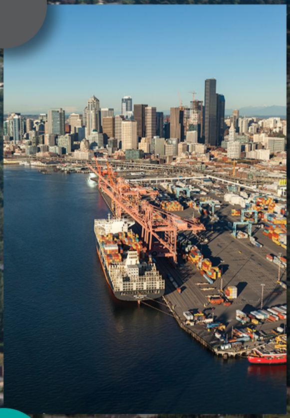
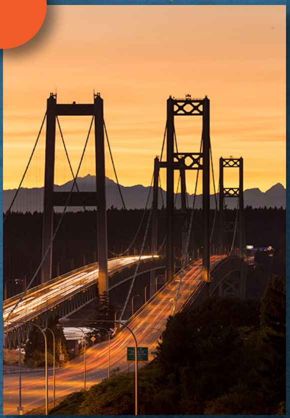
The Regional Transportation Plan — 2018

Appendix N

Technology





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Puget Sound Regional Council

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APPENDIX N: Technology

This is an exciting time for transportation. Emerging technologies, including connected and autonomous vehicles, have the potential to revolutionize how people get around. Combined with car sharing technologies, tools that better inform travelers, and the continued evolution of more established Intelligent Transportation System (ITS) technologies, the future could look quite different than the past.

Technology may be on the verge of significantly changing how we think about transportation systems. In the last several years, emerging technologies such as self-driving cars have shifted from a futuristic vision to a likely reality for which the region must prepare and plan. The key challenge for planners is that much uncertainty remains around when these technologies will mature and become widespread, what the impacts will be on everything from travel behavior to parking, and what must be done to ensure those impacts support the region's policy goals.

Autonomous and connected vehicle technologies have advanced significantly in recent years, but both are still in relatively early stages of development, and the timeline for their widespread deployment on the roadways is unclear. The current lack of observable data makes it difficult to quantify the potentially transformational impacts of these technologies (particularly autonomous vehicles).

Shared mobility services such as Lyft and Limebike, and traveler information tools such as Waze have recently seen significant growth, and there is a better understanding of what their impacts might be. However, shared mobility accounted for only 4% of total global miles driven[1] and it is not yet known exactly how it may fuse with autonomous vehicle technology and integrate with the region's complex multimodal transportation system.

A better understanding exists about more established ITS-based technologies (such as ramp metering, adaptive signal control, and dynamic messaging signs) that have been deployed in the region for decades and are known to be cost-effective options to manage congestion, improve safety, and increase the overall efficiency of our transportation system.

It is important to recognize however that there are still large gaps in the deployment of these ITS technologies throughout the region. And while they are more established, these technologies are also evolving and can be viewed as the foundation of a rapidly-changing transportation technology landscape.

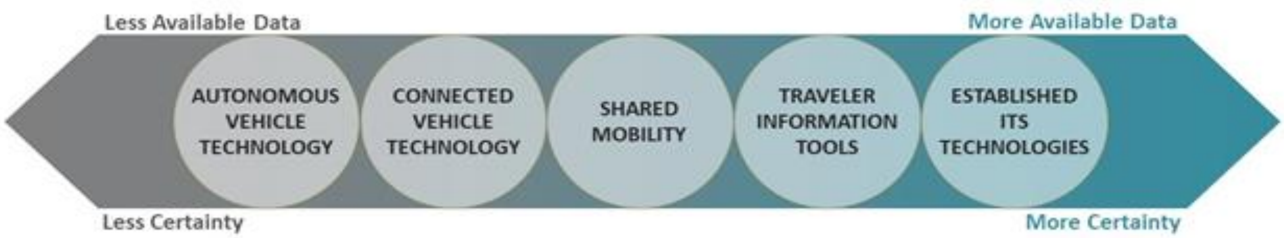
Figure 1 below provides a view of the transportation technology spectrum. On the one end, we have autonomous vehicles that have captured public imagination but are very difficult to plan for due to limited data availability and uncertainty in deployment timelines. At the other end of the spectrum, we see established ITS technologies that have been deployed in the region for some time and hence are an integral part of our planning efforts. Shared mobility and traveler information tools fall somewhere in between. The technology spectrum will evolve as more of

[1] Shared Mobility on the Road of the Future. (2016, June 15). Retrieved from https://www.morganstanley.com/ideas/car-of-future-is-autonomous-electric-shared-mobility

these technologies are deployed and mature. Planning efforts in the region, including PSRC's efforts, need to be flexible to adapt to this changing technology landscape.

There are other technologies that have started receiving attention. Examples include the Hyperloop (a proposed mode of passenger/freight transportation that travels through sealed tubes at very high speeds), unmanned aerial vehicles, and drone deliveries. For the purpose of the Regional Transportation Plan, the focus will be on the technologies highlighted below. PSRC will continue to monitor any changes in the technology landscape and adjust planning efforts as needed.

Figure 1
Transportation Technology Spectrum



This document describes the current state of transportation technology within our region and beyond, highlights critical emerging transportation technologies and identifies key implications and strategies for transportation technologies moving forward.

ESTABLISHED TECHNOLOGIES

With all the attention paid to emerging technologies, it is important not to lose sight of the critical needs, issues and investments related to the more *established* transportation technologies deployed in the central Puget Sound region.

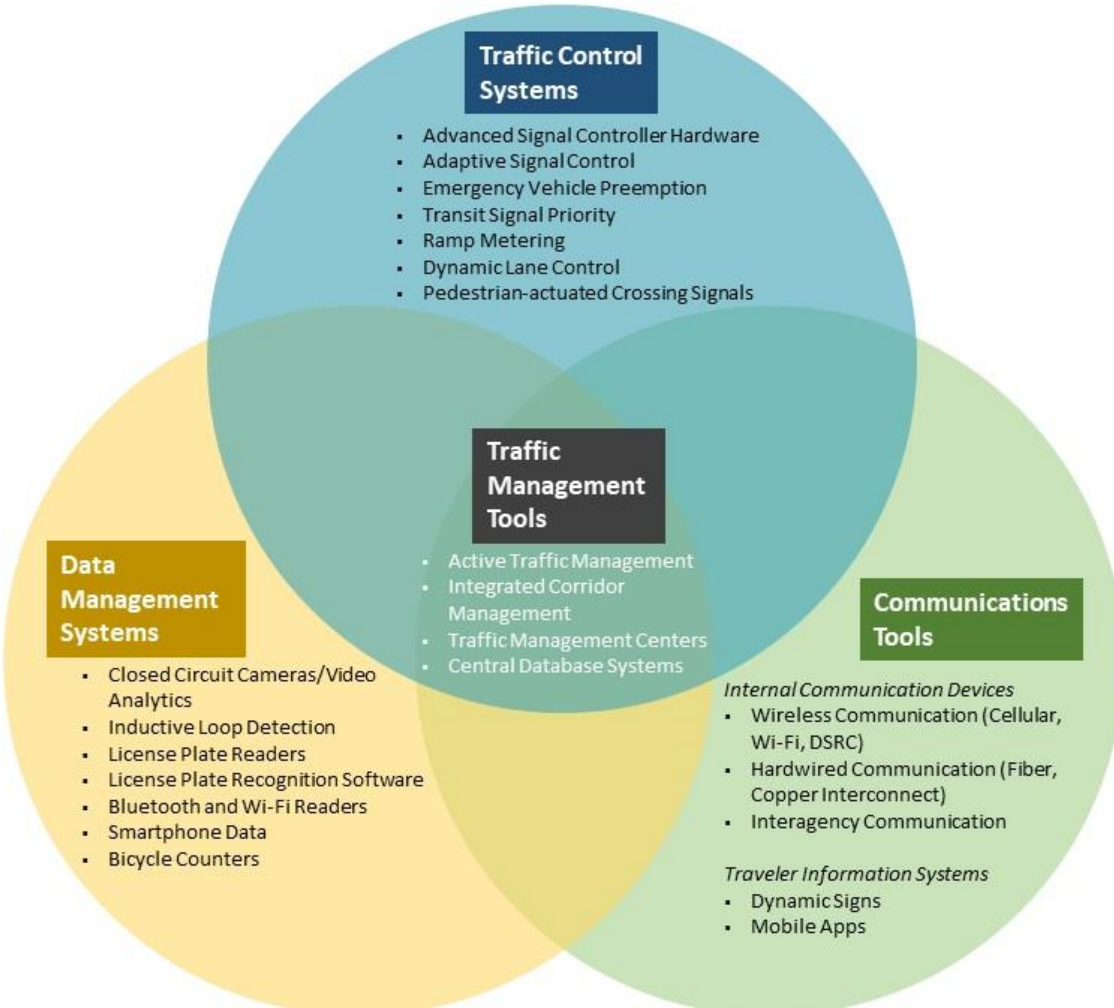
Established technologies refer to ITS and operations-based technologies that have existed and evolved over decades. While these technologies are more established and better understood, they are also continually evolving and there are significant needs and gaps in their deployment across the region. This section takes a closer look at what these technologies are, how they have evolved in recent years, and the benefits associated with their deployment. The section also examines the types of needs and gaps that exist in the region and considers next steps for addressing them.

What Are Established ITS Technologies?

The Puget Sound region has long used ITS strategies throughout the region and there is a strong foundation of ITS deployment in place. The types of established ITS technologies deployed in the region include *traffic control systems*, *data management systems*, *communications tools*, *and traffic management tools*. Listed below are brief descriptions of each of these categories. Figure 2 provides a more detailed list of the specific technologies included in each category.

- **Traffic Control Systems:** Refers to hardware or devices deployed on roadways that interface directly with travelers to improve traffic flow (e.g. ramp metering, adaptive signal control)
- **Data Management Systems:** Includes tools used to collect and store multi-modal traveler data (e.g. loop detectors, bicycle counters) and systems used to collect tolls and other revenues (e.g. license plate recognition equipment)
- **Communications Tools:** Includes both Internal Communication Devices (e.g. Dedicated Short-Range Radio, fiber optic cables) and outward-facing Traveler Information Tools (e.g. dynamic signs). Internal Communication Devices are used to transmit information between devices and to operators, and Traveler Information Tools are used to inform travelers regarding travel times, conditions, schedules, and other travel alerts.
- **Traffic Management Tools:** Refers to operating platforms that rely on various components from the categories above to monitor traffic, identify issues, and manage the transportation system in a coordinated and integrated manner.

Figure 2
Established Technologies Deployed in the Central Puget Sound Region by Category



Benefits of Established ITS Technologies

The direct benefits of ITS technologies can largely be divided into three major categories: *Mobility*, *Safety*, and *Environment*. These benefits are multimodal and apply to personal vehicles, transit vehicles, freight, and nonmotorized modes of transportation. In addition, ITS technologies have the potential to contribute towards other key regional outcomes. Easing congestion and improving mobility through dense, urban areas can improve livability and increase economic benefits.

Common mobility benefits include shorter travel times and decreased congestion. In terms of improving safety, ITS technologies can play a key role in decreasing traffic incidents, decreasing response times for emergency medical services, and improving identification of dangerous intersections/road segments. Environmental benefits can include a decrease in vehicle emissions and fuel consumption by operating vehicles more efficiently. ITS projects have also shown to be especially cost-effective in easing congestion and maximizing efficiency in congested corridors.

It should be noted that in addition to measurable benefits such as the ones described below, there are also benefits that are more difficult to quantify but provide value to roadway users. One clear example is dynamic messaging signs that provide travelers with information on travel times, schedules and other travel alerts. These signs notify travelers of real-time conditions and allow them to make more informed decisions.

Local examples of cost-effective ITS tools being used, resulting in measurable benefits include:

- **King County Metro RapidRide E Line Transit Signal Priority –** King County Metro has installed and activated Transit Signal Priority (TSP) for its 'RapidRide' E-Line at over 25 intersections along Aurora Avenue between Downtown Seattle and the northern border of the City of Shoreline. This feature has provided a 5% reduction in travel time and a nearly 15% reduction in signal delay for the 18,000 daily riders of the E-line. TSP is also being deployed by several other transit agencies in the central Puget Sound region, including Sound Transit, Pierce Transit, and Community Transit.

- **City of Lakewood Traffic Management Center:** The City of Lakewood constructed a Traffic Management Center (TMC) in 2014 as part of a broader, multi-phase effort to upgrade traffic signal management. Performance metrics indicate that the TMC has provided an overall 5 -10% reduction in travel time and a faster response to traffic interruptions. There are currently over 10 TMCs in the central Puget Sound region.

- **WSDOT I-405 Peak Use Shoulder Lane Project:** In 2017 WSDOT converted the existing I-405 Northbound shoulder between SR 527 and I-5 to an additional travel lane during the afternoon commute (from 2-7pm). This adds extra capacity, when it is needed most, to a particularly congested stretch of Northbound I-405. In the three months after implementation of the project, the average travel time between Bellevue and I-5 decreased by 32%, from 41 minutes to 28 minutes.

- **WSDOT I-5 Ramp Meters Through Joint Base Lewis-McChord:** In 2015, WSDOT installed 18 ramp meters at interchanges along the heavily congested portion of I-5 near Joint Base Lewis-McChord (JBLM). According to WSDOT, the average daily vehicle hours of delay through JBLM have decreased by 16%, in part due to the installation of the new ramp meters.

Changes in the ITS landscape

A couple of notable trends in the ITS landscape have emerged over the last several years.

- There has been major advancement and growth in data collection technology and an increased emphasis on data overall. In addition to improved tools, there's been a significant increase in data sharing, data requests from third party vendors, and *data collaboratives,* a model where government agencies, private companies, and research institutions exchange data to develop new tools and increase efficiency.

As an example, the City of Bellevue is sharing signal timing data with a vendor (Connected Signals, Inc.) who is developing a mobile app that will provide roadway users in Bellevue with real-time traffic signal information. This increased focus on data collection allows for better monitoring of trends for investment decisions, for performance monitoring of existing or newly implemented projects, and for improved traveler information tools.

- Many of the technologies have evolved and matured significantly in recent years (e.g. video technology has shifted towards infrared and 360-degree cameras), requiring additional investments to ensure jurisdictions are utilizing the state of the art technology. Certain technologies, such as Adaptive Signal Control have also seen a significant uptick in investment and deployment across the region. Examples include:
  - The City of Bellevue recently completed the installation of adaptive signal control technology in 100% of their traffic lights.
  - King County Metro has deployed transit signal priority at over 200 additional intersections since 2010.
  - The City of Lynnwood is installing adaptive signal control technology along two major corridors (SR 99 and SR 524), with expected completion by spring of 2018.
- ITS tools play a central role in the growing ‘Smart Cities’ approach to transportation planning. Smart cities have emerged as the next generation approach to city management and utilizes information and communication technology to more effectively move people, deliver services, manage assets and improve the overall efficiency of a city’s transportation system. ITS technologies provide the groundwork for cities to integrate technology and develop innovative transportation solutions.

  The USDOT awarded $50 million to Columbus, Ohio, as part of its 2016 “Smart City Challenge.” Columbus’ winning approach included using new mobility technologies to improve access to opportunities and health outcomes for all of the city’s residents. This included deploying three electric self-driving shuttles to link a new bus rapid transit center and a major retail district, providing more residents with access to jobs. Columbus also plans to use data analytics to improve health care access in a neighborhood that currently has an extremely high infant mortality rate, providing improved transportation options to those who are most in need of prenatal care.

  In the central Puget Sound region, the City of Bellevue and the City of Seattle (in partnership with the University of Washington) have launched Smart City programs to harness the benefits of rapidly emerging technologies to improve livability and sustainability. Bellevue has developed a detailed Smart City Strategic Plan and invested significant resources towards developing and implementing innovative Smart City solutions. Examples of planned transportation initiatives include traffic-signal system performance monitoring, enhanced data and information sharing, improved traffic signal response for emergency vehicles, and data-driven shared mobility approaches to improve first and last mile commute trips.[2] In 2016, Bellevue received a $75,000 grant from the White House Smart Cities program to develop a digital service-management platform to better utilize information from multiple departments within the city.[3]

Seattle's MetroLab Studio is part of a national consortium of city-university partnerships committed to providing high-impact, data-driven analytics and research projects to help community stakeholders address complex transportation, land use, environmental, and other challenges.[4] In 2017, Seattle hired their first Smart City Coordinator, who is working with staff across city departments to assist in facilitating a range of Smart City efforts aimed at streamlining traffic flow, fostering economic development and enhancing the city's livability, workability and sustainability.[5]

Challenges

Key challenges related to established ITS technologies in the region include:

- ***Regional deployment of ITS technologies.*** While there are funding sources available for projects that include ITS within their scope, there are still unfunded ITS needs across the region. This is particularly true in the case of smaller jurisdictions, where basic ITS infrastructure is sometimes lacking. In addition, jurisdictions that do not have basic ITS technologies deployed will also be limited in terms of their potential to implement newer, emerging technologies that rely on this infrastructure.

  Another challenge is that, since technology changes at a very fast rate, ITS projects require more frequent improvements and investments to remain state of the art and, in some cases, to remain compatible with other infrastructure.

- ***Lack of performance measures demonstrating magnitude of benefits.*** As discussed earlier, it has been established over decades of deployment that ITS projects have the potential to provide significant mobility, safety, and environmental benefits. However, while jurisdictions and agencies in the region frequently deploy ITS projects with the intent of incorporating performance measures, continued tracking and validation of these measurements often does not occur due to cost, lack of other resources, or the inherent difficulty in quantifying certain benefits.

  In addition, even when tracking and validation do occur, it is difficult to use the data in a meaningful, comparable manner. This is due to jurisdictions using different methodologies

[2] Bellevue Smart: Planning for a Smarter City. (2017). Retrieved from: https://bellevuewa.gov/UserFiles/Servers/Server_4779004/File/pdf/IT/mc2352A-Smart-Cities-Strategic-PlanWEB.pdf
[3] City of Bellevue Receives Grant from White House for Smart Cities Program. (2016, December 8). Retrieved from: http://downtownbellevue.com/2016/12/08/city-bellevue-grant-white-house-smart-cities/
[4] Seattle MetroLab. Retrieved from: http://metrolab.uw.edu/about.html
[5] Seattle Appoints Smart City Coordinator. (2017, July 21). Retrieved from http://www.govtech.com/people/Seattle-Appoints-Smart-City-Coordinator.html

combined with a lack of regional standards and guidelines for collecting and reporting performance metrics. As a result, it is more difficult to quantify and provide a magnitude of the benefits of ITS deployments across the region, which in turn diminishes the ability to make the case for ITS investments to address mobility and other key transportation issues.

ITS technologies continue to be widely deployed in the central Puget Sound region and function as important tools for addressing mobility, safety, and other key transportation challenges.

EMERGING TECHNOLOGIES

In recent years, there has been a rapid increase of potentially transformative transportation technologies. Emerging technologies such as connected and autonomous vehicles have the potential to disrupt the transportation system and revolutionize the way people travel. Combined with car sharing technologies and tools that better inform travelers, the future could look quite different than the past. These technologies have captured the imagination of the public, elected officials, and transportation planners alike.

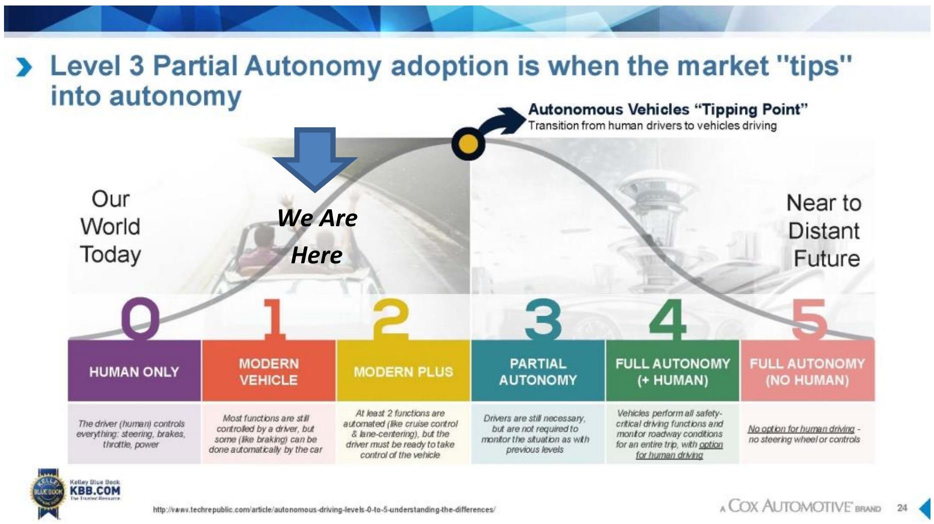
This section focuses on four emerging technology trends: autonomous vehicles, connected vehicles, shared mobility and traveler information tools. Refer to Appendix E: Climate Change Analysis for more details on the electrification of the region's vehicle fleet. PSRC will continue to monitor other emerging transportation technologies and incorporate them as applicable.

The next section provides greater detail on each of these four technologies including a review of the current state of technology and an overview of future projections. The details provided here are the latest available information. However, the technology landscape is in a constant state of change and is continuously evolving. PSRC will continue to monitor for changes and provide updated information accordingly.

Autonomous Vehicles

Autonomous Vehicles (AV), also known as self-driving cars, are vehicles that navigate the roadway with limited or no human interaction. They use an array of in-vehicle technologies to process their surroundings, detect road signage and markings, and determine the most suitable navigation path. As shown below in Figure 3, AV technology refers to a spectrum of functionality between Level 0 (where the driver has full control) and Level 5 (where the vehicle does everything).

Figure 3
The SAE International Levels of Autonomous Vehicles*



**Adopted by the National Highway Traffic Safety Administration (NHTSA)[6]*
Source: SAE International, 2016[7]

State of the Technology

This is a very exciting and fast-moving time for AVs. We are seeing an increasing amount of private sector investment going towards developing and advancing the technology. High-profile endeavors such as General Motors (GM) and Ford efforts to have fully autonomous vehicles on the market by 2020 and 2021 respectively; Volvo's "Drive Me" autonomous driving project aims to offer customers fully autonomous vehicles by 2021; and Waymo's self-driving cars have drawn a lot of public interest and media attention.

Transportation Network Companies (TNCs) that offer ridesourcing services are also becoming increasingly involved. Both Uber and Lyft currently have on-the-road AV pilot programs, and Lyft recently launched a 'self-driving division' with plans to develop their own autonomous

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[6] NHTSA Adopts SAE International Standard Defining Autonomous Vehicles; SAE Releases New Version for Free - J3016 states and defines six levels of automation in on-road motor vehicles. (2016, October 3). Retrieved from https://www.sae.org/news/3550/

[7] KBB Survey: Most consumers would accept SAE Level 4 autonomy, but think safety diminishes. (2016, September 28). Retrieved from http://articles.sae.org/15038/

ridesharing technology.[8] A spring 2017 survey by CB Insights,[9] which tracks the venture capital industry, identified 44 companies around the world actively in the race to develop and deploy self-driving vehicles. The interest in self-driving cars has resulted in the convergence of high-tech companies and traditional automobile manufacturers and suppliers.

An increasing number of cars hitting the market have NHTSA Level 2 detection/response features such as lane departure warning, adaptive cruise control and the highway assistance feature seen in Tesla's Autopilot. Audi recently announced a new level of self-driving vehicles, as part of their next generation Audi A8. This represents the first time vehicles with Level 3 automated driving system will be introduced. This allows the driver to stop monitoring the vehicle under certain conditions and where allowed by the law to do so.[10,11]

Autonomous Vehicles and Freight

Autonomous vehicle technology for freight vehicles is currently being tested and implemented on roadways across the world.

Daimler tested a semi-autonomous truck on a public highway in Nevada in 2015 – the first of its kind to be legally tested and navigate public roads in the US. In 2016 Anheuser-Busch and Otto (part of Uber) partnered for a "beer run" in Colorado that was purported to be the first time that a self-driving vehicle shipped commercial cargo.

Tesla, Uber, Waymo, and Daimler are all currently working to develop autonomous trucks that will hit the market within the next decade (with Daimler claiming theirs could be released as early as 2020).

Photo Credit: Daimler AG

Future Projections

The growing interest in AV technology has led to a great deal of research and speculation in recent years. Not surprisingly, there are wide-ranging projections in terms of when the technology will hit the market and what adoption rates will be seen in the coming decades. Key challenges that could potentially slow down widespread proliferation of autonomous vehicles include: a still underdeveloped regulatory framework, affordability issues, fleet turnover, and concerns regarding the length of time it will take to demonstrate that the more advanced autonomous levels are reliably safe enough.[12,13]

A recent publication in the journal *Transportation Research Part A: Policy and Practice* suggests that Level 4 AV penetration by 2045 could be as low as 25% (although that assumes lower cost

[8] Lyft launches a new self-driving division and will develop its own autonomous ride-hailing technology. (2017, July 21). Retrieved from https://techcrunch.com/2017/07/21/lyft-launches-a-new-self-driving-division-called-level-5-will-develop-its-own-self-driving-system/

[9] 44 Corporations Working on Autonomous Vehicles (2017, May 18). Retrieved from https://www.cbinsights.com/research/autonomous-driverless-vehicles-corporations-list/

[10] Etherington, D. (2017, July 11). Audi's new A8 will have Level 3 autonomy via 'traffic jam pilot'. Retrieved from https://techcrunch.com/2017/07/11/audis-new-a8-will-have-level-3-autonomy-via-traffic-jam-pilot/

[11] Taylor, M. (2017, September 10). The Level 3 Audi will almost be the most important car in the world. Retrieved from https://www.forbes.com/sites/michaeltaylor/2017/09/10/tthe-level-3-audi-a8-will-almost-be-the-most-important-car-in-the-world/2/#57c386d56472

[12] Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016). Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. Journal of Modern Transportation, 24(4), 284-303.

[13] Zmud, J., Goodin, G., Moran, M., Kalra, N., & Thorn, E. (2017). NCHRP Research Report 845 - Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies.

decreases and minimal increases in people's willingness to pay for technology; that number rises significantly if those assumptions are changed).[14] Meanwhile, the Institute of Electrical and Electronics Engineers predicts that 75% of cars on the roads in the world will be autonomous by 2040.[15]

Research firm IHS Automotive projects that 54 million self-driving cars will be in use globally by 2035, and that nearly all vehicles in use are likely to be self-driving cars or self-driving commercial vehicles sometime after 2050.[16] IHS also predicts 60,000 autonomous trucks will be sold annually by 2035 (or 15% of trucks in the big class weight).[17]

Autonomous Vehicles and Transit

Driverless bus and shuttle pilot programs have recently launched successfully in several cities across the world, including Las Vegas, San Ramon (California), Lyon (France), Darwin (Australia), and Singapore. These buses typically travel along restricted roads.

Photo Credit: Pjotr Mahhonin, 2017

[14] Bansal, P., & Kockelman, K. M. (2017). Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. Transportation Research Part A: Policy and Practice, 95, 49-63.
[15] Self-Driving Cars. (2017, August 3). Retrieved from http://www.naic.org/cipr_topics/topic_self_driving_cars.htm
[16] Self-Driving Cars Moving into the Industry's Driver's Seat (2014, January 3). Retrieved from http://news.ihsmarkit.com/press-release/automotive/self-driving-cars-moving-industrys-drivers-seat
[17] Hawes, C. (2016, June 13). Self-Driving Cars Moving into the Industry's Driver's Seat. Retrieved from https://www.trucks.com/2016/06/13/self-driving-truck-sales-forecast/

Connected Vehicles

Connected vehicle (CV) technology allows vehicles to transmit and receive important mobility, safety and other information in real time. Communication can occur with:

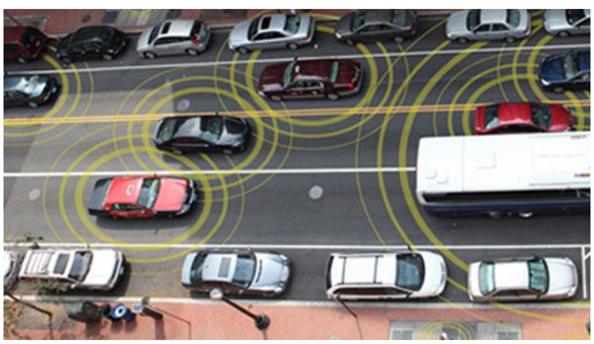
- Other vehicles (referred to as V2V),
- Traffic lights and other stationary infrastructure components (V2I),
- Pedestrians and bicyclists (V2P), and
- Any entity that may interact with or affect the vehicle (V2X).

Both V2V and V2I technology rely on communication systems such as Dedicated Short-Range Communications (DSRC) and cellular network technology. See Figure 4 for examples of V2V and V2I.

CV technology is a *communication platform* that has traditionally been viewed as complimentary to, but distinct from, autonomous vehicle technology. However, these technologies have been increasingly converging in recent years as it has become apparent that both have greater capabilities when utilized together. Some experts now conceptualize the combined technologies as ‘Automated Vehicles’ or ‘Connected Autonomous Vehicles’ (CAV).

Figure 4
V2V and V2I Connected Vehicle Technology

V2V



V2I

Photo Credit: USDOT

State of the Technology

There is a lot happening with CV technology, although it typically receives less media attention and public interest than autonomous vehicle technology. However, in recent years there has been an increase in federally funded CV pilot projects (including in Wyoming, Tampa, New York, and Michigan), increases in research funding, and CV test beds that provide an opportunity to test how CV technologies will perform under real-world conditions.

The American Association of State Highway and Transportation Officials (AASHTO) issued the Signal, Phasing and Timing (SPaT) Challenge in late 2016, urging state and local public sector transportation infrastructure owners and operators to deploy V2I infrastructure with SPaT broadcasts in at least one corridor or network (approximately 20 signalized intersections) in each of the 50 states by January 2020.[20]

There has also been a significant increase in private investment to develop and advance the technology, and a growing number of auto manufacturers are releasing passenger vehicles with connected features. In 2017, the Cadillac CTS sedan became one of the first vehicles with V2V capabilities to hit the market.

V2P Technology: Connected Vehicles and Pedestrians

V2P refers to technology that can send messages to pedestrians' mobile devices to warn of potential safety issues. It can provide functions such as: warning pedestrians when buses are approaching/departing a bus stop; warning passengers getting off a bus of any vehicles that may be out of view; and allowing visually impaired persons to communicate with traffic signals.[18]

A pilot project in Las Vegas (led by the GENIVI Alliance) launched in early 2017 aims to bring advanced CV technology to Las Vegas to help increase awareness for pedestrian safety.[19]

Photo Credit: USDOT ITS Joint Office Programs

V2V technology is also growing for freight movement, where many private sector freight movers envision utilizing it for truck platooning (minimizing the gap between vehicles to improve fuel efficiency) and are currently using it for data collection and various other beneficial measures. Truck manufacturers such as Otto, Peloton, Volvo and Daimler have been investing in developing CV technology. There was recently a successful demonstration project in Europe, where a convoy of connected, self-driving trucks drove across the continent (participants included Daimler and several other truck manufacturers).

Most of the private sector investment in CV technology has been focused on V2V (vehicles communicating directly with other vehicles) since – unlike V2I – it doesn't require significant

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[18] Pina, M. (2017). Can Connected Vehicles Save Pedestrians Too? SXSW 2017 PanelPicker Proposal. https://www.slideshare.net/MikePina/vehicletopedestrian-technology

[19] GENIVI Alliance. (2017, January 3). Press Release. https://www.genivi.org/sites/default/files/press-releases/english/GENIVI-Team%20Nevada%20Press%20Release%20Final%20.pdf

[20] The National Connected Vehicle SPaT Challenge. (2017, April 18). Retrieved from https://www.transportationops.org/sites/transops/files/SPaT%20challenge%20Folio%20imposed.pdf

public sector investment in infrastructure. Meanwhile, public sector usage of V2I technology (e.g. Metro's RapidRide program) have focused more on applications such as providing real time information and creating efficiencies through signal phasing and timing.

In addition to RapidRide, there have been other examples of these types of applications across the country. In 2016, the Colorado Department of Transportation and HERE (a transportation data and mapping technology provider) worked jointly to implement a CV safety alert system along the I-70 Mountain Corridor. The system, which utilizes both V2V and V2I techology, provides drivers with safety hazard information in real time. In 2017, the Regional Transportation Commission of Southern Nevada (RTC), the MPO and transit authority for the Las Vegas Region partnered with car manufacturer Audi to establish a V2I demonstration program that enables select cars to receive real-time signal information from the advanced traffic management system.[21]

Connected Vehicles and Transit: Metro's RapidRide Program

King County Metro's RapidRide network of 6 limited-stop bus routes (covering 64 miles) is equipped with V2I CV technology. Metro invested in installing the necessary V2I infrastructure along the RapidRide routes, which currently allows passengers to obtain real-time information and will allow for additional benefits in the future.

Photo Credit: King County METRO

Future Projections

There have been a range of estimates regarding the proliferation of CVs. IHS Automotive projects that the number of connected cars on the road globally will increase to over 150 million (from just over 20 million in 2015) by the year 2020.[22] Gartner, Inc., a research and advisory firm, is more optimistic, projecting that there will be 250 million CVs on the road by that time. They believe that the technology will continue to rapidly expand from luxury brands to more affordable midmarket models, making the technology increasingly accessible in coming years. The USDOT has stated that by 2045 it is realistic to imagine that 95% of all vehicles on roadways in America will have CV technology.[23]

In December 2016, the USDOT's National Highway Traffic Safety Administration (NHTSA) began rulemaking on a proposed rule that would mandate V2V communication on all newly manufactured light vehicles. As more cars become equipped with V2V technology, its benefits and impacts will have an increasingly greater reach. Similarly, as more public sector agencies invest in CV infrastructure, the benefits of V2I will become more widespread as well.

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[21] Audi launces the first Vehicle-to-Infrastructure (V2I) technology in the US starting in Las Vegas. (2016, December 6). Retrieved from https://www.audiusa.com/newsroom/news/press-releases/2016/12/audi-launches-vehicle-to-infrastructure-tech-in-vegas

[22] McCarthy, N. (2015, January 27). Connected Cars by The Numbers. Retrieved from https://www.forbes.com/sites/niallmccarthy/2015/01/27/connected-cars-by-the-numbers-infographic/#33417a7e1028

[23] *Connected Vehicles: Benefits, Roles, Outcomes* [White paper]. Retrieved from https://www.its.dot.gov/research_areas/pdf/WhitePaper_connected_vehicle.pdf

Shared Mobility

Shared mobility refers to transportation services that are shared among users. Shared mobility options have grown in popularity in recent years, propelled by the rapid advancement of technology enabled apps involving real-time information and an increasing demand for more convenient and flexible transportation options. Several companies offering shared mobility services, such as Uber, Lyft, Car2Go, and ReachNow, have been particularly successful in the central Puget Sound region's growing market (e.g. Seattle, with more than 100,000 members, is now Car2Go's largest U.S. market for carsharing).[24]

Types of Shared Mobility Services

- **Ridehailing:** A service that allows the legal usage of personal vehicles to operate as the functional equivalent of taxicabs. Ridehailing relies largely on mobile phone and GPS technology (e.g. Uber, Lyft).
- **Carsharing:** A shared-use car rental service that allows users to rent vehicles by the hour and, in some cases, return the car to any available parking spot (e.g. Car2Go).
- **Bikesharing:** A bicycle rental service that operates on a shared-use basis, typically only for the short term, while providing various options for where to pick up and drop off the bicycles (e.g. Limebike).
- **Micro-Transit:** A privately operated transit system that has greater operational flexibility than public transit and relies heavily on mobile phone technology (e.g. Chariot, Via).
- **Ridesharing:** Refers to organized carpool services facilitated by transit agencies, carpooling apps that match drivers with riders on daily commutes (e.g. Scoop), and on-demand carpool options (e.g. UberPool).

State of the Technology

In terms of key industry trends, automakers are shifting from being strictly car manufacturers to becoming "mobility providers," which involves expanding the scope of their business to include transportation services such as car sharing, traveler information, and point-to-point rides on demand. Examples include Ford's Smart Mobility Program and GM's Maven carsharing service.

Across the country there are also an increasing number of transit agencies partnering with shared mobility providers to improve first and last mile connections to and from transit and to provide mobility options in areas that transit does not serve well. Examples include Metro Transit's partnership with carsharing service HourCar in the Minneapolis - Saint Paul area to provide key first and last mile connections and King County Metro's TNC-based emergency ride home program (part of their Mercer Island TripPool and Redmond Real-Time Rideshare pilot programs).

The micro-transit market is currently in flux, with providers Leap and Bridj ceasing operations in 2015 and 2017, respectively. The San Francisco based micro-transit service Chariot was acquired by Ford in 2016 and expanded to several additional cities in 2017, including Seattle.

[24] Gutman, D. (2017, October 25). Car2go: Smart cars are out, Mercedes-Benz vehicles are in. *The Seattle Times*. Retrieved from https://www.seattletimes.com/seattle-news/transportation/car2go-smart-cars-are-out-mercedes-benz-vehicles-are-in/

Future Projections

Shared mobility is expected to continue to grow at an accelerated rate. Morgan Stanley estimates that by 2030, 26% of global miles traveled could be accounted for by ridehailing vehicles (up from 4% in 2015).[1]

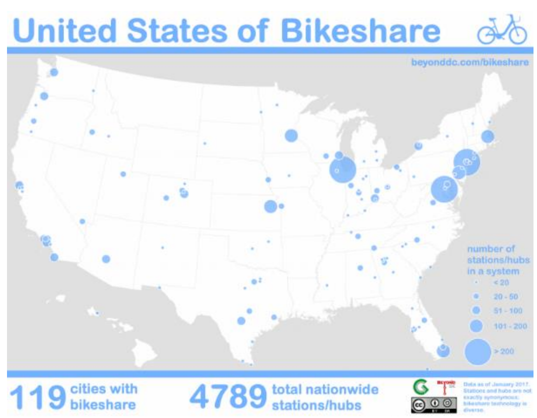
In addition, shared mobility services will likely become increasingly merged with autonomous and connected vehicle technology. According to Morgan Stanley and other industry experts, shared mobility services have the opportunity to be much more efficient with self-driving cars than with those that are human-driven. This process is already underway, as both Uber and Lyft have launched on-the-road autonomous vehicle pilot programs and Lyft recently established a "self-driving division" with plans to develop their own autonomous ridesharing technology.

As shared mobility services grow, a big challenge for local jurisdictions is to integrate these services into their existing transportation systems and plans. Several cities across the country, including Seattle, are attempting to tackle this challenge by developing strategic plans for new technology-enabled, mobility options. In September 2017, the Seattle Department of Transportation published the New Mobility Playbook,[26] which identifies policies and strategies that will help foster new mobility options while prioritizing safety, equity, affordability, and sustainability in the transportation system.

Bikeshare

Bikeshare programs involve short-term rental of bicycles to individuals. As shown in the map below, they are becoming increasingly prevalent across the country. In cities like Washington D.C., and Chicago bikesharing programs have been very popular, with customers utilizing them for shorter trips or for first and last mile connections to transit stops and stations.

In Seattle, several private bikesharing programs launched in 2017, including Limebike, Spin, and Ofo. These programs differ from the traditional bikeshare mode since they do not use docking stations. This offers more flexibility to users in terms of where they can drop off and pick up bicycles.



Source: Greater Greater Washington[25]

[25] Malouff, D. (2017, January 26) All 119 US bikeshare systems, ranked by size. Retrieved from https://ggwash.org/view/62137/all-119-us-bikeshare-systems-ranked-by-size

[26] Seattle Department of Transportation. (2017). *New Mobility Playbook*. Seattle

Traveler Information Tools

Traveler information tools are information technology-based tools that allow travelers to make more informed decisions and travel with greater efficiency and convenience. They include navigation and real-time traffic services (e.g. Waze, Google Maps), real-time arrival mobile applications (e.g. OneBusAway), options to pay via mobile apps (e.g. METRO's Transit GO Ticket app), and other tools that allow for more efficient and effective travel planning.

State of the Technology

As increasingly sophisticated mobile apps and a greater abundance of data becomes available, usage of technology-enabled traveler tools has grown significantly, with more and more travelers around the world relying on them for more informed and efficient travel. By 2016, the community-sourced navigation service Waze had more than 65 million monthly active users in 185 countries,[27] while the OneBusAway transit arrival tool had more than 100,000 daily users in the Puget Sound region alone.

The advancement in tools is also influencing approaches to data collection. For example, while traditional bicycle counters have existed for years (the Seattle Department of Transportation currently has 12), planners are now able to supplement this data with traveler data captured through mobile apps. The City of Portland has recently used bicycle trip data from the mobile fitness app Strava[28] to inform planning decisions, such as where infrastructure improvements are needed and where additional bike paths would be most utilized. Another key innovation developed by researchers at the University of Minnesota includes an app that allows blind and visually impaired pedestrians to get important signal timing and other information before crossing intersections. The app communicates via an audio format, providing key information and ultimately improving pedestrian safety for a particularly vulnerable group of travelers.[29]

Convoy: An On-Demand Service for Truckers

Seattle-based startup Convoy (launched in 2015) provides local truckers a better way to connect with shippers and vice versa. The company's app – relying on recently improved GPS accuracy and better data coverage – encompasses a network that links nearly 10,000 trucking companies with over 300 corporations (including Anheuser-Busch and Unilever) looking to ship goods. The app helps facilitate on-demand connections between truckers and businesses that move thousands of shipments per week and millions in sales.

Other companies providing a similar service to Convoy include Uber Freight and Transfix.

Mobile payment apps that provide more convenient payment options have also become available in recent years. In 2016, King County Metro debuted their TransitGo Ticket app, which allows Metro riders to purchase tickets and day passes via their phone without needing to use an ORCA card. The app also provides this option to riders using the King County Water Taxi or the Seattle Streetcar, as well as some Sound Transit riders. Mobile payment apps have also

[27] Driver Satisfaction Index. (2016) Waze. Retrieved from https://inbox-static.waze.com/driverindex.pdf
[28] Evans-Cowley, J. (2015, April 3) Fitness Apps are the New Planning Tool. Retrieved from https://www.planetizen.com/node/75515/fitness-apps-are-new-planning-tool
[29] Liao, C. (2012). Using a Smartphone App to Assist the Visually Impaired at Signalized Intersections. Retrieved from: https://conservancy.umn.edu/bitstream/handle/11299/132778/CTS12-25.pdf?sequence=1&isAllowed=y

appeared in other parts of the country, including Portland TriMET's app (which works across all TriMET services) and Chicago's VENTRA app.

Another recent trend is the combining of traveler tools into "Mobility as a Service" mobile apps that combine transportation options from various providers and include services such as travel planning and payment. One such example is Ridescout, a mobile app which allows users to search for and compare ground transportation options across modes. In Finland, the mobile app Whim is an all-inclusive multimodal transportation service that allows users to coordinate trips and purchase bus, train, bike and taxi tickets as well as arrange agreements with a car rental service.

An example of a public agency working with the private sector to develop a local "Mobility as a Service" option is Xerox's GoLA app, developed for and in partnership with the City of Los Angeles. The GoLA app aggregates data to provide travel suggestions across personal (car, bike, walk), public (bus, train), shared (ZipCar, bikeshare), and ridehailing (Uber, Lyft, etc.) travel options. Travelers are provided with a menu of trip planning choices that can include various combinations of both public and private transportation options.[32]

These information tools have the potential to enhance traveler efficiency and convenience. As these tools become more mainstream, the challenge for planning agencies is to ensure data quality and more broadly provide continued support for these tools.

Next Generation ORCA Project

In 2009, the seven transit providers in the central Puget Sound region launched ORCA (One Regional Card for All), a fare payment system that allows for seamless travel on the region's system of buses, trains, streetcars and ferries. ORCA has improved regional mobility for customers and has become one of the most popular ways to pay for transit fares in the region.

Photo Credit: King County METRO

Transit agencies are currently working on next generation ORCA to replace the existing system. A key focus of this effort is to improve the customer experience by offering greater flexibility, including providing customers with multiple options for fare payment, allowing purchases to be usable immediately, and various other enhancements.[30] One of the proposed enhancements is an ORCA mobile app which allows customers to use their phone as a virtual card or instantly add value to it while on the go.[31]

This project requires significant coordination among transit partners to ensure a smooth transition to the new system. The new ORCA is expected to come online in phases beginning 2021 and the current system will be phased out in 2022. Additional details on the project are available at: www.nextgenorca.com/

[30] Systems Integrator for next generation ORCA Scope of Work (2017, August). Retrieved from https://www.nextgenorca.com/wp-content/uploads/2017/10/next-gen-orca-si-sow-published.pdf
[31] Viriyincy, O. (2017, November). A Peek at the Next Gen ORCA. Retrieved from https://seattletransitblog.com/2017/11/15/peek-next-gen-orca/
[32] FAQs to Help. Retrieved from http://golaapp.com/help#how-app-work

IMPLICATIONS

While there is a lot of discussion about these emerging technologies, there is also much uncertainty: *When will the technology be widely manufactured and deployed? Will people adopt the new technologies, and how quickly? Will the new technologies be implemented along with electrification or with more traditional gasoline powered vehicles? Will we see a shared vehicle ownership model emerge or will private ownership models remain?*

Answers to these questions are probably years away, but now is the time to start considering how new technologies might impact travel, and how the region ensures that the new technologies support regional policy. Listed below is a high-level summary of these anticipated impacts:

- **Traveler Safety.** According to the National Highway Traffic Safety Administration,[33] human error is the cause of more than 90% of vehicular collisions. Perhaps no single implication of CAV technology is more compelling than the potential to significantly decrease the number of crashes and dramatically reduce fatalities and serious injuries. A study by consultants McKinsey & Company, indicates that by mid-century, a proliferation of driverless cars could reduce traffic fatalities in the US by up to 90%, saving approximately 30,000 lives per year.[34]

  However, while early research implies that these technologies do hold promise, safety benefits are not necessarily guaranteed, and new safety risks may be introduced by CAV technology. Defective hardware or software has the potential to cause accidents that would be less likely to occur under human control, and new cybersecurity risks could result in serious collisions if vehicles are hacked.[35] Another safety concern relates to shared mobility services such as Uber and Lyft and their associated conflicts with active transportation users. Commonly highlighted issues include obstruction of bike lanes, crosswalks and failure to yield to pedestrians during passenger pick-ups/drop-offs.[36]

- **Accessibility and Equity.** Emerging technologies could have significant impacts on transportation access and social equity. Trips that may not have previously been possible for special needs populations (e.g. persons with disabilities, seniors, or youth who are unable to drive; low-income populations who are unable to afford vehicles and lack transit options, etc.) may suddenly become feasible with the advent of CAV technology and expanded shared mobility options. This, in turn, could increase access to employment and educational opportunities for disadvantaged communities.[37]

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[33] Early Estimate of Motor Vehicle Traffic Fatalities in 2015. (2016). Retrieved from: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812269.

[34] LaFrance, A. (2015, September 29). Self-Driving Cars Could Save 300,000 Lives Per Decade in America. Retrieved from: https://www.theatlantic.com/technology/archive/2015/09/self-driving-cars-could-save-300000-lives-per-decade-in-america/407956/ Accessed November 16, 2017

[35] Zmud, J., Goodin, G., Moran, M., Kalra, N., Thorn, E. (2017) Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies. Retrieved from: http://nap.edu/24872.

[36] Moon, M. (2017, November). Uber and Lyft will test dedicated pick-up spots in San Francisco. Retrieved from: https://www.engadget.com/2017/11/09/uber-lyft-pick-up-dropoff-spots-san-francisco/

[37] Cohen, S., Shirazi, S. (2017) Can We Advance Social Equity with Shared, Autonomous and Electric Vehicles? Retrieved from: https://3rev.ucdavis.edu/wp-content/uploads/2017/03/3R.Equity.Indesign.Final_.pdf

Improving mobility will be particularly important in meeting the needs of a growing population of older adults in the region. The Washington State Office of Financial Management projects that by 2040 approximately 20% of the population in the region will be at least 65 years old, nearly double the percentage in 2015.[38] Increasing accessibility to transportation options for special needs populations is also a focus at the national level, with the USDOT's Accessible Transportation Technologies Research Initiative (ATTRI) aiming to advance technology-based applications that can accommodate the needs of all travelers.

However, despite these potential benefits, emerging transportation technologies also present significant equity challenges. Disadvantaged communities could face financial, technological and language barriers to using shared mobility services. Those who are unable to afford a smart phone or open a bank account will not have access to such benefits. In addition, an analysis by the Victoria Transport Policy Institute (VTPI) suggests that fully autonomous technology may not become affordable for less affluent drivers until well after the 2040s. Until that occurs, such drivers are less likely to reap the potential safety and convenience benefits of autonomous technologies.[39]

- **Traffic Congestion/Vehicle Miles Traveled (VMT).** It is possible that the increased efficiency provided by autonomous vehicles, shared mobility options, and readily available traveler information will lead to less congested roadways. For example, a recent study demonstrated that congestion-inducing "stop and go" traffic waves caused by erratic human driving behavior are eliminated when as few as 5% of the vehicles on the roadway are autonomous and carefully controlled.[40] CAV technology may also be able to considerably mitigate crash-related delays, as well as allow for more efficient roadway designs that improve traffic flow.[41]

  However, the greater accessibility and convenience provided by these technologies could also significantly increase travel demand and vehicle miles traveled. For instance, if drivers can use travel time in autonomous vehicles for productive work, leisure, or other non-driving activities, it could dramatically reduce the incentive to take public transit or live close to employment.[42] This would potentially lead to more cars on the road, more miles being driven, longer commute times and increased congestion.

  The yet-to-be-answered question regarding the shift from the current private vehicle ownership model to a shared vehicle ownership model will likely be an important factor in determining how congestion and the total number of vehicle miles traveled (VMT) are impacted. A 2014 PSRC study on the potential impacts of autonomous vehicle technology

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[38] Washington State Office of Financial Management State Population Forecast. (2016). Retrieved from: https://www.ofm.wa.gov/washington-data-research/population-demographics/population-forecasts-and-projections/state-population-forecast
[39] Litman, T. (2017, September 8). Autonomous Vehicle Implementation Predictions: Implications for Transport Planning. Retrieved from: https://www.vtpi.org/avip.pdf
[40] Stern, R., Cui, S., Monache, M., Bhadani, R., Bunting, M., Churchill, M., Hamilton, N., Haulcy, R., Pohlmann, H., Wu, F., Piccoli, B., Seibold, B., Sprinkle, J., Work, D. (2017, May 4) Dissipation of stop-and-go waves via control of autonomous vehicles: Field experiments. Retrieved from: https://arxiv.org/pdf/1705.01693.pdf
[41] Zmud, J., Goodin, G., Moran, M., Kalra, N., Thorn, E. (2017). Advancing Automated and Connected Vehicles: Policy and Planning Strategies for State and Local Transportation Agencies. Retrieved from: http://nap.edu/24872.
[42] Pinjari, A. (2013). Highway Capacity Impacts of Autonomous Vehicles: An Assessment. Retrieved from: https://abdulpinjari.weebly.com/uploads/9/6/7/8/9678119/abdul_pinjari_autonomous_vehicles_whitepaper_recent.pdf

estimates a broad range of possible outcomes; VMT is projected to decrease by 35% in a scenario where personal AV ownership is no longer necessary, while it is projected to increase by 20% if a private ownership model is retained and total market penetration is achieved.[43]

- **Air Quality.** Impacts to air quality are closely tied to the questions around congestion and VMT discussed in the previous bullet. Another critical issue will be whether these technologies are implemented along with traditional gas-powered vehicles or combined with the electrification of the vehicle fleet.

- **Public Transit Usage.** The net impact on public transit is still uncertain. Will the new technologies complement or reduce transit usage? The American Public Transportation Association released a report in 2016 indicating that frequent users of shared mobility services are more likely to rely on public transit and that shared modes complement transit service.[44] However, research from the U.C. Davis Institute of Transportation Studies suggests that ridehailing pulls people away from public transit.[45] Ultimately, it is still too early in the proliferation of these technologies to know exactly how transit usage will be affected.

- **Travel Behavior.** Planners and travel modelers are still working to figure out how travel behavior could be impacted by these new technologies. PSRC's current travel models rely on assumptions about the nature of travel behavior that may change as emerging technologies become more prolific.

  As an example, current travel models do not account for the variation in traveler experience between AV and non-AV vehicles. However, as noted by the University of Washington Tech Policy Lab, people may have a higher tolerance for longer commutes or choose different travel routes if they can complete tasks such as working and sleeping while in the car instead of driving.[46] Such variations in traveler experience may have significant impacts on travel behavior and commute patterns, although what those impacts might be is still uncertain.

- **Land Use.** Autonomous vehicles and shared mobility options may have a significant impact on land use patterns and streetscapes, although how this might occur is also not yet fully understood. A review of existing research on this topic shows a broad spectrum of potential impacts on land use patterns, depending on the convergence of various factors.

  For example, a scenario where autonomous vehicles and shared mobility services are part of a flexible, multi-modal transportation system with public transit serving as the backbone of urban travel would likely facilitate more concentrated development and higher population densities. In this scenario, the proliferation of autonomous taxi/ridehailing services would play

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[43] Childress, S., Nichols, B., Charlton, B., Coe, S. (2014, August 1). Using an Activity-Based Model to Explore Possible Impacts of Automated Vehicles. Retrieved from: https://psrc.github.io/attachments/2014/TRB-2015-Automated-Vehicles-Rev2.pdf

[44] Shared Mobility and the Transformation of Public Transit. (2016). Retrieved from: http://www.apta.com/resources/reportsandpublications/Documents/APTA-Shared-Mobility.pdf

[45] Clewlow, R. Mishra, G. (2017). Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States. Retrieved from: https://itspubs.ucdavis.edu/wp-content/themes/ucdavis/pubs/download_pdf.php?id=2752

[46] Driverless Seattle: How Cities Can Plan for Automated Vehicles. (2017). Retrieved from: https://www.washington.edu/innovation/2017/03/01/driverless-seattle-how-the-city-can-plan-for-automated-vehicles/

a key role in urban mobility (leading to a reduction in land consumption for urban parking), while personal autonomous vehicles would be used less frequently and largely for long-distance or inter-city travel.

However, in a scenario where autonomous vehicles are the key feature in a primarily car-dominated transportation system, increased sprawl and lower density development would be more likely outcomes. In this scenario, the majority of autonomous vehicles would be privately owned and there would be limited pairing of autonomous vehicle travel with public transit.[47] In addition, estimates from a range of sources (including universities, manufacturers, and consulting firms) suggest that fully autonomous vehicles could be substantially cheaper to maintain and operate than today's cars.[48] If this proves to be accurate, it would likely only increase the incentive for low-density development further away from job centers.

[47] Heinrichs, D. (2016, May 22). Autonomous Driving and Urban Land Use. Retrieved from: https://link.springer.com/chapter/10.1007/978-3-662-48847-8_11/fulltext.html
[48] Cortright, J. (2016, September 28) How Much Will Autonomous Vehicles Cost? Retrieved from: http://cityobservatory.org/how-much-will-autonomous-vehicles-cost/

REGIONAL GOALS, STRATEGIES, AND ACTION ITEMS

The rapid growth in technology combined with anticipated changes has the potential to fundamentally alter our transportation systems in terms of how they are planned, designed, built and operated. The potential impacts of these technologies (described in the above section) might result in significant shifts in travel behavior, travel demand, land use patterns, and potentially car ownership models. While these technologies are touted to have immense benefits to the society, there are also substantial risks. Hence, in developing policy and planning strategies, agencies need to consider the wide spectrum of potential impacts, risks and uncertainties inherent in these technologies.

Ultimately, important questions will need to be answered regarding how these technologies align with and support regional goals across transportation, land use, and economic development. *What actions can be taken to accelerate the positive impacts? What sort of mitigation efforts can be undertaken? How will growth management practices adjust in the face of new opportunities and shifting preferences? How can the central Puget Sound region plan and prepare for these changes?*

Despite the uncertainly on deployment timelines and anticipated impacts, it is important for jurisdictions in the region to begin laying out strategies to prepare the region for the rapid acceleration of transportation technology.

Figure 5 summarizes the regional goals, high-level strategies and actions identified for both established and emerging technologies, and the section below describes them in greater detail. These were developed based on the input received from a range of sources, including PSRC's Transportation Policy Board (TPB) and Regional Traffic Operations Committee (RTOC), stakeholders from across the region, internal staff discussions, PSRC's conversations with other MPOs across the country and a review of technology related plans from outside the region (e.g. Los Angeles County's Shared Mobility Action Plan). The goals, strategies and action items highlighted below provide a roadmap to prepare the region for the anticipated changes associated with these technologies.

Figure 5
Goals, Strategies, and Action Items

	GOALS	STRATEGIES	ACTION ITEMS
ESTABLISHED ITS Technologies	A safe, efficient and effective regional transportation system	Increase implementation of ITS throughout the region to increase the safety, mobility, and productivity of the regional transportation system	• **A1:** Update the region's ITS Implementation Plan (RITSIP) to better reflecting existing conditions, current needs and projected changes due to emerging technologies. In addition, develop metrics to better quantify and highlight the benefits of ITS and develop a regional clearinghouse for better data sharing and integration
EMERGING Technologies	A region on the cutting edge of successfully leveraging emerging transportation technologies	Foster emerging technologies consistent with the region's policy goals and prepare for potential disruptions	• **B1:** Establish a technology advisory committee, with diverse stakeholders, to help the region prepare for and foster emerging technologies. Topics to explore include legal frameworks, liability issues, and technical specifications to support new technologies • **B2**: Facilitate regional discussions to identify opportunities to support private sector projects and partnerships and the deployment of pilot programs • **B3**: Continue to enhance the regional models to analyze the effect of autonomous and electric vehicles, shared mobility, and new technology on the transportation system and travel behavior

Established ITS Technologies

Established ITS encompasses more developed technologies such as traffic signal systems, active traffic management, vehicle detection devices, integrated corridor management, and various other technologies. As discussed in the Established Technologies section, what separates these from emerging technologies is that they have been widely deployed in the region and hence there is generally a greater understanding of how they operate and the types of impacts that they have.

***Goal*:**
A safe, efficient, and effective regional transportation system

Strategy:
Increase implementation of ITS throughout the region to increase the safety, mobility, and productivity of the regional transportation system

Action Item A1: Update the Regional ITS Implementation Plan (RITSIP)

To provide a clear road map for where ITS investments should be prioritized, PSRC will collaborate with stakeholders in updating the Regional ITS Implementation Plan (RITSIP) to better reflect existing conditions, current needs and projected changes due to emerging technologies. The plan will prioritize corridors for increased ITS investment and potentially explore other key issues such as equity and incentives for cross-jurisdictional collaboration. It is anticipated that the RITSIP update will be completed prior to the next plan update.

Supporting the proposed RITSIP update, PSRC would also work to develop metrics to better quantify and highlight the benefits of ITS technologies. Although established ITS technologies provide clear benefits, inconsistencies in quantifying those benefits have made communicating their magnitude and true value more challenging. A regional effort (through PSRC's Regional Traffic Operation Committee and other venues) should be undertaken to develop regional guidelines and recommendations for collecting and reporting ITS project performance metrics and local jurisdictions encouraged to build performance metrics into projects during the planning stages.

Further expanding on current data integration work, a regional effort should be pursued to develop a clearinghouse that integrates and standardizes disparate data sources from jurisdictions and agencies across the region. This tool would be a platform for secure, streamlined datasharing and would allow stakeholders to access a broad range of data for more informed decision-making and more efficient collaboration. In terms of technology, it would provide organizations with a seamless and unified view of ITS deployments, needs and metrics across the region, allowing for more informed and effective technology investments and serving as a valuable strategy for both established and emerging technologies. It is worth noting that there are currently other efforts to develop cross-jurisdictional data collaboratives in the region (e.g. the ORCA Data Analysis Project). Opportunities should be sought out to merge with or build on these efforts.

Emerging Technologies

As described in the prior section, 'Emerging' here refers to still evolving, potentially transformational technologies that have more uncertainty attached to them and whose impacts are not as clear as established ITS technologies. This plan focuses on four key emerging technologies, namely, autonomous vehicles, connected vehicles, shared mobility, and traveler information tools.

Goal:
A region on the cutting edge of successfully leveraging emerging transportation technologies

Strategy:
Foster emerging technologies consistent with the region's policy goals and prepare for potential disruptions

Despite uncertainties regarding the broader impacts of emerging transportation technologies, now is the time to begin preparing the region to better maximize potential benefits, prepare for potential disruptions, and help steer these technologies towards aligning with and supporting regional goals. Provided below are action items aimed at effectively transitioning to a quickly-transforming transportation landscape.

Action Item B1: *Establish a Technology Advisory Committee*

PSRC will convene and facilitate a Technology Advisory Committee consisting of local leadership, private sector representatives, transportation planners, traffic engineers, and other key stakeholders from across the region to help the region prepare for and foster emerging technologies. While the exact focus and scope is to be determined, topics to explore include legal frameworks, liability issues, and technical specifications to support new technologies.

The committee is expected to kick-off following the adoption of the Regional Transportation Plan.

Action Item B2: *Facilitate regional discussions to identify opportunities to support private sector projects and partnerships and the deployment of pilot programs*

Regional agencies and private organizations should work together to identify and pursue opportunities to bring demonstration projects and pilot programs to the Puget Sound Region.

Examples of these types of demonstration projects include the USDOT's Connected Vehicle Pilot Deployment Program and Smart Cities Challenge. There are also opportunities for implementing demonstration projects through partnerships with the private sector, for example the Las Vegas partnership with Audi referenced earlier, to establish a V2I demonstration program. This example points to the broader opportunity for jurisdictions to partner with auto manufacturers to prepare their infrastructure for V2I connectivity, potentially allowing for an array of services designed to improve system efficiency, drive time or traffic management.

In June 2017, Washington Governor Jay Inslee signed an executive order that encourages pilot tests of autonomous vehicles on Washington roads and establishes a working group to help ensure state support for autonomous vehicle developers. Within the Puget Sound region, Google performed tests of its self-driving car in partnership with the City of Kirkland in early 2016.

Action Item B3: *Continue to enhance the regional models to analyze the effect of autonomous and electric vehicles, shared mobility, and new technology on the transportation system and travel behavior*

As noted in the Implication section, our current travel demand models do not necessarily account for the variation in traveler experience due to these emerging technologies which in turn affect the demand on the transportation system. PSRC will continue to research and identify ways to improve our current modeling capabilities so that the impacts of these technologies can be better analyzed and understood.