[10] Litman, T. (2018). Autonomous Vehicle Implementation Predictions: Implicatinos for Transport Planning. *Victoria Transport Policy Institute*.

Department of Transportation (USDOT)[11] expect that both automated and connected features must exist together before full-scale impacts of the technologies are achieved. Hence, this briefing paper focuses on the combination of "automated" and "connected" technologies and the associated considerations for long-term planning.

Photo Credit: USDOT ITS JPO

Though vehicles with many self-driving features are in limited use across the world, CAV technology is still being proven and has shown reasons for caution at a policy level.[12] The timeline of implementation and adoption for this technology is highly uncertain, with various groups estimating wide ranges before large-scale adoption. Barriers to mass use are numerous and require coordinated solutions in technology, policy, and planning before a connected and automated system could become a truly feasible reality. However, the potential impacts of CAVs on the transportation system are notable enough that preparation should be considered far in advance of when the technology arrives.

This paper does not attempt to forecast the timeline of CAV technology but does consider the two distinct business models that could emerge and result in different outcomes. Privately owned CAVs are like today's private vehicle ownership, while shared CAV fleets might be similar to existing ride-hailing services offered by companies like Lyft and Uber, except without a human driver. The degree to which one or the other of these business models dominate is dependent on associated costs,

[11] USDOT (2017). Automation ITS benefits, costs, and lessons learned: 2017 Update Report. Retrieved from https://www.itsknowledgeresources.its.dot.gov/its/bcllupdate/pdf/BCLL_Automation_2017_FINAL.pdf

[12] Washington Post (2018, March 27) Tech firms, government officials put the brakes on testing self-driving vehicles after fatal Uber crash. Retrieved from https://www.washingtonpost.com/news/dr-gridlock/wp/2018/03/27/arizona-governor-suspends-testing-of-ubers-self-driving-cars-i-was-very-disturbed-by-video-of-fatal-crash/?noredirect=on&utm_term=.ca5ddaa13cdd

policies and other factors, but could have distinct impacts on mobility, environment, land use, and the transportation system.

Technology Considerations for Land Use Planning

Rapidly evolving transportation technologies are expected to alter our mobility and travel patterns. While there is uncertainty in terms of timelines and impacts, there is consensus on the need to integrate these technologies into the planning and policy framework.

This paper attempts to understand the intersection of technology and land use and identifies topics to consider in local policies, projects and regulations. Provided below are areas of focus to highlight the potential impacts of relevant emerging technologies and identify high-level considerations for stakeholders and jurisdictions.

- Parking
- Right-of-way/Access Management
- Infrastructure
- Development Patterns

These topics are not meant to be exhaustive but represent a starting point for the discussions on technology and its relationship to planning. The evolving technology spectrum is expected to have broad implications on the environment, land use and transportation systems. Moving forward, further review of the potential impacts will be considered and incorporated, as applicable, into PSRC's long-term work program to help the region prepare for these technologies.

Parking

Parking is influenced by various factors including supply and availability, pricing, usage restrictions by time and user type, and management and enforcement, which are in turn governed by policies. While some policy decisions such as pricing and usage restrictions may be changed quickly in response to changing needs, other decisions such as long-term investments in dedicated parking structures or other facilities cannot be easily altered. Potential impacts from relevant transportation technologies are

explored here to help inform policies and ensure efficient investment in parking infrastructure.

Electric Vehicles

The share of electric vehicles is expected to increase across the U.S. and specifically in the Pacific Northwest, which will require investments in infrastructure and an adaptable policy framework to support this growth. Infrastructure investments include EV charging stations and/or dedicated EV parking. EV parking policies for new buildings and public spaces can help or hamper overall policy goals of expanding EVs throughout the region. Building codes and zoning may also be examined to ensure EV charging and parking needs are included, or at least not precluded.

For instance, parking in new developments may consider the ease with which EV chargers could be installed in the future and employ designs that can accommodate additional electrical demands from the grid when needed. These considerations may be similarly important for public infrastructure, including on-street parking. Existing on-street parking could be evaluated to identify optimal locations for EV parking and charging based on ease of access to the electrical grid and anticipated demand. Cities and building managers may also explore how incentives and pricing may support EV adoption, such as subsidized charging, allocation of specific parking locations, extended parking times, or other parking code alterations for EV users.

Shared Mobility

Services offering shared vehicle rentals of all types, including cars, free-floating electric and manual bikes, and scooters, have increased in recent years to provide a diverse set of travel options. As these services continue to develop, coordinated local policies regarding on-street and off-street parking would help to safely accommodate shared mobility operators and all users.

Current parking policies and minimum requirements may overestimate existing demand for parking. A 2015 study[13] by King County Metro has found that, on average,

[13] King County METRO (2015, August). Right Size Parking Final Report. Retrieved from https://www.kingcounty.gov/~/media/depts/transportation/metro/programs-projects/right-size-parking/pdf/rsp-final-report-8-2015.pdf

multifamily buildings in King County supply 40% more parking than is utilized. Due to the nature of shared mobility services, with vehicles picking up and dropping off passengers, growth in these services could lead to decreased parking demand. In planning for growth and changing technologies, current and future demands for parking may need to be reevaluated and considerations made for how to reuse existing parking spaces and structures if they are no longer needed.

Increasing bikeshare/scooter usage would also require proactive local policies to balance different types of users and effectively manage public space for parking. Lack of clear policies can lead to negative outcomes such as incorrectly parked bikes/scooters blocking pedestrian traffic in sidewalks and public right-of-way. The Seattle Department of Transportation[14] identified similar issues in their evaluation of the city's free-floating bikeshare pilot program. The growing share of bikeshare and scooters may prompt local jurisdictions to establish relevant parking standards (e.g. designated areas, parking zones, enforcement) to integrate these services into the broader transportation system.[15]

Connected and Automated Vehicles (CAVs)

The potential impacts of CAVs on parking are dependent on the business model – shared or private – that will emerge as the technology is deployed. In general, parking demands would more likely decline with usage of shared vehicles but could be more complex with the use of private vehicles.

A fleet of shared CAVs could be considered to have the same impacts as existing ride-hailing services, as described above. Users would not be responsible for parking vehicles at their origin or destination, which could decrease parking needs overall. Personal CAVs might affect parking demand differently depending on the context. Vehicles could drop off passengers at destinations and park remotely at any location. This would reduce on-site demand for parking, allowing redevelopment of existing

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[14] Seattle Department of Transportation (2018, August). 2017 Free-Floating Bike Share Pilot Evaluation Report. Retrieved from http://www.seattle.gov/Documents/Departments/SDOT/BikeProgram/2017_BikeShare_Evaluation_Report_113018.pdf

[15] Institute of Transportation and Development Policy (2018). Optimizing Dockless Bikeshare for Cities. Retrieved from https://www.itdp.org/2018/05/11/dockless-bikeshare/

surface, on-street, and garage parking, but would shift parking demand to other locations. Similarly, if parking were currently unavailable at a home location (e.g., for denser housing without access to private off-street parking), personal vehicles might be stored at other locations with potentially lower parking costs. In this context, policies such as occupancy-specific pricing might be required to help manage the number of empty vehicle trips, as well as parking needs at home and other destinations.

Right-of-Way/Access Management

The technologies addressed in this paper could introduce new and unique demands for right-of-way designation, curb space usage, and access to destinations. From EV charging on public streets to increased drop-off/pick-up from ride-hailing and CAVs, growth in these technologies could influence existing curb space needs and spur redesigns of spaces to serve emerging needs.

Electric Vehicles

Plug-in electric vehicles require access to charging stations for widespread adoption. As owners and managers of curbside space, jurisdictions can play a role in providing or incentivizing charging services in specially allocated EV parking spaces to be used only while charging. Parking time limits may need to be adjusted to accommodate a range of EV charging times and needs. Where curbside parking is limited, the needs of EV users may need to be balanced with other uses like short-term loading, delivery spaces, and other non-parking usage such as bike or bus-only lanes. Electric bicycles and scooters may also benefit from publicly available charging access ports in designated parking spaces, especially if personal ownership and usage of these smaller modes continues to grow.

Shared Mobility & Connected and Automated Vehicles (CAV)

Ride-hailing services currently have a need for safe, designated drop-off and pick-up points, especially in congested areas. CAV technology could add to those demands if privately owned vehicles were used to drop-off passengers directly at destinations and self-park elsewhere. Allocating more drop-off/pick-up curb space (versus parking and other uses) may be required at key locations, especially during peak times to avoid vehicles creating delays or unsafe conditions for other road users. Existing roadway

access to buildings and destinations are often designed for use by private vehicles that are parked on site, but increased drop-off/pick-up demands may require redesigns to reorient traffic patterns, alter curb cuts and prioritize space in new ways. Other policies may include working with ride-hailing companies to define set pick-up locations or create restricted "geofence" areas where pick-up and drop-off are not allowed. Seattle recently restricted rideshare pick-up along the busy 3rd Avenue transit-priority corridor, which has restricted access for non-transit users during peak periods.[16]

Shared vehicle rentals also have an impact on right-of-way needs. Some of the existing carsharing services have a set of reserved, carshare-only parking locations, both on- and off-street, which are not subject to standard vehicle rules. For example, carshare vehicles can park in paid, time-limited spots for any amount of time without paying in some locations. As services expand across jurisdictions, coordination will be required between agencies to ensure parking rules are clear for users and providers. Similarly, bike and scooter parking guidelines are currently in flux, with varying expectations across cities and by company. Designated parking locations along jurisdiction right-of-way adjacent to sidewalks or in converted vehicle parking spaces could help provide clear parking locations and provide alternatives that reduce sidewalk blocking.

Infrastructure

In addition to the impacts addressed above, the technologies are likely to add pressure to existing infrastructure and increase demands for new supporting infrastructure. A robust and resilient infrastructure is critical to realizing the full-scale benefits of technology. Highlighted below are some of the considerations, relevant to discussions on planning for growth.

Electric Vehicles

A critical factor for widespread adoption of electric vehicles in the region is ensuring easy and equitable consumer access to charging stations. An added challenge is understanding and providing the relevant type of charging technology (Level 1, Level 2,

[16] Daniels, C. (2018. December). Geofencing preventing rideshares on Seattle's 3rd Avenue. Retrieved from https://www.king5.com/article/news/local/seattle/geofencing-preventing-rideshares-on-seattles-3rd-ave/281-618265865

and DC Fast charging) required at various locations, including residences, workplaces, public charging stations within cities and along highway corridors.[17]

Growing adoption of EVs will require local jurisdictions to use a range of policies and actions, including incentives, parking ordinances, zoning, code changes, and public awareness campaigns to remove barriers and facilitate EV readiness within their boundaries.[18,19] Actions by local governments could include right-of-way improvements, updating regulations and policies such as building codes and ordinances, and working with private developers to ensure charging infrastructure becomes more prevalent in the future. Increasing use of EVs across the region will also involve ongoing coordination across jurisdictions and active partnerships with stakeholders to effectively plan and deploy charging infrastructure. The West Coast Electric Highway is one such example of cross- jurisdictional and multi-state coordination to provide an extensive network of fast charging stations every 25 to 50 miles along Interstate 5, Highway 99, and other major roadways in British Columbia, Washington, Oregon, and California.[20]

The sections above describe some of the key needs related to parking and provision of charging infrastructure in new developments and the public right of way. Policies encouraging the rapid growth of EVs will also need to account for impacts to the electric grid. Factors such as the condition of existing infrastructure, seasonal and daily variations in electricity demand, targeted capacity additions, and upgrades to distribution and communication systems will determine grid reliability in handling

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[17] Center for Automotive Research (2018, November). Are we Building the Electric Charging Infrastructure We Need? Retrieved from https://www.cargroup.org/are-we-building-the-electric-vehicle-charging-infrastructure-we-need/

[18] Philip, R. & Wiederer, A. (2010). Public options for electric vehicle charging infrastructure in C40 cities. Retrieved from https://www.innovations.harvard.edu/sites/default/files/1108934.pdf

[19] Seattle Office of Sustainability & Environment (2014, October). Removing Barriers to Electric Vehicle Adoption by Increasing Access to Charging Infrastructure. Retrieved from http://www.seattle.gov/Documents/Departments/OSE/FINAL%20REPORT_Removing%20Barriers%20to%20EV%20Adoption_TO%20POST.pdf

[20] West Coast Electric Highway. Retrieved from http://www.westcoastgreenhighway.com/electrichighway.htm

demands from increased EV adoption.[21] With these considerations come also the corresponding impacts to and from land use and development decisions. These include provision of adequate electrical power and conduit in new construction and additional or upgraded substations in key locations. As the number of EVs increase, there needs to be active engagement between jurisdictions and private utility providers in balancing decisions on growth with appropriate locations for charging stations and grid infrastructure, to effectively manage demand and prevent disruptions.

Shared Mobility & Connected and Automated Vehicles (CAV)

The rapid increase in shared mobility services in the last few years has primarily been driven by advances in smartphone technology. Continued rise of these services and anticipated growth in CAV technology is dependent on effectively leveraging the underlying information and communication infrastructure. While the exact nature of investments is still being understood, new supporting infrastructure would be required to deploy, integrate, and fully realize the benefits of these technologies. Examples of potential investments include roadside sensors, lights and meters; fiber optic infrastructure; and wireless infrastructure and communication devices. The anticipated increase in the amount of data generated from these technologies will also require convergence and modernization of different types of infrastructure assets – transportation, telecommunication and digital – to effectively manage and use large volumes of data.[22]

Planning for expected growth in shared mobility services and developments in CAV technology may require specific policies and targeted investments in infrastructure to keep pace with these changes. The changing nature of technology also requires a shift in the way jurisdictions value and leverage their existing infrastructural assets. As an example, fifth generation (5G) wireless networks are considered critical to the deployment of connected vehicles. The rollout of 5G networks in turn depends on

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[21] Davidson, T.F., Tuttle, D., Rhodes, J.A., Nagasawa, K. (2018, December). Is America's Power Grid Ready for Electric Cars? Retrieved from https://www.citylab.com/transportation/2018/12/americas-power-grid-isnt-ready-electric-cars/577507/

[22] Finger, M., Bert, N., & Kupfer, D. (2017). Infrastructure Funding Challenges in the Sharing Economy, Transport Area of the Florence School of Regulation (FSR Transport) at the European University Institute (EUI). Report prepared for the Research for the TRAN Committee of the European Parliament, Directorate-General for Internal Policies.

significant increases in the number of cell sites/antenna locations and data centers to handle the build-out of wireless communication technology. While existing infrastructure assets such as traffic lights, light poles, and public buildings could be used to locate smaller cell sites, the rollout of 5G would also require installation of new cell phone towers to handle the growth in wireless traffic.

In this context, local jurisdictions would need to balance decisions against factors such as the availability of space within their boundaries for locating infrastructure such as new cell towers, capacity and resiliency of existing infrastructure, and the ability to upgrade or provide new infrastructure. If the growth in shared mobility services and connected vehicles were to continue, there would need to be coordination on the provision of supportive infrastructure in public right-of-way within and across jurisdictions. The public sector might need to provide financial incentives and pursue partnerships with the private sector to provide infrastructure in the least-served areas or upgrade existing infrastructure to prepare for the deployment of these technologies and ensure equity in benefits.

An added consideration, relevant to the above discussion on infrastructure, relates to the steep growth of e-commerce and the increase in the number of deliveries to residential locations. Growth in e-commerce, combined with the increasing share of shared mobility services, is already causing impacts in dense urban areas. The lack of supportive delivery infrastructure within public right-of-way (load/unload spaces in alleys or at the curb) and within private buildings (loading docks, freight bays, and package rooms)[23] can exacerbate congestion on local streets and increase competition for curb space. If the anticipated growth in e-commerce and shared mobility services were to continue, provision of supportive public and private delivery infrastructure through approaches such as partnerships with private stakeholders, building code changes, and local policies should be factored into policy discussions

[23] University of Washington (2019, January). The Final 50 Feet Urban Goods Delivery System. Seattle Department of Transportation. Retrieved from https://depts.washington.edu/sctlctr/sites/default/files/SCTL_Final_50_full_report.pdf

on accommodating growth. Refer to PSRC's briefing paper on freight movement for additional information on this topic.

Development Patterns

Development patterns refer to where people live, work, and participate in other activities and how different land uses are geographically organized. With respect to emerging transportation technologies and land use planning, it could be useful for planners to consider how new ways to travel and move goods may influence existing land uses and help shape future development patterns as the region grows.

Since transportation and land use are interconnected systems, different development patterns can provide different opportunities and challenges for travel and may help shape the development and applications of various emerging transportation technologies. Variations in development patterns across the region, ranging from sparsely rural to intensely urban, provide a range of contexts that may also lead to differences in adoptions of these technologies. Recognizing these factors and planning for potential changes in land use development patterns may allow communities to more easily achieve their growth management goals.

In addition to electric vehicles, shared mobility, and connected and automated vehicles, the rise of e-commerce may influence development patterns. Broadly, e-commerce includes on-line shopping, entertainment, and education; telecommuting and web conferencing; and remote medical consultation. These applications could reduce the need for in-person travel, but do not necessarily eliminate the need for goods movement. Increases in online shopping may result in greater demands for goods delivery. This trend, combined with new delivery methods including electric cargo bikes, unmanned aerial vehicles, and smart lockers in central and publicly accessible locations, may affect location choices for freight distribution centers (see PSRC's briefing paper on freight movement for additional information). The ability to avoid travel for many activities could reduce the importance of proximity to work and other services as a factor in housing location choice, which may increase residential development in rural and other less developed areas. Further, "brick-and-mortar" spaces that currently provide these work, shopping, and other uses may experience

lower demands. As such, underutilized developments in rural to urban contexts may become opportunities to be adapted for new uses or redeveloped.

Electric Vehicles

The adoption of plug-in electric vehicles over ones powered by internal combustion engines may impact demand on gasoline and other fossil fuels and the supply chain system that supports their delivery to consumers. If a significant portion of vehicles are powered by electric motors in the future, then reuses of land currently used for fueling stations, some oil refineries, and other delivery systems may be possible. An important environmental consideration would be the remediation of contaminated sites and the processes needed to ensure they are appropriately cleaned up for other uses.

More broadly, electric bicycles and e-scooters may help provide connections to transit and be part of a suite of transportation solutions to help solve the "first/last-mile" problem. These mobility options may support transit-oriented developments and help provide additional travel choices to existing development patterns that are automobile-centric or not well-served by non-driving modes.

Shared Mobility & Connected and Automated Vehicles (CAV)

In a shared ownership model of motor vehicles, if centralized fleets with centralized servicing are adopted, then there could be lower demands for supporting services to individual consumers. This potential scenario may disrupt the automobile retail sector and the ecosystem of operation and maintenance services that currently support private vehicles, and as such, demand for land to support these purposes may decrease.

As mentioned earlier in this document, the potential for a shared ride CAV system could significantly affect the need for and the location of parking facilities across the region. Depending on the extent to which land and buildings currently dedicated to parking are redeveloped for other purposes, there could be significant changes to existing development patterns. In addition, if emerging transportation technologies can reduce overall personal travel costs and improve access to more places that are further apart, then there may be greater potential for development pattern changes that compound the decrease in demand for parking. Lower travel costs can favor longer-

distance travel and dispersed land uses within a region. Lower travel times and greater reliability, if achieved, can also encourage the spread of urban development.

Summary

This paper highlights areas of intersection between transportation technologies and land use. Recognizing that there are still many unknowns regarding the timing and impacts from these various new mobility options, consideration of new technologies during the planning process will be critical to ensure that decisions regarding future growth and infrastructure support mobility for people and goods. As a final alternative for the VISION 2050 regional growth strategy is determined, and the plan adopted in 2020, jurisdictions are encouraged to consider the issues identified here as they work towards their comprehensive plan updates and future land use decisions. PSRC will continue to engage with stakeholders on these issues as part of our larger technology work program and as a key element of the 2022 Regional Transportation Plan.