Introduction

This memorandum documents and summarizes key trends in emerging transportation technologies that may impact transportation planning. The discussion is based on findings of a background literature review and industry expert feedback. While many state departments of transportation (DOTs) are already tackling immediate issues related to regulating and adapting to changing technologies, ODOT is increasingly being asked to consider how these changes in technology will impact our planning for the future. This memorandum focuses on how these emerging trends in the context of societal technological change may impact ODOT’s planning functions.

The memorandum is organized into three sections:

- Vehicle technologies
  - Connected Vehicles
  - Automated Vehicles
  - Electric Vehicles
- Mobility options
  - Transportation Network Companies (TNCs)
  - Microtransit and Automated Vehicles
  - Car Share
  - Bike Share
  - Mobility as a Service
- Freight and logistics
  - App-based Demand Responsive Delivery and Logistic Services
  - Connected and Electric Freight Vehicles
Each identified emerging technology includes a summary of the current state of practice, trends, potential regional and statewide impacts to Oregon's transportation system, and operational impacts to ODOT.

**Overarching trends enabling transportation advancements**

Technological advancements continue to have significant impacts to transportation, becoming more profoundly evident in recent years. Of the myriad interconnected technological advancements likely to shape the transportation system in the future, some of the most significant include:

- Improvements in computing power and miniaturization
- Communications and networking
- Increase of available data.

**Improvements in Computing Power**

Microchip advancements have continued with the miniaturization of integrated circuits and have resulted in the ability to bring tremendous amounts of computing power into smaller form factors year-over-year. Moore’s Law is a commonly referenced theory which postulates that the number of transistors in a dense integrated circuit will double about every two years. For the most part, this observation held true until around 2012. And while transistor sizing has reached a threshold, other advancements in microcircuit and software development have allowed continued improvements in computing power and application capabilities. The smartphone is a prime example of these type of advancements.

Neural networking and artificial intelligence are good examples of how developers have been able to stretch beyond the physical limits of the transistor. This is becoming evident in some of the automated vehicle improvements in the past few years.

**Communications and Networking**

Communications improvements have also enabled previously unimaginable connectivity capabilities. The newest generation of cellular communications (5G) holds the promise of very low-latency exchange of data at much higher bandwidths than the current 4G LTE cellular system. Other newer wireless communication capabilities are now being introduced that allow “ad-hoc” or “peer-to-peer” networking. These type of networking functions will allow communications directly between parties which will eliminate the need to go through a back-end network controller.

**Available Data**

Computing power, communications and networking improvements will now create an increase in the amount of data that can be consumed. This increase in data is coined “big data.” An entire industry based on cloud computing, storage and the Internet of Things (IoT) has

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1 Moore’s Law: [https://en.wikipedia.org/wiki/Moore%27s_law](https://en.wikipedia.org/wiki/Moore%27s_law)
developed to explore opportunities to capitalize on this increase of data and to seek out patterns that inform real-time decisions in complex systems.

Vehicle Technologies

Connected vehicles (CVs)

Technologies Enabling Communications

Advancements in communication technology is enabling vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. This is supporting the development of a variety of integrated products, services and applications.

Cellular Communication

Satellite communications were the first connectivity platforms imbedded in vehicles. By using the Global Positioning System (GPS) satellite network, real-time navigation systems have become standard in vehicles. However, cellular technology is now the most predominant form of communication inside vehicles and has introduced navigation systems that can bring in real-time traffic, incident and weather information. While in 2015, only 20% of new vehicles produced had imbedded cellular connectivity, this will likely increase to more than 75% by 2024.

Dedicated Short-Range Communication (DSRC)

Another emerging communication technology is Dedicated Short-Range Communication (DSRC) radio. The U.S. DOT supported the deployment of these radios in both passenger and freight vehicles as part of their Connected Vehicle Pilot Program. DSRC radios installed in vehicles will allow vehicles to communicate with each other (V2V) as well as with roadside unit DSRC radios installed on infrastructure (V2I). These radios communicate in the 5.9 GHz band that the Federal Communications Commission (FCC) has set aside for vehicles to make use of a suite of applications. These radios communicate directly with each other (peer-to-peer) and communicate in both directions (bi-directional). The radios are intended to communicate over short distances up to 300 meters. Consequently, the intent of this type of communication system establishes communication links very quickly and enables low-latency exchange of data packets or messages to improve vehicle safety. Because of its ability to establish a peer-to-peer network, there is no need to communicate through a master controller or communications intermediary.

While still in the pilot stage, the U.S. DOT DSRC system enables a vehicle to broadcast what is known as the Basic Safety Message (BSM). The BSM is a 10 Hz signal that communicates in real-time the essential characteristics of a traveling vehicle including vehicle trajectory, speed, and steering wheel angle. The BSM is “heard” by other equipped vehicles which allows advanced awareness of a vehicle’s movement in the real 3-D world. Applications can make use of this BSM to improve driver safety by the issuance of warnings or, in some cases, take control of a vehicle’s movements, as in the case of emergency breaking or vehicle platooning. BSM

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2 Motor Authority; “5G technology could unlock vehicle-to-infrastructure communication” https://www.motorauthority.com/news/1115604_5g-technology-could-unlock-vehicle-to-infrastructure-communication
communications with traffic signals can be used to help prevent red light running or intersection collisions.

5G Cellular Communication
Since the establishment of DSRC protocol and communication technology (2012), cellular companies embarked on a new generation of cellular called 5G. This version of cellular has much lower latencies than 4G LTE and there are variants of this communications system to communicate point-to-point. Consequently, while much research and development has been invested in DSRC to date, some are considering the possibilities of using 5G in lieu of DSRC.

Despite the advancement of 5G, some manufacturers are committed to DSRC; in 2018, GM was the first American car manufacturer to voluntarily install DSRC in the Cadillac CTS sedan. This year, Toyota announced that all vehicles will have DSRC beginning in the year 2021. Volkswagen announced it will deploy vehicles with DSRC in the European Union in 2019. Some manufacturers, although they may continue to work towards installing DSRC radios in their cars at some point, have aligned around the 5G Automotive Association (5GAA). These manufacturers include AUDI AG, BMW Group, and Daimler AG.

Federal Rulemaking
CVs have been a focus area of the U.S. DOT Intelligent Transportation System (ITS) Joint Program Office (JPO) since the early 2000s and the agency has supported research to advance CVs and encouraged their deployment. As communications technologies that enable CVs have matured, U.S. DOT and the National Highway Traffic Safety Administration (NHTSA) began to develop and propose federal rules to govern their deployment. The U.S. DOT is “technology agnostic” when it comes to advocating for a particular communication type. The U.S. DOT is more focused on the use of a wireless technology in CVs to help improve safety, mobility and the environment rather than focusing necessarily on which technology to use.

Figure 1 illustrates how the JPO conceptualizes a large suite of applications categorized by benefit area³:

³ https://www.its.dot.gov/pilots/cv_pilot_apps.htm
In late 2016, NHTSA, in conjunction with U.S. DOT, initiated a federal rulemaking process that proposed a mandate for all light vehicles to include dedicated short-range communication (DSRC) radio devices. The joint U.S. DOT/NHTSA V2V Communication Notice of Proposed Rule Making (NPRM) stated that car manufacturers should include DSRC devices in new model cars two years after the final rule is adopted. Additionally, manufacturers would have a three-year phase-in period to accommodate production cycles. It is expected that the rule will be finalized in 2019, which would mean that the phase-in period would begin in 2021 and that all new production vehicles would need to comply by 2023. Although the Associated Press reported that the White House was not interested in supporting this Obama-era mandate, U.S. DOT has publicly committed to the current timeline. Building on this uncertainty, the U.S. DOT redacted FHWA's V2I Deployment Guidance that was first issued in December 2016.
In 2016, the U.S. DOT awarded three agreements collectively worth more than $45 million to initiate a design/build/test phases of the Connected Vehicle Pilot Deployment Program in three locations: New York City (NYC), Tampa, and Wyoming.

- NYC – This pilot focuses on primarily passenger and transit vehicles and includes the deployment of 5,850 taxis, 1,250 city buses, 400 UPS trucks, and 500 city vehicles, that all communicate with one another and 350 roadside units.
- Tampa – This pilot focuses primarily on passenger vehicles and includes the deployment of 10 buses, 10 streetcars, and 1,600 cars.
- Wyoming – This pilot has a freight focus and includes the deployment of 400 trucks and 75 roadside units on a heavy trucking corridor.

To promote roadside installations of DSRC radios, the Cooperative Automated Transportation (CAT) Coalition led by American Association of State Highway and Transportation Officials (AASHTO), Institute of Traffic Engineers (ITE), and Intelligent Transportation Society of America (ITS America) initiated the currently active Signal Phase and Timing (SPaT) Challenge to challenge state and local transportation infrastructure owners and operators to achieve deployment of DSRC infrastructure with SPaT broadcasts in at least one corridor (20 signalized intersections) in each state. Several states and local authorities are installing these roadside units to evaluate and consider potential connected vehicle applications. Oregon is not currently participating in SpaT. Figure 2 displays a map of locations on SPaT activity across the country (source: National Operations Center of Excellence (NOCoE)).

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Regardless of technology (satellite, cellular as 4G LTE or 5G and DSRC), CVs will continue to evolve as the U.S. DOT moves through its proposed CV program. The U.S. Government Accountability Office (GAO) suggests high levels of V2V and V2I deployment by 2040 as shown in Figure 3.

Figure 2. SpaT Deployments and Activities (source: NOCoE)

Figure 3. U.S. DOT's Planned CV Path to Deployment (Source: GAO)
AASHTO sponsored a study to assess the range of potential CV deployment scenarios and their related impacts in the National Connected Vehicle Field Infrastructure Footprint Analysis\(^5\). CV applications have the potential to improve safety, enhance mobility, improve operational performance, and reduce environmental impacts. AASHTO identifies and outlines several deployment scenarios for CVs:

- **Rural roadways**: safety improvements through increased traveler information relating to the roadway configurations and conditions (i.e. curve speed warnings, road weather conditions).
- **Urban highways**: safety, mobility, and environmental benefits including active traffic management and advanced real-time traveler information,
- **Urban intersections**: primary safety improvements through red light and stop sign violation warnings.
- **Urban corridors**: can provide safety, mobility, and environmental benefits through increased information for transportation management centers but are more likely to require high-bandwidth communication networks than single intersections or rural sites.
- **Freight intermodal facilities**: applications can include real-time traveler information for freight carriers and support monitoring shipments to prevent or identify tampering.
- **Smart Roadside freight corridors**: enables more efficient demand management and operations by providing targeted information to truckers, carriers, and shippers.
- **DOT system operations and maintenance**: applications support operational improvements including gathering data and providing it to operations and maintenance staff.
- **User fee collection**: applications can potentially reduce the operation and maintenance costs associated with toll facilities and provide more effective and secure revenue collection.

When correcting for a recession-based decrease in vehicle miles travelled (VMT), the number of annual deaths due to vehicular crashes has plateaued over the past decade.
Implications of Communications Technologies

While there is some uncertainty on the fate of DSRC as a mandated installation in American vehicles, the automotive industry as well as many departments of transportation regard short-range, low-latency communications as being able to significantly impact safety and thereby decreasing the numbers of annual deaths. The U.S. DOT pilots have purported that nearly 80 to 90 percent of all non-impaired accidents could be prevented by CV short-range communication technology. This potential impact alone has many DOT’s engaging in CV initiatives to be certain they are prepared to match new CVs with roadside units which will further enable the capabilities of CVs.

Cellular communications, even if deployed using the currently available and mature 4G LTE network, will continue to provide great improvements to mobility by bringing real-time traveler, incident and weather information inside vehicles. Even as vehicles catch up to market demands for imbedded cellular vehicle systems, smartphones continue to be used as a surrogate.

For DSRC and cellular networks alike, the common need will be improved backbone communications. Some CV applications do not need connectivity to the Internet or other networks and in-fact some applications can operate “at the edge” of a network. However, a rich, interconnected enterprise network will enable DOTs to better harvest and push real-time vehicle data. Backbone communication improvements are typically most needed in rural areas where fiber-line or microwave backbone communications can be sparse. In addition, the lack of communication hubs can cause bottlenecks in data movement which could stand in the way of the promise of CVs.
Implications for Oregon

While there is some uncertainty regarding the communications platform that will support CVs, (DSRC or 5G), there are some documented benefits to CV deployments, most notably improved safety. In addition, many experts believe that automated vehicles (AVs) will eventually be deployed in combination with CVs. These uncertainties make it difficult for jurisdictions to determine an appropriate level of investment to generate safety, mobility, and operational benefits.

The Oregon Department of Transportation (ODOT) has already invested resources in Intelligent Transportation Systems (ITS) and this is a common place for CV initiatives to develop. To fully reap the benefits of CV and to provide those to the motoring public, ODOT’s information technology team will likely need to be further engaged to create networks capable of addressing the daily terabytes of data anticipated when the CV system is fully developed in coming years.

Currently half of all States have committed themselves to the SPaT challenge, thus demonstrating the collective optimism for deploying DSRC radios with traffic signals. ODOT could make modest investments in CVs while still maintaining their ITS initiatives. In the near term, the agency’s long-range plans, including the Oregon Transportation Plan, the Oregon Highway Plan and the Transportation Safety Plan, could be updated to include policies targeted to increase CV deployments to support improved safety, mobility, and operations.

Operational impacts to ODOT
(ODOT will draft this section)

Automated vehicles (AVs)

Automated vehicles (AVs) are often discussed in context of connected vehicles or as “connected and automated vehicles” or CAV. Many see automated vehicles as being capable only as much as they are connected to infrastructure or other vehicles through wireless communications. As shown in Figure 4, the U.S. DOT recommends that they are considered in unison:

6 U.S. Department of Transportation ITS Joint Program Office
Connected and Automated Vehicles

The path toward connected vehicles will ultimately lead to automated vehicles.

AVs will impact travel and transportation but there is some uncertainty about how they will. While AVs have the potential to create public benefits, such as reductions in the occurrence and severity of collisions and improved mobility, there are however, potential social and environmental costs. One viewpoint on the extent of the anticipated benefits and costs related to AV deployment can be summarized in three potential operational models. Table 1 describes the operational models and related impacts.

Table 1. Automated Vehicle Operational Model

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<td>Personal automated vehicles – Motorists own or lease their own self-driving vehicles.</td>
<td>High convenience. Usage available immediately. Personal items, such as equipment, tools and snacks, can be left in vehicles.</td>
<td>High costs. Must arrange storage either in a personal garage, driveway or curb space. Does not allow users to choose different vehicles for different trips, such as cars for</td>
<td>People who travel a lot, reside in sprawled areas, want a particular vehicle, or want to use the vehicle anytime as-needed.</td>
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Figure 4. U.S. DOT’s Vision for Connected and Automated Vehicles

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7 Adapted from Victoria Transport Policy Institute
As automotive manufacturers began testing prototypes and requesting live street runs of these vehicles around 2010, the U.S. DOT and NHTSA stepped up their determination to provide guidance to assure public safety and standards. Beginning in 2016, U.S. DOT issued agency guidance for AVs, which focused on ways to accelerate acceptance of highly automated vehicles. These guidance principles provided vehicle performance guidelines and included voluntary reporting to NHTSA. It also included models for states to consider in developing each of their own policies. In early 2017, U.S. DOT updated this guidance and included 12 new areas of recommendation including state and local laws.

In September 2017, the House passed the SELF DRIVE bill by voice vote. Highlights include:

- Preempts states from implementing certain laws governing the new technology.
- States will still be responsible for vehicle registration, insurance, driver education, law enforcement.
- NHTSA will be in charge of regulating the industry’s traffic safety standards.
- Allows car manufacturers to deploy up to 100,000 self-driving cars a year that don’t meet normal safety standards.
- In the first year, however, that number will be capped at 25,000.
- Manufacturers will be required to include cybersecurity and privacy protections in their vehicles.

With the rapid development of AV technology, many states are considering or have enacted autonomous vehicles legislation. In 2018, 34 states have introduced AV legislation, an increase from 20 states in 2016. Figure 5 illustrates which states have enacted legislation and executive orders. The National Conference of State Legislatures hosts a database where users can

search 2017-2018 automated vehicle legislation by state, topic, keyword, year, status or primary sponsor.

In January 2018, FHWA issued a Request for Information (RFI) to better understand what is needed to accommodate automated driving system technologies. The results of this RFI are currently being used to provide an update to the U.S. DOT AV Framework.

NHTSA and the Society of Automotive Engineers (SAE) have established levels of automation that are used to describe different levels of vehicle autonomy and driver interaction. There are six levels organized along a spectrum from no automation (level 0) to full automation (level 5). The AV system monitors the driving environment at levels 3 and above. See Figure 6.

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9 National Conference of State Legislatures, Autonomous Vehicles State Bill Tracking Database
Many automotive manufacturers have already put cars into production that meet what is considered Level 2 Partial Automation which will require a driver to remain fully engaged in controlling the vehicle. In the past year, some manufacturers have announced plans for highly automated (Level 3 or higher) vehicle production; Figure 7 summarizes public statements made by manufacturers.

AV technology has advanced rapidly in the past five years. The most common technologies that enable AV operations can be summarized in three main components: sensing, mapping, and control.
• Sensing: This is accomplished through the application of a variety of technologies, including high-resolution cameras, radar, and LiDAR.
  o High definition CCTV: provides information for video analytic engines to interpret and classify objects as they appear in the vehicle’s field of view (FOV).
  o LiDAR: a sensor device that uses light waves to determine the distance of objects, thereby representing the dynamic and stationary elements in the FOV of the vehicle.

• Mapping: Data collected with sensing technologies is analyzed and used to develop an accurate environmental model and high definition 3D, real-time map that informs the robotic control of the AV and of all the factors that need to be taken into consideration as the vehicle travels along its virtual map route.
  o GPS: a receiver that utilizes triangulation calculations in communication with satellites to determine location of the vehicle on earth. However, GPS has reliability issues when a receiver cannot be in line-of-site with at least three satellites. This can happen in cities or “urban canyons” where tall buildings and other infrastructure can interfere with communications.
  o Differential GPS: To help address GPS issues, differential GPS is sometimes utilized to supplement the satellite system. This is done through the installation of terrestrial positioning base stations within range of the device needing to be located. These extra signals allow the device to determine its location more accurately. This type of installation can be costly.
  o Dead reckoning: AVs are now mostly using a combination of GPS and dead reckoning to geolocate. Dead reckoning is the process of calculating a position by using a previously determined position and may be accomplished by initially creating or programming a digital terrain map for the vehicle, which can be done through training runs, if the route is fixed. Once the digital map is programmed into the vehicle, the vehicle can determine its location at any given time, through accelerometer readings which provide trajectory, speed, and directional information to the vehicle.

• Control: AV control requires a highly developed, intelligent computing engine that can reinforce learning and decision making and is able to command vehicle reactions as the vehicle encounters various real time scenarios.
  o Artificial Intelligence (AI): Some AVs are being developed with machine learning and cognitive intelligence. Machine learning allows a vehicle to record previous activities and utilize pattern recognition to determine a course of action when encountering new situations. Cognitive intelligence provides an inference engine in the vehicle, so that it has the ability to make more human-like decisions. Based on cost and the fact that Artificial Intelligence (AI) is still in its early development phase, AI is usually limited to driving functions that address unforeseen visual cues.
Implications for Oregon

The University of Michigan’s Center for Sustainable Systems has summarized some of the anticipated metrics of impacts, benefits and costs of AVs.\(^\text{10}\) The following lists key metrics and associated potential impacts to consider as they apply to Oregon’s transportation system:

- **Congestion:** Congestion is predicted to decrease, possibly reducing fuel consumption.

- **Increased VMT:** With improved convenience from decreased congestion and higher vehicle use, this may lead to increased VMT. Elderly, disabled or those without a driver’s license may now contribute to higher VMT.

- **Platooning:** Platooning, a train of detached vehicles that collectively travel closely together, is expected to reduce energy consumption between 3%-25% depending on the number of vehicles, their separation, and characteristics. (This is more thoroughly addressed in the freight application section later in this paper.)

- **Improved Crash Avoidance:** Due to the increased safety features of AVs, crashes are less likely to occur, allowing for the reduction of vehicle weight and size.

- **Higher Highway Speeds:** Increased highway speeds are likely due to improved safety and diminished headways.

- **Changed Mobility Services:** Ride-sharing on-demand business models are likely to utilize AVs due to the significant reduction of labor costs.

AV adoption and impact may look very different in Oregon’s large and medium-sized cities than in the rest of the state. In rural areas, AVs might be privately owned and may increase VMT making rural living more accessible and desirable to those who work in urban centers. In urban areas, AVs might reduce the cost of car or ride sharing services making private vehicle ownership less attractive.

Oregon’s Sustainable Transportation Initiative (OSTI) suggests strategies for reducing the greenhouse gas emissions from Oregon’s transportation system. Given the range of potential VMT impacts of AVs, Oregon may need to revisit strategies contained in the Statewide Transportation Strategy to continue to move toward the state’s GHG reduction targets. The state may also need to enhance modeling tools like GreenSTEP and RSPM to allow for testing AV adoption.

As AVs increase in usage, infrastructure needs will change. Along with the benefits of connectivity from CV technologies, CAVs will be able to utilize road surfaces more efficiently. Particularly with interstate roadways, less road space will be needed since CAVs will be able communicate with other vehicles and sense their surroundings much better than humans. This will allow roads to be narrower and require less use of highway safety equipment. Signing and striping however will need to continue to be standardized in form and placement for improved machine vision recognition.

\(^{10}\) http://css.umich.edu/factsheets/autonomous-vehicles-factsheet
Operational impacts to ODOT
(ODOT to draft this section).

Electric vehicles (EVs)
Electric vehicles (EVs) have drawn considerable attention and have become more prevalent due to their ability to travel long distances on a single charge and reduce transportation emissions. However, adequate charging infrastructure for these vehicles has been a concern.

Table 2 describes the two types of EVs on the market, Plugin Hybrid (PHEV) and 100% Battery (EV) and Table 3 describes types of charging stations\(^\text{11}\). Figure 8 illustrates charging infrastructure types.

**Table 2. Types of EVs Available on the Market**

<table>
<thead>
<tr>
<th></th>
<th>Plugin Hybrid (PHEV)</th>
<th>100% Battery (EV)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range:</strong></td>
<td>440 miles</td>
<td>100 miles</td>
</tr>
<tr>
<td><strong>Refuel Time:</strong></td>
<td>&lt;1h</td>
<td>4– 8h</td>
</tr>
<tr>
<td></td>
<td>Level 2 Charge</td>
<td>Level 2 Charge</td>
</tr>
<tr>
<td><strong>Energy Efficiency:</strong></td>
<td>More Efficient</td>
<td>Most Efficient</td>
</tr>
</tbody>
</table>

**Table 3. Types of charging stations**

<table>
<thead>
<tr>
<th>DC Fast Charger</th>
<th>Level 2 Charger</th>
<th>Level 1 Charger</th>
</tr>
</thead>
<tbody>
<tr>
<td>- DC provided at 40-100 kW</td>
<td>- AC provided at 3.3-19.2 kW</td>
<td>- AC provided at 1.4-1.9 kW</td>
</tr>
<tr>
<td>- 80% charge in 20 minutes</td>
<td>- 10-20 electric miles per hour</td>
<td>- 2-5 electric miles per hour</td>
</tr>
<tr>
<td>- 480V supply at 80-200 A</td>
<td>- 208/240V supply at 20-80 A</td>
<td>- 120V supply at 12-16 A</td>
</tr>
<tr>
<td>- $7,000-$40,000 per port</td>
<td>- $600-$5,000 per port</td>
<td>- $500-$1,000 per port</td>
</tr>
</tbody>
</table>

\(^\text{11}\) Jacobs, 2018
In December 2015, the Fixing America’s Surface Transportation (FAST) Act was signed, becoming the first federal law in over a decade dedicated to providing long-term funding certainty for surface transportation.12 Under the FAST Act, FHWA issued a notice in July 2016, requiring the Secretary of Transportation to designate alternative fuel corridors, to include EV charging. This notice outlined the criteria for designating alternative fuel corridors. As a result, FHWA, USDOT’s Volpe National Transportation Systems Center, the U.S. Department of Energy (DOE), and DOE’s National Renewable Energy Laboratory came together to select all public EV charging and other alternative fuel stations located within five miles of the nominated corridors.13

FHWA aims to establish and expand a national network of alternative fueling and provide this formal corridor designation process annually. Rounds 1 and 2 of the Alternative Fuel Corridor Designations have resulted in 58 nominations, includes portions of 84 interstates and 43 U.S. highways/state roads, comprises 44 states and D.C., and covers over 100,000 miles of the National Highway System.14 Figure 9 displays the ready and pending EV fuel corridors from Rounds 1 and 2.

12 https://www.transportation.gov/fastact
13 https://www.fhwa.dot.gov/publications/publicroads/18winter/02.cfm
14 https://www.fhwa.dot.gov/environment/alternative_fuel_corridors/
Agencies are taking big steps towards accelerating the widespread adoption of EVs. In 2017, EVs saw the emergence of more luxury EVs and more mileage per charge. While these trends are anticipated to continue, EVs are also expected to see growth in electric mass transit, which is discussed in the Mobility Options section.

**Implications for Oregon**

Oregon is well positioned to leverage environmental benefits from EVs in the future and is a national leader in supporting EVs. Oregon, with seven other states spanning east to west, collaborated to create a “Multi-State ZEV Action Plan” to guide efforts to get 3.3 million zero emission vehicles on the roads by 2025. The plan focuses on infrastructure, policies, standards and other components critical for the success of a growing market. In addition, Oregon is part of the West Coast Electric Highway, an extensive network of EV charging stations located along I-5, Hwy 99, and other major roadways in British Columbia, Washington, Oregon, and California.¹⁶

Oregon should continue to adopt standards on placement of EV supply equipment (EVSE) and to assure that the increased EV fleet can be matched by sufficient EVSE infrastructure. Oregon is already at the forefront of managing the biggest impact from EV adoption – a decline in gas tax revenues. If EV adoption continues, the state will need to consider how to fully implement a road usage charging (RUC) system for all vehicles that do not pay fuel taxes.

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¹⁵ [https://hepgis.fhwa.dot.gov/fhwagis/ViewMap.aspx?map=Highway+Information|Electric+Vehicle+(EV-Round+1+and+2)]

¹⁶ [http://www.westcoastgreenhighway.com/electrichighway.htm]
Another issue of growing concern is the environmental impacts of EV batteries. Accidents involving EVs over the past year have shown that the chemical makeup of EV batteries are such if ignited, they cannot be extinguished. First responders have had to let these ignited batteries burn out organically. The run off from these batteries are toxic and are considered environmental hazards. Planning efforts for EVSE will continue to increase as EV manufacturing increases. Environmental impacts of battery chemical run off and disposal should be considered in planning efforts as soon as possible.

The growth of EVs will help Oregon meet the greenhouse gas reduction goals established in the Statewide Transportation Strategy (STS). The STS assumes adoption of EVs along with other strategies to meet state climate goals.

**Operational impacts to ODOT**

A major operational impact to ODOT is related to revenue. ODOT is advancing road usage charging system to mitigate impacts to transportation revenues as EVs comprise a larger share of the vehicle fleet.

(ODOT to draft this section).

**Mobility Options**

Mobility options are also advancing rapidly, as the number of transportation modes in the last decade have expanded beyond the realm of private motor vehicles, carpools, vanpools, taxis, public transportation, bicycling, and walking. Technological advancements in mobility options include: Transportation Network Companies (TNCs), Car Share, Bike Share, Microtransit, and Mobility as a Service (MaaS). Figure 10 below displays the different types of shared mobility service models.
A 2017 consumer survey indicates shared mobility should see further growth (Figure 11). Of those currently using TNC ride-hailing services, 63 percent expect to increase their usage “a lot” in the next two years, and of those using carshare services, 67 percent expect to increase their usage a lot in within the same timeframe. Other shared mobility services are expected to proliferate in the coming decades. As a result, many anticipate significant changes to the transportation system, with implications related to travel behavior, access to mobility options, safety, physical infrastructure, and land use patterns.

Figure 10. Shared Mobility Service Models

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Consumer surveys indicate continued growth potential for shared mobility.

![Graph showing expected growth in shared mobility](image)

**Figure 11. Expected Growth in Shared Mobility**

**Transportation Network Companies (TNCs)**

Transportation Network Companies are private companies that utilize online-enabled platforms to connect passengers with drivers using personal, non-commercial vehicles. TNCs are often referred to as ride-sharing or ride-sourcing services, and the TNC market is dominated by Lyft and Uber, though in select markets other TNCs such as Via and Juno (now Gett) have gained limited popularity. Since Uber first began operating in San Francisco in 2011, TNCs have expanded to more than 600 cities worldwide, and use of TNC services is substantially increasing. TNCs first began Oregon operations in 2014, and currently operate in the Portland metro area, Willamette Valley (Salem, Albany, and Corvallis area), Central Oregon (Crook, Deschutes, and Jefferson Counties), and Eastern Oregon (Douglass, Jackson, and Josephine Counties).\(^\text{19,20}\)

In most markets where they operate, TNCs are subject to different regulations than taxi services, which are able to accept street hails, have on-board meters, and are governed by standard rates set by municipalities. While a select few state DOTs have implemented regulations applicable to TNCs, most regulatory oversight has come from municipal governments within their broader authority to regulate private-for-hire transportation companies.\(^\text{21}\)

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In some instances, TNCs have been able to provide services in less populated area not regularly served by taxi and public transportation services. However, TNCs have been found to increase total VMT and contribute to congestion in urban areas. Ultimately, TNCs are viewed as a transitional to autonomous shared fleets, most of all by TNC businesses, which are developing, testing, and using autonomous driving technologies themselves.

TNCs are protective of application programming interface (API) data they provide to traveler-facing tools such as Google Maps, Transit, or other trip planning and mobility-as-a-service applications, limiting the information available for the traveling public as a whole. Similarly, TNCs have placed restrictions on cataloging aggregate data, which could be used to develop independent assessments on TNC service by public agencies, educational institutions, and private entities, such as evaluating the accuracy of arrival predictions and travel times.  

TNCs are also protective of ride history data that has specific applications for planning, only a fraction of which is available to public agencies. A recent memo to the Cybersecurity and Long-Term Policy Subcommittee of Oregon AV Task Force outlines key types of data that may be available and could be utilized by state and local governments, which are applicable to AVs as well as TNCs. These types of data include:

- Service provider (e.g., Uber, Lyft) and type of service (e.g., UberBLACK, UberPOOL)
- Trip origins, destinations, types (passenger, goods delivery, or zero-occupancy/goods), and time of day
- Route traces and parking data
- Traffic volumes and length of trips (in minutes) and/or vehicle speeds
- Booking type (advance/real-time); wait time; cost of trip; and location, date, and time of unfulfilled, declined, and cancelled rides
- Data on safety incidents and traffic violations by TNCs.

Use of TNC services is increasingly significantly. TNCs transported 2.61 billion passengers in 2017, a 37 percent increase from 1.90 billion in 2016. Combined TNC and taxi ridership is likely to surpass local bus ridership in the U.S. by the end of 2018, making them among the largest urban transportation providers. TNC users in the U.S. are predominantly more affluent, younger, and have a higher educational attainment than the population as a whole.

Without public policy intervention, it is likely that a TNC-driven autonomous future mirrors today’s conditions: more traffic, congestion and carbon emissions, and less public transit options and equitable access to services.

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Microtransit and AV Transit

Small shuttles, eventually operating autonomously, have been hailed as a solution to offering “microtransit”—flexibly-routed, on-demand transit service that can compete as an alternative to TNCs such as Uber and Lyft. Microtransit offers the convenience and direct service of TNCs at a price more comparable to taking a traditional bus ride. In some cases, transit agencies have experimented with eliminating low-ridership fixed-route service in favor of microtransit rides that can be summoned through an app or phone call. This service may be door-to-door or, more commonly, provides first/last mile connections to or from an existing transit hub, so that microtransit services may be utilized for the remainder of the trip.

Microtransit is also being explored as an alternative to traditional paratransit services. Most shuttles have been designed with ADA accessibility in mind, and automated vehicles show promise in increasing independent travel options for elderly and differently-abled citizens, along with improving scheduling, dispatch, and reliability of paratransit services.

Additionally, advancements in data and trip planning have significant potential to improve demand-responsive transit and related microtransit options. The new GTFS-flex format describes demand-responsive transportation, enabling greater utilization of trip-planning applications. Similarly, the Vermont Agency of Transportation (VTrans) is implementing a flexible trip planner through FTA’s Mobility on Demand Sandbox Program to allow for DRT services described in GTFS-flex to be displayed in OpenTripPlanner.

AV transit vehicles are still in their preliminary stages and are gradually being introduced to the public. These vehicles are SAE level 4 and higher, allowing an automated system to perform driving tasks, and could potentially improve safety and mobility, the efficiency of rides on demand, and reduction of carbon emissions. Las Vegas, Detroit, Austin, San Ramon, CA, and several locations in Florida have piloted autonomous shuttles that can transport 6-12 people and are ADA-accessible. These microtransit AVs are generally deployed within a heavily controlled environment, are separated from traffic, travel at a low speed (~12 miles per hour), and do not pass through signalized intersections. EV shuttle and bus manufacturers Proterra, EasyMile, and NAVYA have also introduced electric, driverless models in the United States, and it is anticipated that future AV transit vehicles will be electrified.

In the near-term, the implementation of microtransit services has been one of trial and error. The privately-operated on-demand shuttle service Bridj in Boston and Washington DC, failed to develop a sustainable revenue model in partnership with transit agencies and eventually ceased operations. Microtransit services that serve specific goals, such as expanding first and last mile

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25 https://trilliumtransit.com/tag/gtfs-flex/


connections and mobility on demand services, have had greater success. For example, the Big Blue Bus in Santa Monica, CA, which has partnered with Lyft to provide on-demand, late-night service directly to Santa Monica Expo light rail stations for a subsidized rate of $3 per ride. Such microtransit programs are not intended to replace frequent, fixed route service, but expand public-private mobility options available to the public. At least 24 microtransit pilots are planned for 2018, and it is anticipated that microtransit services will expand as sustainable operational models are fully established.

New technologies are continuously evolving, aiming to be fully autonomous. Toyota introduced its e-Palette concept vehicle, a level 5 automation, all-electric vehicle that intends to meet individual and business needs, such as ride-sharing or delivery. Toyota plans to conduct feasibility testing of the e-Palette Concept in the early 2020s. Similarly, Volkswagen’s SEDRIC is a cross-brand ideas platform that offers autonomous shared mobility services. The SEDRIC vehicle will begin testing on public roads in 2021. Although these vehicles are currently exploratory, they can be considered as a mobility service platform, similar to the human-operated services of Lyft and Uber.

AV shuttles and fleets will likely be used initially to address first and last mile trips. All AV shuttle pilots currently deployed in the states are used for circulator fixed-routes. As the intelligence and capabilities of these vehicles increase, on-demand services will be piloted and deployed. Licensing and permitting for these services typically has been taken on by local jurisdictions but as these routes expand, ODOT may be called upon to address their use on their facilities.

Most of the AV shuttles deployed are being developed to use DSRC communication with signals. Currently, traffic signal state is determined visually by using CCTV video analytics on signal lights. However, weather or other obstructions can inhibit a shuttle’s ability to determine signal state. To assure against these situations, AV shuttle manufacturers intend to equip their vehicles with DSRC radios so that they may soon be able to communicate with roadside DSRC radios connected to traffic signal controllers. This communication link will allow vehicles to receive SPaT messages as they approach signalized intersections. This link will allow vehicles to not only adjust their speed to pass through on a green phase, but it will also help prevent collisions.

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30 Lazo, Luz.


32 http://fortune.com/2017/03/07/volkswagen-self-driving-car-sedric/

Car share

Car share refers to the “shared use of a vehicle fleet by members for trip making on a per trip basis.” In 1998 car sharing was first introduced in North America. As of 2017, there were 20 business-to-consumer carshare operators in the U.S. and the three largest car share operators ZipCar, Car2Go, and ReachNow, account for nearly 95% of car share members. The majority of car sharing vehicles are in the major cities of metropolitan areas and 90% of car share fleet vehicles are located in metropolitan areas with a population of a million or more. In Oregon, care share operators provide services in the Portland metro area, along with larger cities such as Bend, Corvallis, Eugene, and Medford. Overall, there are over 1.4 million car share members in the U.S. sharing over 17,000 vehicles, and the total market value for car sharing in the U.S. is worth $23 billion.

Car share services allow individuals to pick up a fleet vehicle from a fixed point for a round trip or a one-way trip to another fixed point anywhere within the car share operator’s service boundaries. Unlike TNCs, which rely on independently contracted drivers to provide services to consumers, car share operators provide a direct business-to-consumer model that enable members to drive fleet vehicles themselves. Currently, most care share operators have a one-time fee for membership and charge a pay-by-the-minute rate. In select markets, including Portland, some car share operators have recently piloted flat rates for a fixed length of time as an alternative to pay-by-the-minute rates. Flat rates for fixed length of time vary from a 1-hour trip or 3-hour trip, or up to 1-5 days.

In addition, peer-to-peer car sharing services have emerged as an alternative to business-to-consumer car share operators that provide their own fleets like ZipCar, Car2Go, and ReachNow. Peer-to-peer car sharing allows existing car owners to make their vehicle available for others to rent for short periods of time. As of 2017, there were six major peer-to-peer car share organizations operating in North America. These six organizations comprised a peer-to-peer fleet of over 130,000 vehicles with 2.9 million members.

Research indicates that car sharing programs can help members reduce vehicle miles traveled, sell a car or avoid purchasing a car, and in some cases increase use of public transit. Car sharing services tend to locate in communities with higher incomes and educational attainment, and studies of car sharing users have found that they are more likely to be Caucasian,

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male, between the ages of 20 and 35, and well educated compared to the general. As a result, car sharing may not provide added transportation options to community members who have more limited resources and mobility.

Similar to TNCs, there are no open data standards for car share data, and most operators do not share data, including any anonymized or aggregated data. However, some shared mobility service providers have shared data with public agencies often as part of a regulatory mandate. For example, Washington, D.C. requires carshare operators to provide data about the impact of their fleet’s parking program. While public agencies have limited access to all of the data that car sharing operators collect and access, the availability of information is likely to reflect much of the same information collected by TNC operators as described above.

Car sharing, like other shared mobility services, is expected to continue to grow. Current members indicate that they anticipate using the service more in the future, and automakers are already preparing for the change by entering the car sharing market, such as BMW Group’s ReachNow service, and GM’s new Maven peer-to-peer service. Automakers and others are working to introduce AV car sharing services, and it is likely that the public will be introduced to AVs through shared-fleet services instead of through private AV ownership. Table 4, from the Transportation Sustainability Research Center, describes projections for shared automated vehicle market penetration, which vary slightly due to different assumptions.

Table 4. Predictions of Shared Automated Vehicle Adoption Rates Compared

<table>
<thead>
<tr>
<th>Description</th>
<th>Projected Date</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 percent of miles driven in U.S. could be in shared, automated EVs</td>
<td>2030</td>
<td>Boston Consulting Group, 2017</td>
</tr>
<tr>
<td>Majority of shared cars on the road will have utilization rates of 50 percent</td>
<td>2030</td>
<td>Fujitsu America, Inc., 2017</td>
</tr>
<tr>
<td>1 out of 10 vehicles sold is shared</td>
<td>2030</td>
<td>McKinsey &amp; Company, 2016</td>
</tr>
<tr>
<td>95 percent of VMT will occur in shared EVs</td>
<td>2030</td>
<td>AirBnB and Seab, 2017</td>
</tr>
<tr>
<td>SAVs reach 35 percent market penetration</td>
<td>2040</td>
<td>Cambridge Systematics, Inc., 2016</td>
</tr>
</tbody>
</table>

Bike share

Bike share in its modern form first arrived in the U.S. in 2010. Bike sharing is similar to car sharing in that it is the shared use of a fleet on a per trip basis, and the market includes business-to-consumer and peer-to-peer operators. As with most car sharing services, bike

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41 Ibid.
42 Ibid.
44 Ibid.
45 Ibid.
sharing services are limited to a specific geographic coverage area, and many services require fleet bikes to be picked up and dropped off at specific locations.

Common traits of bike share systems include a dense network of stations across a coverage area, commuter-style bicycles with fully automated locking systems and wireless tracking systems, real-time monitoring of station occupancy rates, real-time user information through web and mobile applications, and pricing structures that incentivize short trips to encourage

Bike share operators include governments and universities, as well as public-private partnerships, business campuses, and other types of organizations that have not, to date, been involved in operating car share services. As of 2017, most U.S. bike share equipment and services were provided by three major companies, B-Cycle, Motivate, and Social Bicycles.

In Oregon, the largest bike share system is BIKETOWN, a partnership between the Portland Bureau of Transportation and Nike, which launched in 2016 and has a total of 1,000 bikes available in every quadrant of the city. Other bike share systems in the state include PeaceHealth Rides, Pedal Corvallis, OSU Cascades Bike Share, and Rogue Bike Share. PeaceHealth Rides a partnership between the City of Eugene, University of Oregon, and Lane Transit District which launched in 2018. Pedal Corvallis, OSU Cascades Bike Share, and Rogue Bike Share, all of which launched in 2017 and are provided by Zagster.

Bike sharing applications used by members to find bike stations and available bikes, to reserve a bike, and track trips taken, rely on General Bikeshare Feed Specification (GBFS) data. Like GTFS, GBFS is an open data standard, and data is provided by bikeshare operators about the location and capacity of stations as well as the number of docks and available bikes at each station. Other information GBFS can provide includes pricing, hours of the system, and location of bikes outside of stations. While bike share data is often considered proprietary and is shared differently from city to city, some operators publicly provide data that can help agencies and decision-makers better understand the impacts of bike sharing.

Ridership, and use of bikeshare systems in the U.S. have grown steadily since 2010, and this trend is anticipated to continue with the expansion of dockless bike share systems. In 2017, bikeshare members took 35 million trips - up 25% from 2016, and the number of bike share bikes more than doubled – from 42,500 bikes at the end of 2016 to about 100,000 bikes by the end of 2017.

Overall, as with car share membership, bike share users have been overrepresented by younger, Caucasian men with higher levels of education. To provide more accessible bike share services, some cities with station-based bike share systems (32%) implemented an income-based discount program as of 2017, which represents a more than 30% increase over 2016. Some systems have also partnered with financial institutions to address barriers for individuals who are unbanked.

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49 National Association of City Transportation Officials.
Bike sharing systems can serve different functions in different geographies depending on whether the system is fixed or flexible. For example, in smaller cities, bike sharing bikes are used more for recreation, while in larger cities they are used more for commuting.\(^{50}\) In addition, a study in Seattle indicated that fixed bike share stations have standard rush-hour peaks, while the flexible services had trips “spread out over the day with highest use seen on weekends, suggesting more recreational use.”\(^{51}\)

Public transportation systems have started to partner with bike-share systems as a key mobility solution for first mile and last mile connection to transit. LA Metro, for example, launched their own bike-share service in 2016. In fall 2018, Metro’s TAP fare card will integrate payments for LA Metro’s bus and rail services and its bike share system.\(^{52}\)

**Dockless Bike and Electric Scooter Share**

Recently dockless shared mobility options have emerged, including dockless, shared bikes, and electric bikes and scooters. In 2017, five new major dockless bike share companies – Jump (formerly Social Bicycles), Limebike, MoBike, Ofo, and Spin launched systems across the U.S.\(^{53}\) These companies and others have also launched electric scooter share programs in more than two dozen cities across the U.S., as of August 2018. Users rent and ride a scooter or bike to their destination and park bikes and scooters wherever they are allowed, including bike racks or next to bike racks.

In late July 2018, the Portland Bureau of Transportation (PBOT) launched a four-month pilot to deploy dockless electric scooters. PBOT issued permits to three companies (Bird, Lime, and Skip) and will allow up to 2,500 scooters to be operated until November 20, 2018.\(^{54}\)

There have been mixed responses to electric scooter share services. Many people found them to be convenient and fun to ride. However, there have been complaints of scooters parked illegally effectively blocking sidewalks and ramps, and illegally riding on sidewalks.\(^{55}\) Dockless bike share systems present similar issues but seem to be less disruptive because many cities have existing bicycle facilities, including bicycle lanes and parking.

E-scooters have the potential to solve first/last miles problems by giving users a quick option to access transit or complete a trip. However, this is likely to be played out at the local level as cities grapple with regulating their use to minimize disruptions and maximize benefits.

\(^{50}\) Federal Highway Administration.

\(^{51}\) National Association of City Transportation Officials.

\(^{52}\) Sotero, Dave. Metro Bike Share fares to be reduced and system to be expanded. LA Metro – The Source. May 24, 2018. https://thesource.metro.net/2018/05/24/metro-bike-share-fares-to-be-reduced-and-system-to-be-expanded/


Mobility as a Service (MaaS)

The most widely cited definition for Mobility as a Service (MaaS) comes from the European MaaS Alliance, which defines the concept as ‘the integration of various forms of transport services into a single mobility service accessible on demand.’ The single unifying feature of MaaS implementation is the integration of multiple mobility services to provide a more compelling alternative to driving your own car than any one service would be on its own.\(^{56}\)

MaaS can include many different features, such as a unified mobile app, multimodal journey planning, service bundles, a fixed monthly subscription, or pay-as-you-go billing.\(^{57}\) The full vision of MaaS is to incorporate real-time trip planning, transportation options, payment systems, and mobility providers into a single user interface that can be utilized for individual trips.

To effectively implement MaaS, it is necessary to have data about schedules, service availability, and real-time vehicle statuses and arrival predictions to be provided in customer-facing applications. Data interoperability is essential to ensure identical standards-based datasets can be used in applications and enable travelers to find and compare a variety of transportation services from public transportation options to bikeshare services to TNCs.\(^{58}\) Outside of the GTFS developed for public transportation systems, there are limited data standards and specifications that currently exist. Ultimately, MaaS would also incorporate e-payment systems that allow customers to book and pay for a variety of transportation services. Figure 12 shows screenshots of customer interfaces for finding and comparing mobility services.

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\(^{57}\) Ibid.

Google Maps includes transit directions, real-time, biking, and walking. Lyft, Uber, other TNCs, and taxis are shown as alternatives in markets where they are available.

Uber currently shows transit information and is planning to incorporate other modes such as bikeshare and carshare.59

Whim from MaaS Global provides access to taxis, carshare, and other transit options in Helsinki and other regions.60

Figure 12. Comparison of Mobility Service Interfaces

Oregon is a pioneer for innovation in transit data, as TriMet worked with Google to develop the GTFS standard, which is now available for more than 1,350 public transportation providers and has enabled hundreds of applications to use interoperable GTFS data. In Oregon, trips can now be planned across more than 43 public transportation services using mobile devices.

Future opportunities with GTFS include rolling out GTFS “real-time,” for all public transit agencies, which allows reporting of real-time transit arrival and departure information. Currently, TriMet’s OpenTripPlanner Shared-Use Mobility (OTP SUM)61 project, funded through the Federal Transit Administration’s Mobility-On-Demand Sandbox project uses open data and open-source software to “help customers make informed decisions about their mobility choices, including the critical first and last miles of transit trips where a bus or train alone doesn’t provide full access.” The trip planner includes transit, walking, biking, bike share, car share, and TNC modes, as well as drive-to-transit (park-and-ride). The trip planner is being implemented

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EMERGING TECHNOLOGY IMPACT ASSESSMENT KEY TRENDS

alongside Hop Fastpass transit card, opening the door to future trip planning and payment integration.

While public transportation agencies in Oregon and the U.S. have moved toward greater open data accessibility, many mobility firms such as TNCs and carshare operators limit how their services can be shown and accessed in third-party applications (see Transportation Network Companies section). Vertical integration in the new shared mobility industry — for example Uber and Lyft have recently purchased bikeshare operators — has the potential to silo data, restrict competition between mobility providers, and limit the implementation of MaaS. At the same time, major TNCs such as Uber are beginning to offer a mobility-as-a-service experience that incorporates other modes.62

Implications of Shared Mobility Options for Oregon

Geographic and Equity

For Oregon, shared mobility options are concentrated within urbanized areas of the state and are anticipated to remain so in the future. Because most shared mobility providers are private, for-profit entities, they do not have an incentive to provide services in less profitable rural markets without specific subsidies or mandates. Even within urbanized areas, current trends suggest, shared mobility services will better serve wealthier, less diverse communities that already have greater mobility options at their disposal. Additionally, as shared mobility options become increasingly reliant on smartphones and web-based payment applications, users that are unbanked and/or have limited access to digital devices will not be as well served by the marketplace.

User Experience and Travel Behavior

Oregon has already seen a significant advancement in real-time trip-planning applications that integrate a variety of transportation options, and card and application-based e-payment systems for transit and shared mobility services. While there is some uncertainty about the timeline for implementation of Mobility as a Service, as a fully realized MaaS environment requires the integration and interoperability of real-time data and travel information, including information from shared mobility service providers.

As real-time information becomes increasingly available through MaaS applications and reflects the costs and tradeoffs of a variety transportation options for individual trips, there are significant implications regarding the change in the travel behavior and travel patterns, particularly in urban areas. One potential implication is an overall reduction in VMT, particularly as shared mobility options evolve, proliferate, and are increasingly accessible to the public at large. At the same time, greater near-term utilization of TNC providers such as Uber and Lyft have the potential to increase VMT and add to travel demand on streets and urban highway corridors. Another significant implication of shared mobility options is fostering greater connectivity between a variety of travel modes from motorized transportation to public transit to active transportation, particularly through trip planning tools and integrated payment systems.

Data and ITS Infrastructure

Recent advancements in GTFS real time data, GBTS for bike share systems, and GPS utilization, along with the proliferation of smartphones and mobile internet access, have greatly enabled the expansion of shared mobility options. Meanwhile organizations such as the SharedStreets and MaaS Alliance respectively are in the process of developing non-proprietary data standards to describe and support the complexity and interconnectedness the modern transportation system and developing international standards and a shared operating framework for MaaS.

The Oregon Department of Transportation (ODOT) has already invested significant resources in Intelligent Transportation Systems, which includes PORTAL data archive for the Portland-Vancouver Metro region and is well positioned to help integrate real-time travel information for trip-planning and MaaS applications, and potentially foster public-private collaboration. As the new, shared mobility ecosystem expands and requires greater connected and real-time data, however, ODOT will need to be strategic with how it invests in and accommodates technology infrastructure that can support emerging mobility options. ODOT is also positioned to help facilitate conversations with partner DOTs around data standardization to ensure inner-operability of shared information about the transportation system between federal, state, regional, and municipal partners.

Planning and Policy

It will be important to integrate emerging, shared mobility options into future updates to the statewide Oregon Transportation Plan along with modal and topic plans, including the Oregon Highway Plan, Oregon Public Transportation Plan, Oregon Transportation Options Plan, and Oregon Bicycle and Pedestrian Plan. Similarly, statewide guidance on Transportation Systems Plans and Transit Development Plans can be updated to reflect the new shared mobility landscape. The proliferation of shared mobility options and their impact on travel behavior and travel patterns could also be considered in prioritization criteria for future iterations of STIP. In addition, grants through the Transportation and Growth Management program can help Oregon communities increase opportunities for transit, walking, and bicycling, as well as shared mobility options.

In addition, as open source and real-time data about mobility and travel becomes more accessible, utilization of key data sets can help refine ODOT modeling, analysis and scenario planning tools, along with enhancing information to define level of service performance measures and volume-to-capacity ratios. Moreover, such data can help ODOT update the Analysis Procedures Manual to reflect the impact of emerging technologies and be utilized for future TPR rulemaking and land use applications. As the OTC considers the implementation of congestion pricing, the utilization of data can help guide research and analysis into dynamic and variable pricing models for future updates to congestion pricing programs.

Operational impacts to ODOT

(ODOT to draft this section)
Freight and Logistics

The freight industry is undergoing significant changes and advancements in logistic practices enabled by automated technologies affecting both long-distance freight movements as well as distribution networks.

Consumer expectations and new e-commerce services have influenced the freight industry to develop more demand responsive delivery services. These services include individual delivery service (i.e. UberEATS), an increased emphasis on car and bike deliveries, and fleets of smaller trucks.  

App-based Demand Responsive Delivery and Logistic Services

Although there are many companies like Uber that offer rapid dispatch via apps, Uber’s scale and reach are unmatched. The company is adept at building other services that can be seamlessly integrated into its digital platform. In urban contexts, Uber could have an advantage in the business of making deliveries because it does not bear the cost of owning and maintaining a large fleet of vehicles.

The emergence of new technologies and business models could substitute for conventional delivery services. For example, surface and aerial drones for package deliveries could substitute for use of human-operated delivery trucks and vans for deliveries like parcels, groceries, or prepared foods.

One impact at the urban level is management of shared curb space to account for emerging delivery services. Similar to how TNCs have impacted how cities, airports, and transit facilities approach pick-up and drop-off, emerging freight delivery requires re-thinking of freight loading zones and commercial vehicle spaces. For example, outsourced freight delivery services like Amazon Flex involve “gig economy” drivers delivering packages in private vehicles. Such vehicles and drivers do not typically have privileges to legally access commercial loading zones like the US Postal Service or conventional parcel delivery services.

In addition to rapid-dispatch delivery services, companies are developing applications to streamline freight logistics. For example, Convoy, Transfix, and UberFreight are apps that help pair shippers and suppliers and can reduce the occurrence of empty vehicles on the freight system. However, the shipping industry is still reliant on direct interactions between carriers and shippers, brokers, and online load boards.

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65 Ibid.

Connected and Electric Freight Vehicles

Similarly, disruptive technologies are emerging for long-distance and intermodal freight services. For example, CAV technology is being utilized in pilots that enable trucks to engage in cooperative adaptive cruise control, or “platooning.” At the forefront of this development is a company called Peloton. Trucks that are equipped with DSRC radios and other vehicle monitoring equipment are able to use breaking, acceleration, and other information from a leading “master” truck to negotiate and control other following “slave” trucks. Platooning decreases wind drag and thereby results in fuel savings by both lead and following trucks.

Alternative propulsion technologies for long-haul freight include battery-electric and fuel-cell trucks. In November 2017, Tesla unveiled the Tesla Semi, a Class 8 tractor-trailer truck, which is advertised to have range of approximately 500 miles. This range raises the possibility that a long-haul tractor-trailer could conceivably operate a full day of travel, and even multiple daily hauls from origin to destination, on a single charge. Public-private initiatives are also underway to deploy hydrogen fuel cell infrastructure, particularly in California. The emergence of these alternative propulsion technologies promise cost savings to operators and reductions in diesel particulate emissions. However, they also require significant deployments of supporting fueling infrastructure, both in urban/logistics centers as well as along long-haul corridors.

With all of these freight technologies, cost and efficiency benefits are driving innovation and investment by the private sector. As with passenger technologies, a key unknown is the ultimate balance between private and public-sector investment necessary to catalyze emerging technologies and to facilitate their adoption at full scale.

Implications for Oregon

The emergence and impacts of digital platforms aimed at streamlining the freight industry are still uncertain. It will be important to consider the range of potential future in Oregon’s planning efforts. However, plans like the Oregon Freight Plan and Oregon’s ITS programming could explore the application of platooning on state highways. Emerging freight technologies will impact Oregon at many scales, from long-haul deliveries to the front doors of individual Oregon homes and businesses.

Within urban areas, key issues will include adaptation to increased automation of business, manufacturing, and end consumer deliveries to support just-in-time and on-demand deliveries. This will include many of the same safety, capacity, and regulatory challenges for autonomous freight vehicles as will be faced with autonomous passenger vehicles. Additionally, management of urban curb space will be a challenge, particularly in urban areas. Addressing the blurring lines between commercial vehicles and for-hire distribution by freelance contractors using personal vehicles is another issue already impacting the estate.

Oregon’s location, size, and geographic/economic diversity raise a number of long-haul freight challenges as well. Impacts of automated vehicles and platooning need to be considered for Interstate corridors like I-5 and I-84, which are used heavily by out of state vehicles, require a coordinated approach with USDOT and adjacent states to address long-haul movements into, out of, and across the state. This includes access to and from ports such as the Port of Portland and Port of Vancouver, and rail intermodal facilities, which are major notes for both intrastate and interstate freight.
Automation technologies will also be impacted by geographic and climatic factors across the state. For example, automated vehicles would need to be tested and certified for operation under challenging weather conditions, e.g. winter mountain pass crossings on major through routes across the state. Communications infrastructure to support automated freight operations operation on rural long-haul and farm/ranch to market routes may also impact where use of autonomous technology is feasible in the near term.

Alternative propulsion may be most feasible in the near term in urban areas, where short-distance delivery and multimodal connections enable freight vehicles to remain within proximity of electric charging or fuel cell facilities on a short range. As long-haul alternative propulsion becomes more feasible and widely adopted, there will be increasing need for fueling infrastructure along long-haul routes like I-5, I-84, US 97, US 20, and others. This technology will be required initially on a pilot basis to support long-haul trips by a relatively small proportion of the fleet. Over time, it will be necessary to scale this infrastructure to accommodate widespread adoption.

**Operational impacts to ODOT**

(ODOT to draft this section)