January, 2017

Public Transportation Technology

White Paper

Oregon Public Transportation Plan

Contents

SECTION 1

Introduction

The Oregon Public Transportation Plan (OPTP) is the public transportation element of the Oregon Transportation Plan (OTP). The OPTP functions as one of several statewide transportation mode and topic plans that refine, apply, and implement OTP goals, policies, strategies, and key initiatives for specific modes. The OPTP will provide a long-range vision and policy framework to help shape the public transportation system over the next 25 years in light of emerging statewide trends, opportunities, and challenges.

The purpose of this paper is to provide an overview of key emerging transit technologies in support of OPTP development. The paper outlines overall technology trends to provide context in which transit technologies are being developed and implemented. Key technologies are then discussed more specifically. The rapid pace of technological change presents certain challenges to public transportation providers. The challenges are then discussed along with strategies to overcome them. The paper concludes by suggesting potential implications for policy in the OPTP and for the state. Interviews with public transportation technology professionals in Oregon, as well as research and staff knowledge, informed the development of this white paper.

SECTION 2

Overall Trends in Technology

General trends in technology can have a major influence on transportation and provide context in which public transportation agencies operate. Major current developments in technology - and their implications for public transportation – are discussed below.

2.1 The Internet of Things

The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or even people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.[1] By allowing objects to be sensed and controlled remotely, it creates opportunities for more direct integration of previously disconnected objects, activities, and systems. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.[2] This computer-to-computer communication has major implications for public transportation, with the potential to improve system efficiency and target service more accurately to user needs.

[1] https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT

[2] https://www.forbes.com/sites/steveolenski/2015/10/20/how-the-internet-of-things-will-transform-high-tech-marketing/

2.2 Explosion of Data

In addition to the expansion of Internet-connected automation, the IoT is also expected to generate large amounts of data, require quick aggregation of that data, and create a need to index, store, and process such data much more effectively. IoT is one of the platforms of today's Smart City and Smart Energy Management Systems.[3] The additional data generated by interconnected objects such as vehicles, sensors, and smart phones will enable public transportation agencies to understand and communicate with their customers in unprecedented ways, while enabling the agencies be more transparent to their customers. This potential is further discussed in Section 3. New capabilities will, in turn, create a need for staff and systems to analyze, manage, store, and protect a vast amount of new data. This presents a challenge, particularly for smaller transit agencies.

2.3 Mobile Devices

A *mobile device* is a general term for any type of handheld computer. These devices are designed to be hand-held and extremely portable. Some mobile devices—like tablets, e-readers, and smart phones—are powerful enough to do many of the things that previously only a desktop or laptop computer could do.[4] The proliferation and power of mobile devices presents many opportunities to increase efficiency for public transportation providers and improve the transit user experience. These include improved communication, data collection, mobile payment, and integration of transit with other modes of travel.

2.4 Open Source

Open source software is developed with source code that is designed to be publicly accessible so that anyone can inspect, modify, and enhance it. What started as a term for software has come to represent a broader set of values that encourages collaboration, participation and transparency for software, data, and more.[5] While some data is necessarily private – Including individual identifiers and business or trade secrets – many public transportation agencies are finding ways to achieve the benefits of open source data while minimizing the risks. Open source software and data allows both the private sector and public agencies to mine a vast array of data and create programs that benefit customers and, in some cases, the agency itself. Transit agencies can publish an application program interface (API), which is a set of routines or protocols that are necessary to allow software development. For example, *Google Maps Transit* uses online transit route and schedule information provided by public transportation agencies and incorporates it into an integrated trip planning tool.[6] Increasingly, programs and applications are able to interact directly (program to program) with each other and accomplish complex transactions without direct human action or intervention. Open source approaches have the potential

[3] Ibid.

[4] https://www.gcflearnfree.org/computerbasics/mobile-devices/1/

[5] https://opensource.com/resources/what-open-source

[6] https://maps.google.com/landing/transit/index.html

to enable agencies to make management decisions that improve the speed, reliability, and cost effectiveness of the public transportation system.

General Transit Feed Specification (GTFS) is a common format for transit schedules and geographic information. Using GTFS allows public transportation agencies to publish their transit data, including schedules, routes and bus stops, in an open source format that enables software developers to create applications that use the GTFS data. Examples include way finding and real-time information apps, as well as system maps with links to needed services and information.

2.5 Automated Vehicles

Automated vehicles are those in which at least some aspects of a safety-critical control function, such as steering or braking, occur without direct driver input.[7] The Society of Automotive Engineers[8] developed five "levels" of vehicle automation, with Level 1 corresponding to vehicles that can sometimes assist drivers complete some driving tasks (cruise control, for example), and Level 5 corresponding to vehicles that can complete all driving tasks without driver intervention. A fully autonomous car is capable of sensing its environment and navigating without any human input.[9] Level 1 and 2 personal vehicles are available on the market today, with car manufacturers testing Level 4 vehicles that could be on the market by the early 2020s. Fully autonomous buses are also operating in several cities around the world, though generally on limited routes or for special purpose trips.[10]

Automated and autonomous vehicles are being developed, tested, and deployed rapidly. The implications and potential benefits of these technological advances for public transportation are immense, encompassing a range of safety and service improvements. Truly autonomous vehicles could profoundly alter the public transportation landscape, changing the way people interact with transit services. The effects of autonomous vehicles are further explored in the *Private Sector Roles in Public Transportation White Paper* that was produced earlier in this planning effort.

2.6 Shared Use Mobility (SUM)

Shared-use mobility encompasses transportation services that are shared among users. The term describes all shared vehicles and transportation services – including public transportation, taxis, bikes, cars, ridesharing, shuttles, and even parking spaces. Transportation Network Companies (TNCs) represent a subset of shared-use mobility. TNCs provide paid, prearranged rides using a digital platform that connects a potential passenger with a driver using a personal vehicle. TNCs and their implications for public transportation are further explored in the *Private Sector Roles in Public Transportation White Paper* that was produced earlier in this planning effort.

[7] http://www.nhtsa.gov/Research/Crash+Avoidance/Automated+Vehicles

[8] https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf

[9] https://en.wikipedia.org/wiki/Autonomous_car

[10] https://gizmodo.com/5-cities-with-driverless-public-buses-on-the-streets-ri-1736146699

Shared-use mobility has major implications for public transportation, offering people many more options for trip making. These options present opportunities for trip planning and integration with traditional public transportation services – and in some cases may disrupt or displace those services.

2.7 Smart Cities

As cities adopt smart technologies, such as those described in this paper, it changes the environment for transit and creates more opportunities. The City of Portland has embarked on such a transformation. It is using the IoT and local proven open source data-sharing and security protocols to implement Ubiquitous Mobility for Portland.[11] Through the use of scalable distributed data architecture, mobility options and performance data will be consolidated and accessible to citizens, agencies and businesses. It will allow people in all modes to buy and sell mobility in a secure environment with transparent pricing. The user-interface will provide accurate data on cost, schedule and other factors across modes. It will utilize data analytics and improved communications to enhance operations and optimize functionality.[12]

SECTION 3

Key Emerging Public Transportation Technologies

In addition to the broader technology trends described earlier in this paper, technologies specific to public transportation are changing the way people interact with transit service, as well as increasing the efficiency of providing that service for public transportation agencies. This section provides an overview of major emerging technologies under the following broad categories:

- trip planning and passenger communications
- network planning
- electronic ticketing and fare collection systems
- operations and fleet management
- intelligent vehicles
- security

The next section (4) summarizes the opportunities and challenges these technologies pose to public transportation agencies.

3.1 Trip Planning and Passenger Communications

A major hurdle for many potential public transportation riders is access to easy-to-understand bus schedules and routes. Technologies to address this challenge are proliferating rapidly, and are ever more available on mobile devices. Websites with scheduling information allow passengers to plan a trip,

---

[11] https://www.portlandoregon.gov/transportation/69999

[12] https://www.portlandoregon.gov/transportation/article/564105

reduce wait times, and coordinate transfers – even between modes. An ever-increasing number of people have access to the internet, and are using it to get directions and other transportation information. Smart phones are quickly outpacing traditional computers for activities such as directions, and studies have reported that smart phone usage in the United States is higher among populations who are minorities than other groups. [13] In addition, conventional public transportation timetables and maps can be confusing to many riders.[14] As a result, it is important that public transportation schedule and geographic information be user-friendly and easy to navigate – even for those with limited reading ability or English language proficiency. GTFS enables this type of information to be provided by Google Maps or other third party mapping applications. TriMet, for example, pioneered the OpenTripPlanner application, which not only maps transit trips but also provides schedule and system information, and integrates bicycling and walking options.[15]

3.1.1 Real-time Travel Information

On-board systems, such as next-stop audio, help passengers in unfamiliar areas reach their destinations. Electronic status information signs at bus stops increase certainty for riders and make public transportation more attractive by allowing people to see when the next bus is anticipated to arrive. According to a 2013 APTA survey of transit agencies, over 50% of respondents offered real time information to their customers. Agencies typically cited lack of resources or technical expertise as the reason for not offering this information. [16]

Providing this information on mobile devices allows customers throughout the public transportation network to conveniently plan their trip, reduce wait times, and improve transfers. Real time information requires transit vehicles to be outfitted with GPS automatic vehicle location (AVL). GTFS realtime is an open source feed specification that allows public transportation agencies to provide application developers with real-time updates about their fleet. [17]

In the 2013 survey by APTA, about one-third of transit agencies published APIs that allowed third party developers to create apps with their real-time data for those that did not publish APIs, the main reason many transit agencies cited was existing contract restrictions with third party providers. To be included in Google Maps or other mapping applications, arrival predictions and service advisories would need to be published in an API using GTFS-realtime format. Several example open source software products are available using GTFS data, including OneBusAway (available in Seattle, New York and Atlanta) and Transitime, hosted by Swiftly. [18]

[13] US Census, <1.usa.gov/1Eea24y>

[14] University of south Florida, http://bit.ly/I vCMqR7

[15] https://www.opentripplanner.org/

[16] https://www.apta.com/resources/reportsandpublications/Documents/APTA-Real-Time-Data-Survey.pdf

[17] https://developers.google.com/transit/gtfs-realtime/

[18] Aaron Antrim/Trillium, September 15, 2016 memorandum to Matt Barnes and Bridget Wieghart.

3.1.2 Multimodal Trip Planning

Most public transportation trips begin or end with another mode – and increasingly, millennials and others want to consider multiple transportation options. The ability to include other modes, such as bike share and TNCs in trip planning software, represents a major opportunity. There is as yet no comprehensive app that includes all modes, although more limited versions exist. One of the barriers to comprehensive multimodal journey planners is the lack of standardized data format for all modes. TriMet has been awarded funding from the FTA Mobility on Demand Sandbox Program to include shared-use mobility on their OpenTripPlanner.[19] This type of integration will be increasingly important to keep public transportation service attractive. In addition, it may present opportunities to augment or replace certain types of transit service, including those in areas with more dispersed land use patterns that are harder to serve.

3.1.3 Demand Responsive Transit

Demand responsive transit services (DRT) can be difficult to use due to the need to schedule trips in advance. Several public transportation agencies, including Jacksonville (Florida) Transit Authority, are planning projects to allow DRT services described in GTFS-flex to be included in their OpenTripPlanner. Cambridge Systematics has developed a trip planner, called “1-click”, that includes both fixed-route and DRT services and enables matching based on eligibility criteria. It has been implemented in several locations including Broward County, Florida.[20] This presents the possibility of additional or alternative service models for certain locations and service types.

3.2 Network Planning

A number of tools offer the ability to improve public transportation network planning by allowing easy integration of additional information and visualization. The Rail and Public Transit Division at ODOT has hired Oregon State University to create an open source, web-based application called the Transit Network Analysis Tool. The software will bring in the entire state public transportation network utilizing the same GTFS data used for trip planning to locate routes and stops, combined with census information for agency analysis. Remix is an example of a privately developed transit planning platform that utilizes GTFS. Used by public transportation agencies around the world, Remix allows these agencies to pull in their existing public transportation networks to quickly evaluate service alternatives. It offers the ability to immediately understand the cost and demographic impact of a proposed route or schedule change. It is easy to use and integrates with existing programs.[21] ODOT’s Rail and Public Transit Division has purchased access to the "Pro” version of Remix for all public transportation agencies in the state. OSU is also completing research to develop a transit ridership data standard for all Oregon public transportation agencies to follow. This will allow the development of open-source, web-based tools for public transportation agencies, ODOT and others involved in public transportation in Oregon, and will improve data collection and sharing, performance monitoring, and analysis.

[19] ibid

[20] http://oneclick-broward.camsys-apps.com/en/users/199247/trips/new

[21] https://www.getremix.com/

3.3 Electronic Ticketing and Fare Collection Systems

The inconvenience of purchasing tickets or lack of understanding of fares can be a barrier to public transportation use. Today, many public transportation agencies already offer online ticket purchases. Tickets may also be purchased on board or at transit stations through various technologies. Electronic transit fare payment systems, enabled by smart card, smart phones or magnetic stripe technologies, can provide greater customer convenience and generate significant cost savings by increasing the efficiency of money handling operations.[22] Larger public transportation systems, including those in New York City, San Francisco, and Seattle, have implemented electronic fare payment systems.

Currently, TriMet offers electronic ticket purchases online and by smart phone. In 2017, the agency will launch a new, system wide e-fare system, Hop Fastpass, which takes a technological leap forward to contactless payment. It will utilize a smartcard with payment activated by tapping it on a reader. It is built using open architecture, designed to make adding or modifying elements easy, so that it will be possible to include other agencies in the system. At opening, in addition to TriMet, the Hop Fastpass system will include C-TRAN (the transit agency for Clark County, WA) and Portland Streetcar.[23] ODOT is working with other transit agencies to complete the planning necessary to enable them to join in the future. In the longer term, these types of payment systems could also include other mobility providers, such as Uber and Lyft, although there are potential issues around mixing public agency and private company transactions within the same application.

Electronic payment systems, while offering numerous customer and agency benefits, have also raised equity concerns, including the lack of a smart phone, a bank account, or difficulty in understanding new systems for certain riders. For example, TriMet performed a comprehensive equity analysis of its Hop Fastpass program to understand any disproportionate burdens that may occur and mitigate these impacts.[24] Mitigation measures include maintaining the ability to purchase paper tickets and receive paper transfers at no added cost, reducing the price of obtaining Fastpass cards from the originally proposed fee, and providing training and technical assistance on how to use the new system.

3.4 Operations and Fleet Management

Implementation of automated vehicle location (AVL) and computer aided dispatch (CAD) systems can improve public transportation system reliability, coordinate transfers and reduce passenger wait times. Data from AVL/CAD systems and automatic passenger counter systems and other technologies can assist in the planning of new and modified public transportation services. In-vehicle self-diagnostic equipment can automatically alert maintenance personnel of potential problems.

3.4.1 Automated Vehicle Locators/Computer Aided Dispatch

Automatic vehicle location (AVL) and computer aided dispatch (CAD) systems facilitate the management of public transportation operations, providing up-to-date information on vehicle locations to assist

[22] http://www.itsoverview.its.dot.gov/Options.asp?System=EPS&SubSystem=TFP&Tech=Transit

[23] Interview with Tim McHugh, TriMet, September 2016.

[24] https://trimet.org/pdfs/equity/2016-fare-equity-analysis

transit dispatchers as well as inform travelers of bus status. AVL, combined with dispatching and reservation technologies, facilitates the implementation of flexible public transportation routing and scheduling. Many agencies have implemented these types of systems and also use the information they provide in route planning. [25] The cost of demand-responsive operational software and computer-aided dispatching systems can range from $10,000 to greater than $50,000 per deployment.

Low-end systems can facilitate scheduling, accounting, and report generation activities. Higher-end systems provide more advanced transit demand management features including automated passenger registration, real-time trip scheduling, communications with digital mobile messaging systems, and data exchange with GIS and AVL fleet management systems. More advanced systems could be used to coordinate service within or between public transportation agencies. The more advanced applications present more challenges, including on-going maintenance, upgrades and staffing requirements, and have not been broadly deployed due to the costs and complexity. [26] Additionally, some of these systems are not open source; meaning they are typically more expensive while less transparent and readily adapted and modified.

3.4.2 Automated Passenger Counters (APC)

APC systems are electronic machines that count the number of passengers that board and disembark at every bus stop. They, together with AVL systems, have traditionally formed the two most important technologies that public transportation systems seek first. In systems that have them, they replace the schedule checkers that previously collected ridership information manually.[27] In addition to use in evaluating service, for larger agencies, ridership information they collect can be used to fulfill National Transit Database reporting requirements. Many public transportation agencies cannot afford AVL and APC systems which cost $2,500 to $15,000 each per bus,[28] in addition to the software needed to run the system.[29]

There is potential in the future to obtain rich information regarding passengers and other data using Bluetooth technology. This more sophisticated data collection could inform agencies regarding potential customer demand. However, this data has not yet been accepted as means for documenting ridership.

3.4.3 Signal Priority and Roadway Communications

Transit Signal Priority (TSP) systems detect approaching transit vehicles and alter signal timing to improve system performance.[30] Systems can extend the duration or expedite a green signal for an approaching bus or train. TSP detection systems range from $2,500 to $40,000 per intersection and $50

[25] http://www.itsoverview.its.dot.gov/Options.asp?System=TM&SubSystem=TDM&Tech=DynamicRouting

[26] https://www.itscosts.its.dot.gov/ITS/benecost.nsf/ID/78B1282BE4E0574885256DD700505A33?OpenDocument&Query=CApp

[27] https://www.thoughtco.com/automated-passenger-counting-apc-2798822

[28] https://www.thoughtco.com/automatic-vehicle-location-avl-2798823

[29] https://www.itscosts.its.dot.gov/ITS/benecost.nsf/ID/5A7F0EEEBA4F6C5A85257A610065F58C?OpenDocument

[30] http://www.itsoverview.its.dot.gov/Options.asp?System=TM&SubSystem=FM&Tech=Priority

to $2,500 per vehicle, depending on the need to upgrade signal hardware and software and the type of detection used.[31] A recent study in Arizona found that TSP decreased bus travel times by 8.2%.[32] More sophisticated systems integrate signal control with transit management operations. These require more advanced Intelligent Transportation Systems (ITS) on-board transit vehicles and can perform more complex transactions, such as calculating whether the bus is ahead or behind schedule and modifying the priority request accordingly. Systems are being piloted that allow for driver interaction. For example, a system could allow a driver to modify a standard treatment request or request priority only when it will be beneficial.

3.4.4 Maintenance

Maintenance monitoring technologies allow for the automatic collection and reporting of vehicle maintenance information. Information can be uploaded at the end of a run, or while in service via wireless communication.[33] TriMet has a grant application to create an IoT gateway on vehicles so that all fitness of fleet infrastructure is connected to it. All systems related to maintenance would be actively monitored and the information provided in a single location. This would make it much easier and more efficient for agencies to maintain a state of good repair and avoid breakdowns that inconvenience riders. This approach can be particularly important with rail systems since the disabling of one vehicle can affect the entire line or network.

3.5 Intelligent Vehicles

While intelligent vehicle technologies provide numerous benefits and are used for a variety of reasons in passenger vehicles, the focus of their adoption in transit agencies has been safety. Safety is a priority for transit vehicle expenditures due to limited resources and responsibility to the public. Although bus transit is one of the safest ways to travel, nationwide, in 2011 alone, bus transit properties reported 3,260 collisions, 12,928 injuries, 92 fatalities, and $483,076,010 in casualty and liability expenses. That amounts to an average of $8,069 per bus.[34] As a result, intelligent vehicle technologies shown to reduce the severity and frequency of accidents are being developed and widely deployed on transit vehicles.

3.5.1 Collision Avoidance

Vehicle-mounted collision warning systems (CWS) use a variety of sensors to monitor the vehicle's surroundings and alert the driver of conditions that could lead to a collision. Examples include forward collision warning, obstacle detection systems, and road departure warning systems. Given the moderate costs associated with existing technologies (in the range of several hundred to several thousand per bus, depending on the capability), and the noted safety benefits, these technologies are widely deployed.[35]

[31] Alan R. Danaher, et.al, TCRP Synthesis 83: Bus and Rail Transit Preferential Treatments in Mixed Traffic, Transportation Research Board, 2010. https://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_syn_83.pdf

[32] Kyoungho Ahn, Hesham Rakha, and David K. Hale, Multi-Modal Intelligent Traffic Signal Systems (MMITSS) Impacts Assessment, U.S. Department of Transportation Federal Highway Administration, 2015.
https://rosap.ntl.bts.gov/view/dot/3557

[33] http://www.itsoverview.its.dot.gov/Options.asp?System=TM&SubSystem=FM&Tech=Maintenance

[34] https://www.apta.com/resources/safetyandsecurity/Documents/Autonomous%20Bus%20Technology.pdf

[35] http://www.itsoverview.its.dot.gov/green_level.asp?System=CWS

Battelle Memorial Institute undertook an analysis of the Transit Safety Retrofit Package (TRP) on three University of Michigan transit buses for the USDOT. While the TRP on-bus software provided effective alerts and the drivers expressed acceptance of the concept, there was a high rate of false alerts with several of the applications due to the limitation of GPS and micro-wave based crosswalk detectors.[36] Eight public transportation agencies in King County Washington are engaged in a pilot where bus mounted visual sensors scan the area and notify the driver if pedestrians, bicycles or other vehicles are in close proximity in time for them to take evasive action.[37] Automated driving technology is rapidly advancing and automobiles are entering the market with systems that not only sense that a collision is imminent but take control of various functions, including braking, to avoid or mitigate collisions. New Jersey Transit and the American Public Transportation Association (APTA) have submitted a proposal seeking a federal partnership with the goal of applying enhanced collision avoidance technologies to transit buses.[38]

3.5.2 Driver Assistance

Numerous intelligent vehicle technologies exist to assist the driver in operating the vehicle safely. Systems are available to aid with navigation. Others, such as vision enhancement, which incorporates data from other sensors, and speed control systems, are intended to facilitate safe driving during adverse conditions. Other systems assist with difficult driving tasks such as transit vehicle docking. These technologies are developing rapidly within the passenger vehicle market. As they become more sophisticated, there will be more applications in public transportation properties. Costs range significantly depending on the capability, from several hundred dollars to $50,000 or more per bus.[39]

3.5.3 Collision Notification

Collision notification systems have been designed to detect and report the location and severity of incidents to agencies and services responsible for coordinating appropriate emergency response actions. These systems can be activated manually (Mayday), or automatically with automatic collision notification (ACN), and advanced systems may transmit information on the type of crash, number of passengers, and the likelihood of injuries. These systems have resulted in improved response times and reduction in loss of life.[40]

3.5.4 Positive Train Control

Positive Train Control (PTC) is a computer-assisted system for controlling trains intended to reduce accidents. PTC uses computers and satellites to ensure safe locomotive operations; for example, PTC systems can stop trains if they miss a signal due to engineer error.[41] In 2008, congress required all Class

---

[36] Battelle Memorial Institute, Transit Safety Retrofit Package Development – Final Report, FHWA-JPO-14-142, 2014. https://www.its.dot.gov/

[37] https://www.kingcounty.gov/depts/transportation/news/2016.aspx

[38] https://www.apta.com/resources/safetyandsecurity/Documents/Autonomous%20Bus%20Technology.pdf

[39] https://www.itsbenefits.its.dot.gov/ITS/benecost.nsf/SingleLink?OpenForm&Tax=Intelligent+Transportation+Systems+Driver+Assistance+In-Vehicle+Monitoring+Safety+%26+Security&Location=Cost

[40] http://www.itsoverview.its.dot.gov/green_level.asp?System=CNS

[41] https://www.fra.dot.gov/Page/P0358

1 railroads handling hazardous materials and any with passenger train service to implement PTC over a number of years. It is costly to retrofit railroads for PTC, and the deadline has since been extended.[42] The benefits of PTC include increased railroad safety and the potential for passenger trains to operate at higher speeds, which are presently limited to 79 MPH without PTC.

3.6 Security

Advanced software and communications enable data as well as voice to be transferred between transit management centers and transit vehicles for increased safety and security, improved public transportation operations, and more efficient fleet operations. Transit management centers can monitor in-vehicle and in-terminal surveillance systems to improve quality or service and improve the safety and security of passengers and operators.[43] These kinds of technologies tend to be expensive, however, so, despite their benefits, are mostly deployed in larger, urban transit agencies. Security – or the prevention of intentional acts against the transit properties or its passengers – has long been a concern of transit agencies. The focus on security in transit has increased since 9/11, making these technologies more relevant to a broader range of transit systems.

3.6.1 In-Vehicle or Facility Surveillance

Video cameras monitor the interior of buses or train cars. Wireless communication can make images available to transit dispatch or transit management centers. Microphones and transmitters can also enable audio surveillance. Automatic vehicle location systems often incorporate silent alarm features, allowing operators to report problems and vehicle location to dispatchers. Basic systems can cost $10,000 per bus.[44]

3.6.2 Remote Disabling

Transit vehicles in distress can be remotely shutdown via wireless communication and control, typically from dispatch centers. This is becoming more prominent in passenger vehicles and trucks, especially in fleets. As of 2013, this technology appeared to have limited deployment in transit agencies, mostly among those with larger fleets.[45]

---

[42] https://www.fra.dot.gov/ptc

[43] http://www.itsoverview.its.dot.gov/Options.asp?System=TM&SubSystem=SS&Tech=SafetySecurity

[44] https://www.itscosts.its.dot.gov/ITS/benecost.nsf/0/8B8C41B27B397636852573E7006B1AFE?OpenDocument&Query=Home

[45] http://www.itsdeployment.its.dot.gov/CrossCutting.aspx

SECTION 4
Challenges and Opportunities for Public Transportation Agencies

This section reviews the major challenges and opportunities for public transportation agencies related to existing and emerging technologies and their implementation.

4.1 Awareness of, and responsiveness to, the pace of change

Public transportation technology experts in Oregon interviewed for this paper suggested that a major challenge for public transportation agencies in dealing with technology is the rapid pace of change. The most important first step public transportation agencies can take in preparing for these technologies is awareness: follow technology in industry publications and blogs; watch what other agencies are doing; engage in pilot projects.

Interviewees suggested that, while some of the changes such as the growth in Shared Use Mobility (SUM) may appear to compete with public transportation, agencies should view SUM as an opportunity. New technologies present great opportunities for public transportation and agencies that actively embrace them stand to reap great rewards (though adopting new technologies is a significant barrier, described below). For example, agencies that develop applications that interfaces with or links to other modes and services (like TNCs) can benefit from access to a growing customer base. Failure to do so may lead to attrition of their customer base as more and more people rely on TNCs and other shared mobility solutions. However, agencies have obligations such as providing access to riders with disabilities and will need to ensure that new services also meet such obligations.

It is important to note that some technologies can present barriers for riders. For example, mobile ticketing applications and e-fare may require that riders have a mobile device as well as a credit or debit card to make purchases. This example illustrates that the needs of disadvantaged riders must be considered in the implementation of these technologies moving forward. (See the OPTP Private Sector Roles in Public Transportation white paper for a further discussion of opportunities and barriers with SUM services.)

4.2 Resources

The public transportation technology experts interviewed noted that most public transportation agencies are stretched for funding and must devote most of their resources to day-to-day operations. Therefore, finding financial resources to adopt, implement, and maintain these technologies is a challenge. Additionally, many public transportation providers, and particularly the smaller agencies, are unlikely to have staff with expertise in this area.

While having in-house expertise is invaluable, agencies lacking those resources can follow what larger agencies are doing. In fact, it may be more efficient for smaller agencies to let larger agencies serve as first adopters and testers and pick up technologies once they are proven. Experts also suggested that agencies seek opportunities to pilot projects.

Collaboration was a common theme heard in interviews. Smaller agencies can band together or can partner with larger ones. Those interviewed strongly encouraged all public transportation agencies to work towards open source platforms, which enable sharing of information both with the public, software developers, and between agencies.

Funding for adoption is a major challenge. The costs to acquire technology can be high and then on-going training of staff, maintenance, and upgrades are required. There are a few programs to help, for example, transit agencies can find some funding sources for pilots and new technologies such as through FTA's research and development program.

4.3 Procurement

Several of those interviewed noted that procurement rules were developed many years ago and are focused on physical products, such as buses. New technologies often require hiring of expertise or purchase of software more akin to staff or ideas than objects. When procuring technology, agencies have tended to issue a single RFP for multiple components, even an entire program. This works against innovation and competition. Some smaller agencies have gotten into long contracts for use of proprietary products. Suggestions heard during interviews include revamping the procurement rules, requiring that vendors use open source technologies, and unbundling procurements into individual functions.

In summary, lack of awareness, limited resources and outdated procurement processes all slow the rate of adoption of new technology among transit agencies. The gap between the rapid pace of technological change and responsiveness by transit agencies presents a serious problem within transit industry. This issue is further addressed in the next section.

SECTION 5

Implications for the OPTP

The technologies reviewed in this paper as well as opportunities and challenges related to the adoption and implementation of technologies present a number of potential implications for development of the OPTP. An overarching theme is the difficulty the public sector, due to financial and staffing limitations, has had in keeping up with the rapid pace of technological innovation by the private sector. This section broadly reviews potential considerations for the OPTP:

- Awareness of new technologies and their potential benefits was identified as a barrier during interviews with public transportation technologies experts. Sharing of technical information as well as trainings could expand awareness of technologies throughout the state. This would be especially useful for smaller and medium-sized public transportation agencies that lack the in-house staff to keep track of and respond to technology trends.
- Coordination among agencies on new and emerging technologies is currently lacking. Increased coordination, especially between "adopter" agencies (typically larger public transportation agencies) and small agencies could improve the dissemination of technologies to agencies with

fewer resources. Partnerships can also allow sharing of resources, providing a financial benefit to those involved. Some coordination is already occurring at the state level through the ODOT Rail and Public Transit Division; for example, it is conducting work to establish open source standards that will allow Oregon agencies to share data and collaborate more easily. It has also hired Oregon State University to develop a statewide public transportation network planning tool. There is additional work to make GTFS for all fixed routes in the state available via Google maps and other third parties.

- Improved coordination among public and private transportation providers could yield benefits in terms of facilitating seamless connections between modes and improving user experience. New technologies, like mobile apps, are now making these connections between public and private transportation services easier, but there are potential issues associated with close coordination and collaboration between public and private providers (for example, sharing of resources or information and mixing private and public funds).
- The state plays an important role with respect to coordination and implementation of technology today. Stakeholders suggested that it should continue and grow in the future. ODOT and the Rail and Public Transit Division are currently engaged in a number of projects and programs that facilitate expansion of certain technologies to providers, or offer technical assistance to providers. For example, the state purchased premium access to Remix (online public transportation planning software) for all public transportation agencies in the state and is offering training on this planning software. As technologies continue to advance more rapidly than transit agencies can keep up, the state’s role in coordinating and providing guidance and expertise to smaller agencies across the state will remain critical.
- Procurement is a barrier to implementing new technologies. Revising state and local procurement processes to enable those that are more geared for on-going software development and maintenance, rather than one time equipment purchases. In addition, providing “blanket” procurement arrangements that allow public transportation providers access to services in a streamlined manner could help with adoption of beneficial technologies, especially for smaller agencies.
- “Open source” software and technologies are important to ensure transferability of technologies between providers. Many software applications, for example, are proprietary and expensive to license and maintain. Open source alternatives can result in reduced costs, increased transferability, and can facilitate innovation.
- Pilot projects represent an opportunity to try new technologies and ascertain their benefits and drawbacks. Funding or technical support for pilot projects fosters technological advancement and supports adoption of beneficial technologies statewide.
- Funding for technology is a principal barrier to implementation, especially for smaller agencies. Existing and emerging technologies can be costly to implement. In addition to the capital resources for the new technology itself, implementation may require replacement of older

equipment or software in associated systems. Additionally, staff with IT skills is required to utilize and maintain many technologies. Partnerships can facilitate pooling of resources to support adoption.

- With regard to technologies that improve the customer experience, like e-fare or mobile apps, it is important to recognize that not everyone can access these technologies due to potential barriers like owning a mobile device. Care needs to be taken with implementation of these technologies to avoid disproportionately burdening disadvantaged populations.