Appendix J:

Transit Automation

Transit Automation

Transit Vehicle Automation / Shared Mobility

Legislative and Regulatory Consulting Services – 12.10

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Executive Summary

This paper is a high level review of current trends and activities in transit automation technologies that have the potential of enhancing revenues, reducing costs and increasing efficiency, effectiveness and safety associated with the mobility related programs of the Tahoe Transportation District.

It summarizes a review of recent relevant literature and the experiences of many transit agencies that have utilized technologies relevant to transit vehicle automation and systems that utilize shared data in order to facilitate the shifting of trips made by private auto to those utilizing various modes linked to public transit. It discusses the importance of resolving the challenges of the "first and last" mile as it relates to this linkage between modes of travel.

Examples of autonomous transit vehicle projects include those at Contra Costa Transportation Authority (CCTA), San Ramon, California, where they announced in March 2018 that approval was received from the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) and California's DMV to operate an autonomous bus on public roads. In January 2018, the Minnesota Department of Transportation (MnDOT) conducted tests of autonomous buses at their MnROAD pavement testing facility in Albertville, MN during winter conditions in order to demonstrate the viability of these systems in their weather environment.

Other examples of transit vehicle automation technologies relate to vehicle safety like in Eugene, Oregon, where systems that utilize collision avoidance and driver assist systems are being tested; and in the state of Washington, where eight transit systems across the state are testing a variety of safety related automation applications including pedestrian and bicyclist warning systems.

The technologies associated with shared mobility initiatives, the report summaries the evolution of GPS based systems including those supported by General Transit Feed Specification-Real Time Format (GTFS-RT) that provide real time information needed to link together various modes of transportation for an individual to complete a trip. Similar to the Transit App that currently TTD utilizes, these systems take advantage of the power, flexibility and mobility of smart phone technology. Recognition is also made to the current limitations in the Tahoe Basin as it relates to internet broadband gaps and efforts made to address them.

Finally, it identifies applicable grant resources that may be used to advance these technologies such as those available through the Federal Transit Administration – Public Transportation Innovation 5312 program (Research and TCRP).

Recommendations:

Digital Wireless Communications

- Virtually all of the technological advances reviewed in this paper will require that individuals with smart devises, vehicles with GPS capabilities and traffic management/control devices in the Tahoe Basin have access to effective and robust

hardline fiber and wireless broadband communications network. This would include the I-80 and Highway 50 and 395 corridors. The "Dig Once" policy within the Basin is an excellent example of the type of initiative that needs to be fully programmed and implemented.

- The TTD should consider taking the lead in planning, promoting and where appropriate implementing the broadband network with sufficient capacity and reliability to support the many technological initiatives.

Transportation Corridor Management

- Implement technologies associated with transit operational efficiency initiatives such as queue jumping, signal prioritization and coordination. Recognition is given to the recent grant application submitted under the Caltrans Sustainable Transportation Planning – Sustainable Communities Grant Application program - the objectives of which include transit optimization.

Development of Transit Trip Planning systems.

- The TTD currently utilizes a trip planning application, Transit. It is recommended that this program be integrated with ride-hailing services like Uber and Lyft and taxies to the extent that these services become a link in an individual's trip which includes TTD public transit services. Currently Uber and Lyft are offered as an alternative to transit and not part of a coordinated trip. Transit offers an enhanced application "Transit+", currently in beta, which incorporates Uber/Lyft as a connection to transit services. The application is referred to by the company as "transit-oriented ridehailing". The TTD should consider partnering with Transit to implement Transit+. Contact should be made with Transit's Communications Lead, Stephen Miller, at partners@transit.app.

  This report discusses how other agencies like the Regional Transportation Commission (RTC), Clark County, NV and Pinellas Suncoast Transit Authority (PSTA, Pinellas County, FL are effectively utilizing Transit+ (page 27)

Transit Vehicle Automation / Shared Mobility

- Track the progress of the FTA funded pilot projects relative to driver assist projects identified in this report to determine best practices, lessons learned and applications that would apply to the TTD initiatives.

- Identify specific vehicle automation systems that would increase operating efficiencies and safety and reduce costs, such as the Active Safety-Collision Warning Pilot underway in Washington State.

- As the TTD executes the near and intermediate strategies associated with increasing the connectivity of travel in the Tahoe Basin and the transit mode split in particular, it should anticipate how and where autonomous vehicles could best be integrated into the mobility network in the longer term such as those advanced by the Minnesota Department of Transportation and the City of Arlington, Texas.

- The TTD should review the evaluation reports completed by Booz Allen Hamilton on the MOD Sandbox programs as they become available for applicable lessons learned and the development of best practices.

Grant Funding

- FTA is expected to announce in early 2019 the continuation of the Mobility on Demand (MOD) Sandbox program which is designed to enable transit agencies to innovate in order to provide better transit service. There is also an element of the program which focuses on integrating mobility payments.

  Subscribe on www.grants.gov to receive notification of all FTA research opportunities by entering 20.514 where it requests the CFDA Number. These funds may be issued on a discretionary basis; therefore it is important to stay apprised of emerging grant opportunities.

Transit Automation

This paper is a high level review of current trends and activities in transit automation technologies that have the potential of enhancing revenues, reducing costs and increasing efficiency, effectiveness and safety associated with the mobility related programs of the Tahoe Transportation District.

It is organized under two major topics, "Transit Vehicle Automation" and "Shared Mobility" and each is supported by review of recent relevant literature and the experiences of many transit agencies that have utilized technologies relevant to transit vehicle automation and systems that utilize shared data in order to facilitate the shifting of trips made by private auto to those utilizing various modes linked to public transit

Transit Vehicle Automation

Federal Transit Administration (FTA) literature research

The Federal Transit Administration (FTA) supports initiates related to transit automation through its Office of Research, Demonstration and Innovation. In an October 2018 report titled *"Transit Automation Research"* the FTA affirmed its commitment to funding transit automation programs by stating:

"In recent years, there have been significant developments in vehicle automation technologies. Although transit agencies are interested in automating some aspects of transit bus operations, they are hesitant to invest in automation deployments due to the risks, lack of information on life-cycle costs and quantified benefits, uncertain performance and reliability of automated systems, and other factors.

FTA seeks to address these concerns by continuing automation research, providing knowledge and technology transfer of research results, and supporting a path from automation research to commercialization and deployment. These efforts have informed the planning and execution of FTA-sponsored transit automation development and demonstration projects, and future research efforts that may include elements of automation.

Automated vehicle technologies can range from simple systems, such as driver assistance applications, to fully automated systems that do not require a human driver. The Society of Automotive Engineers defines the level of automation on a scale of 0-5 (SAE level 0 represents no driver assistance and level 5 represents full driverless automation)."[1] (See Exhibit A)

[1] Strategic Transit Automation Research Team, Office of Research, Demonstration and Innovation, Federal Transit Administration, *Transit Automation Research,* <*https://www.transit.dot.gov/automation-research*>

"FTA plans to explore the application of automation levels to bus operations. (For this initiative, bus is defined broadly to consider a range of sizes and passenger capacities, and could include both traditional and novel vehicle designs, e.g. full-size city buses, articulated buses and small shuttles.) This includes:

- advanced driver assistance systems (ADAS);
- automated shuttle services;
- maintenance, yard, and parking operations;
- mobility-on-demand service; and
- automated bus rapid transit applications

Equipping buses with automation technology across a range of capabilities may aid in adoption and deployment of these systems."[2]

Strategic Transit Automation Research Plan" (STAR Plan)

In January 2018, the Federal Transit Administration (FTA) published a report titled "Strategic Transit Automation Research Plan" (STAR Plan).

"The STAR Plan is part of the STAR Program, which was launched in the summer of 2016. The purpose of the program is to "to define a five-year Strategic Transit Automation Research Plan that will establish a research and demonstration framework to move the transit industry forward."[3]

"Automation capabilities have grown rapidly in recent years and have changed the dialogue around all aspects of the surface transportation system. Whereas automation is relatively mature in rail transit operations, this is not the case in bus transit. The domestic transit bus industry lags behind both light-duty vehicles and heavy-duty trucking, as well as international transit manufacturers and providers. Transit bus automation could deliver many potential benefits, but transit agencies need additional research and policy guidance to make informed deployment decisions."[4]

"FTA's Office of Research, Demonstration and Innovation is exploring the use of vehicle automation technologies in bus transit operations. The goal of this effort is to advance transit readiness for automation by:

- conducting enabling research to achieve safe and effective transit automation deployments
- identifying and resolving barriers to deployment of transit automation
- leveraging technologies from other sectors to move the transit automation industry forward
- demonstrating market-ready technologies in real-world settings
- transferring knowledge to the transit stakeholder community"[5]

[2] Ibid, page 1
[3]Federal Transit Administration, supported by: John A. Volpe National Transportation Systems Center, *Strategic Transit Automation Research Plan*, Page v. <https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/114661/strategic-transit-automation-research-report-no-0116_0.pdf >
[4] Ibid, page 1
[5] Ibid, page 3

The sequence of task elements are referenced in: Strategic Transit Automation Research Roadmap"[6] (see Exhibit B).

Transit Bus Automation Project: Transferability of Automation Technologies

In September 2018, the FTA published another report, "Transit Bus Automation Project: Transferability of Automation Technologies *Final Report"* The FTA stated in the abstract:

"This report examines the feasibility of transferring 13 current automated systems technologies from light-duty vehicles and commercial trucks to 40-ft diesel transit buses. It explores the associated technical and safety challenges of implementing those systems in transit buses and ways to overcome some of the identified barriers to implementation. The transferability of each systems was given a grade of Red, Yellow, or Green, with Green indicating most ready to be transferred.

Transferring existing automation systems from other vehicle formats will generally require modification, replacement, or redesign of components and systems on the bus. Sensors are relatively mature and should be able to be adapted to buses without modification. To enable other automation systems, however, the transit bus industry will need to implement foundational and interfacing systems that can support electronic actuation. Modifications to propulsion systems should be more easily made than modifications to other foundational systems (i.e., steering and braking). Steering systems may require more modification, but heavy-duty vehicle steering solutions that enable automation exist and may not require extensive changes. Implementation of electronic control of a transit bus brake system appears to be a major challenge, as pneumatic brakes found in buses are less conducive to automation and more extensive design changes may be needed. Automated applications may require a new communication system architecture with bandwidth to carry numerous complex signals reliably. Finally, buses will require new human-machine interfaces to control automation systems, although these should be relatively easy to design and implement."[7]

"The scope of the report is limited to SAE Level 2 and lower automation systems currently in production for light-duty vehicles and commercial trucks with potential applicability to transit buses. This report considers 13 relevant automation systems, assesses their potential transferability to transit vehicles, and assigns each system a grade Green, Yellow, or Red based on an analysis of the extent of modifications required and the severity of safety concerns:

- A grade of **Green** suggests that for the introduction of the automation system, minor modifications to foundational bus systems may be required and that safety issues or concerns are few and of low severity.
- A grade of **Yellow** suggests that major modifications to the foundational bus systems may be required for the implementation of the automated system and that safety issues or concerns are considered low to moderate.

[6] Ibid, Page 11, Figure 1-1

[7] Federal Transit Administration, Ahmad Nasser, John Brewer, Wassim Najm, Joshua Cregger, Advanced Vehicle Technology Division, Volpe National Transportation Systems Center, *Transit Bus Automation Project: Transferability of Automation Technologies Final Report,* FTA Report No. 0125, Page v.

- A grade of **Red** suggests that significantly new technology may be required for one or more foundational bus systems to accommodate the automated systems and that safety issues or concerns may be relatively high."[8]

In determining what technology applications have the best potential for bus applications, the report identified "use cases" in its evaluation. "The use cases consider environmental, infrastructure, and operational elements. Each use case was assessed for relevance to the operation of the specific vehicles.

Based on the evaluation of these use cases, transit buses would benefit from automation systems that improve safety, improve the operation of the bus during passenger pick-up and drop-off, or facilitate the handling of the bus in the bus yard/barn and maintenance facility.

Transit bus safety can be improved by providing assistance to the driver in maintaining the bus in the intended lane and avoiding collision with other vehicles and (more importantly) pedestrians. Automation systems that provide steering and braking assist under most operating conditions should improve bus safety.

Automation systems that improve the entry and exit of the passengers into the bus include those that provide assistance to the driver for improved docking at bus stops regardless of the complexity of the road geometry. These systems can help optimize the distance between the bus entrance and the passenger pick-up spot.

Park assist automation systems might provide assistance in parking the bus in different orientations (e.g., perpendicular or parallel) and getting the bus out of the parking spot. Some automation systems can provide assistance in maneuvering the bus safely through pre-determined paths to a parking location.

Based on the above strategy, a subset of available automation systems was selected for detailed analysis of transferability."[9]

Transit Automation Demonstration and Pilot Projects – Vehicle Assist

The following are examples from the report of domestic and international applications of transit automation demonstration and pilot projects that could be considered in the Tahoe basin:

- "Vehicle Assist and Automation (VAA) Pilot in Oregon

  FTA identified automation as a topic of interest more than a decade ago, leading to the development of the VAA project, which was active between 2009 and 2016 with testing in revenue service between 2013 and 2015. The California Department of Transportation and California Partners for Advanced Transportation Technology (PATH) launched a pilot program to demonstrate the VAA system on transit buses. The system used magnets embedded in the roadway to guide vehicles. Deployed applications of VAA included lane

[8] Ibid, Page 1
[9] Ibid, page 21

keeping and precision docking at bus rapid transit (BRT) stops. The system was deployed in Eugene, Oregon, on a Lane Transit District 60-foot articulated bus. The on-board equipment included two magnetometer sensor bars (one in front and one under the middle door), a steering actuator, a computer controller, and a human-machine interface (HMI) display. Magnets were installed along 3 miles of a 23-mile BRT line.

- **Driver Assist System (DAS) Pilot in Minnesota**

  The Minnesota Valley Transit Authority (MVTA) received $4.2 million from FTA to develop a DAS, a lane guidance system for bus-on-shoulder operations along Cedar Avenue (Trunk Highway 77). The DAS system uses a differential global positioning system (DGPS) and lidar (light detection and ranging), a surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor, to enable a bus to travel on typically unused shoulder right-of-way, bypassing congestion during peak rush hours. When highway speeds on general-purpose lanes drop below 35 mph, MVTA buses are authorized to use the shoulder along a 22-mile stretch between Apple Valley and Minneapolis. The DGPS aids with triangulation and positioning, while the lidar system scans the environment for objects to avoid collisions. If an object is detected, the system warns the driver through visual (head-up display) and haptic (seat vibration and steering wheel resistance) feedback. MVTA hopes to enhance driver confidence in operating buses on shoulders, particularly during bad weather. Secondary goals include reduced travel times, increased reliability, safety, and customer satisfaction. In 2015, FTA awarded MVTA $1.79 million to upgrade the system, which is being demonstrated in revenue service. An evaluation of the system was completed in June 2018 and available at the following link: http://www.dot.state.mn.us/automated/bus/finalreport.pdf

- **Active Safety-Collision Warning Pilot in Washington**

  In 2016, eight transit agencies across the state of Washington participated in a pilot project to test and analyze the Mobileye Shield+ collision avoidance system on buses. Participating transit agencies included Metro Transit, Community Transit, Pierce Transit, Intercity Transit, C-Tran, Kitsap, Ben Franklin, and Spokane Transit. The Mobileye Shield+ system uses bus-mounted cameras to identify and alert bus drivers when other road users, including pedestrians, cyclists, and other vehicles, are dangerously close to the bus. The system was installed on 38 buses statewide. Funding for the project was provided by the Washington State Transit Insurance Pool, Alliant Insurance Services, Government Entities Mutual, Pacific Northwest Transportation Consortium, and Munich Re America. The pilot program evaluation was funded by the Transportation Research Board (TRB) with an Innovation Deserving Exploratory Analysis (IDEA) grant.

  In January 2017, FTA awarded Pierce Transit a $1.66 million Safety Research and Demonstration (SRD) grant to fund a $2.9 million project to implement and research collision warning and automated braking technology in buses. The Mobileye Shield+ warning system will be installed on 176 buses, and an AEB system will be installed on up to 30 buses. The Virginia Tech Transportation Institute is assisting with the evaluation of impacts on the AEB system on passengers.

- **Mercedes-Benz Future Bus with CityPilot Demonstration in the Netherlands**

  In July 2016, the Mercedes-Benz Future Bus with CityPilot was demonstrated in the Netherlands, running along the 12-mile BRT route between Schiphol airport and the town of Haarlem. The bus uses a (SAE) Level 2 system (operator in the driver seat and ready to reassume control) with automated lane-keeping, acceleration, and braking. The bus also reacts to traffic lights, uses precision docking at stops, and automatically opens the doors for boarding and alighting passengers.

- **Yutong Bus Project Demonstration in China**

  In September 2015, Chinese bus manufacturer Yutong conducted a demonstration of its automation system on a 20-mile stretch of public roads through an urban environment from Zhengzhou to Kaifeng. The trip involved automated lane changes, overtaking other vehicles, and responding traffic lights (26 in total) without human intervention. The bus was equipped with a lidar unit (light detection and ranging), a surveying method that measures distance to a target by illuminating the target with pulsed laser light and measuring the reflected pulses with a sensor, and cameras on each side.

- **Automated Bus Testing in Singapore**

  Singapore's Land Transport Authority (LTA) and Nanyang Technological University (NTU) signed an agreement in October 2016 to equip two hybrid electric buses with sensors and other capabilities to enable automated driving. The roads between NTU and CleanTech Park (located in the Jurong Innovation District) were identified as potential test routes for the trial. In January 2018, Volvo announced that it had signed an agreement with NTU to provide automated electric buses to begin testing in Singapore starting in early 2019."[10]

Transit Automation Demonstration and Pilot Projects – Autonomous Vehicles

The following two projects highlight the use of autonomous buses which could serve as references to the TTD if and when the use of this technology is considered.

- **"The Contra Costa Transportation Authority (CCTA)**

  The Contra Costa Transportation Authority (CCTA) and GoMentum Station announced that permission was granted and testing of autonomous vehicles on public roads will begin at Bishop Ranch, the largest mixed-use business community in Northern California, located in the city of San Ramon. This is the first time the California Department of Motor Vehicles (DMV) has allowed a shared autonomous vehicle to travel on public roads in the state.

  CCTA is leading a pilot demonstration project testing electric, low-speed, multi-passenger autonomous vehicles manufactured by Easymile, that are not equipped with a steering wheel, brake pedal, or accelerator. The California State Legislature passed

[10] Ibid, Pages 7-10

pioneering legislation in 2016, Assembly Bill 1592, to allow for the pilot program. After successful testing at the GoMentum Station autonomous vehicle proving grounds in Concord, Calif. and in parking lots at Bishop Ranch, CCTA is advancing to the third phase of testing.

CCTA received permission from the U.S. Department of Transportation's National Highway Traffic Safety Administration (NHTSA) in October 2017 and permission from the California DMV in January 2018, to operate the EasyMile shuttle on public streets within the business park.

Shared autonomous shuttles offer safe, accessible service that could soon provide first- and last-mile transit solutions in office parks, campuses, suburbs, and town centers. Zero-emission, low-speed autonomous shuttles have the potential to ease congestion, reduce harmful emissions, and provide affordable access to transportation hubs throughout Contra Costa County.

As CCTA moves to the third phase of testing, members of the general public will not be able to ride the shared autonomous vehicles on public streets. The vehicles are currently staffed by trained testers. It is anticipated that during the upcoming year, additional predetermined testers and evaluators chosen from employees of various employers within Bishop Ranch will be able to ride the vehicles as they traverse public streets within the business park.

The permission for the EasyMile shuttles from the California DMV is separate from their autonomous vehicle testing program that has been underway since 2014."[11]

- **"The Minnesota Department of Transportation (MnDOT)**

  The Minnesota Department of Transportation (MnDOT) authorized testing and demonstration of an automated vehicle (AV) in February of 2017. MnDOT's research into previous AV efforts in other states indicated that testing had not been completed in winter weather conditions. MnDOT also wanted to address the lack of exposure to the AV technology within the state, while increasing Minnesota's influence in AV development nationally. The testing and demonstration goals included the following:

  1. Identify the challenges of operating automated vehicle technologies in snow/ice conditions and test potential solutions through field testing.
  2. Identify the challenges and strategies of having third parties safely operate automated vehicles on the MnDOT transportation system.
  3. Identify infrastructure gaps and solutions to safely operate automated vehicles on the MnDOT transportation system.
  4. Prepare transit for improving mobility services through automated vehicles.
  5. Increase Minnesota's influence and visibility on advancing automated & connected vehicles.
  6. Enhance partnerships between government and industry to advance automated & connected vehicles in Minnesota.

[11] Metro Magazine, Testing of first autonomous shuttle on public roads in Calif. Begins, March 8, 2018) <http://www.metro-magazine.com/technology/news/728819/testing-of-first-autonomous-shuttle-on-public-roads-in-calif-begins>

7. Provide opportunities for public demonstrations of automated vehicles and obtain public feedback.

MnDOT tested an automated shuttle bus supplied by EasyMile at the MnROAD facility in December 2017 and January 2018 under the direction of MnDOT staff with support from project consultants. The testing methodology can be found in Chapter 2. Public tours and demonstrations of the automated shuttle bus were held for select transportation professionals in December 2017 and January 2018 at MnROAD. This was followed by public demonstrations of the automated shuttle bus between January 24th and January 28th in conjunction with community activities that preceded Super Bowl LII in Minneapolis, Minnesota. Five additional demonstrations were held between February and April of 2018 at 3M, the City of Rochester, the University of Minnesota, Hennepin County, and Bismarck, North Dakota."[12]

- **"City of Arlington, Texas**
  As part of an innovative transportation pilot program, visitors to Arlington's Entertainment District may soon be able to catch a free ride on a driverless shuttle to help make getting from their vehicles to the stadium venues more convenient.

  In August 2017, the Arlington City Council approved a one-year lease agreement with EasyMile of Toulouse, France, for the use of two low-speed, autonomous shuttles. As early as June, the City will begin offering free shuttle rides on pre-programmed routes along select Entertainment District off-street trails during Stadium and Ballpark events.

  This pilot program will allow Arlington to test the application of autonomous shuttles in a real-world setting.

  'The City seeks to position itself at the forefront of the connected and autonomous vehicle technology movement,' Community Development and Planning Director John Dugan said. 'The pilot project will allow us to see how this driverless vehicle system really works and to look at the overall picture of how these vehicles could enhance the City's transportation options.'

  Although the EZ10 shuttles will run autonomously, they will always have an operator on-board. The vehicles can hold up to 12 passengers and will have a maximum speed of about 20 miles per hour as they travel on select pathways, not city streets, during the pilot program.

  Driverless vehicles are one of the many options being explored by the Council-appointed Transportation Advisory Committee, which is expected to present recommendations on how to address Arlington's transportation needs to City Council later this year.

  'The Committee is working on a large-scale transportation plan, looking out over the next 10 to 20 years. Autonomous vehicles could play a role in their final recommendation,'

[12] WSB & Associates, Inc. AECOM, *MnDOT Autonomous Bus Pilot Project Testing and Demonstration Summary*, June 27, 2018, Page 6)< http://www.dot.state.mn.us/automated/bus/finalreport.pdf>

Dugan said. 'After a year or so, we will be in a much better position to decide if this technology can help us meet our future transportation needs.' "[13]

The concept of autonomous vehicles was mentioned in the LTCCP as it relates to long term strategies associated with meeting the needs of recreational travel: "Further possibilities may be created with the eventual introduction of autonomous vehicles into traditional transit fleet operations that operate within specific corridors to key destinations. This could create a fairly substantial demand responsive fleet at much lower costs to systems with operators and reduce the overall number of vehicles traveling on Basin roadways. This type of operating system is currently in beta mode and could be deployed in the near future if transit agencies and the general public are ready to make the associated improvements to facilitate autonomous transit vehicles."[14]

Recommendations:

- Track the progress of the pilot projects identified in this report to determine best practices, lessons learned and applications that would apply to the TTD initiatives.

- Identify those vehicle automation systems that would increase operating efficiencies and safety and reduce costs.

- As the TTD executes the near and intermediate strategies associated with increasing the connectivity of travel in the Tahoe Basin and the transit mode split in particular, it should anticipate how and where autonomous vehicles could best be integrated into the mobility network in the longer term.

Shared Mobility

The following is a summary of current discussion and practices on "Shared Mobility" as way to integrate public transit into other modes of travel and mobility technologies.

Shared-Use Mobility Center (SUMC) titled "Shared Mobility and the Transformation of Public Transit"

In a 2016 study prepared for the American Public Transportation Association by the Shared-Use Mobility Center (SUMC) titled "Shared Mobility and the Transformation of Public Transit", the authors stated that "Technology is transforming transportation. The ability to conveniently request, track, and pay for trips via mobile devices is changing the way people get around and interact with cities." [15]

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[13] Susan Schrock, City of Arlington MyArlington Website, *Driverless Shuttle Pilot Program to Roll Out in Arlington's Entertainment District* March 28, 2017 <http://www.arlington-tx.gov/news/2017/03/28/driverless-shuttle-pilot-program-roll-arlingtons-entertainment-district/>

[14] Stantec, *Linking Tahoe – Corridor Connection Plan,* Page 26, August 2017

[15] Shared-Use Mobility Center (SUMC), American Public Transit Association, *Shared Mobility And The Transformation Of Public Transit,* Page 3 <https://www.apta.com/resources/reportsandpublications/Documents/APTA-Shared-Mobility.pdf>

Their report examined the "relationship of public transportation to shared modes, including bikesharing, carsharing, and ridesourcing services provided by companies such as Uber and Lyft."[16] Although their research involved larger urban areas including Austin, Boston, Chicago, Los Angeles, San Francisco, Seattle and Washington, DC., their findings and recommendations may applied to the Tahoe Basin and provide a relevant backdrop for mobility and connectivity solutions sought by the Tahoe Transportation District (TTD)

Their **key findings** were:

"1. The more people use shared modes, the more likely they are to use public transit, own fewer cars, and spend less on transportation overall. "Supersharers"—people who routinely use several shared modes, such as bikesharing, carsharing (e.g. car2go or Zipcar), and ridesourcing (e.g. Lyft or Uber)—save the most money and own half as many household cars as people who use public transit alone.

2. Shared modes complement public transit, enhancing urban mobility. Ridesourcing services are most frequently used for social trips between 10pm and 4am, times when public transit runs infrequently or is not available. Shared modes substitute more for automobile trips than public transit trips.

3. Shared modes will continue to grow in significance, and public entities should identify opportunities to engage with them to ensure that benefits are widely and equitably shared. Public transit agencies should seize opportunities to improve urban mobility for all users through collaboration and public-private partnerships, including greater integration of service, information and payment methods.

4. The public sector and private operators are eager to collaborate to improve paratransit service using emerging approaches and technology. While a number of regulatory and institutional hurdles complicate partnerships in this area, technology and business models from the shared mobility industry can help drive down costs, increase service availability and improve rider experience." [17]

Transform Public Transportation Agencies Into Mobility Agencies

One of their key recommendations involved a rethinking of public agency roles within a section titled "Transform Public Transportation Agencies Into Mobility Agencies"[18] and included the following highlights:

"• Coordinate public transit operations—along with regulation of bikesharing, carsharing, ridesourcing, shuttles, parking, and curb access—toward common mobility goals." For example, 'The San Francisco Municipal Transportation Agency and several agencies in Seattle are

[16] Ibid, Page 3
[17] Ibid, Page 3
[18] Ibid, Page 33

transforming themselves into mobility managers, with responsibilities that go beyond a public utility model of transit provision or a streets department'
• Address mobility beyond direct provision of transportation services—especially through spreading awareness and training people how to use the full mobility menu to reduce the need for personal vehicles.
• Create a network of mobility managers at different levels (e.g., regions, municipalities, public transit agencies, and large employers) to communicate and coordinate mobility needs across departmental, jurisdictional and public/private lines.
• Create cross-agency working groups to get multiple entities—including public transit agencies, departments of transportation, business affairs divisions, consumer watchdogs, zoning departments, planners, and public safety agencies all in the same room to create policies that ensure they're not working at cross-purposes in pursuit of similar goals."[19]

In order to gain an appreciation for the technologies involved in assessing the capabilities of data sharing among transportation modes, the researchers performed an analysis titled: "Ridesourcing and Public Transit Capacity and Demand Analysis"[20] as part of their report.

The following is an excerpt from their report on the subject: "While ridesourcing companies like Lyft and Uber are extremely protective of their trip data for both competitive and customer privacy reasons, the companies do provide a way for computer applications to get information about their services via a tool called an application protocol interface (API), a portal where two computers can pass specific information back and forth in a structured way.

Queries from the Uber smartphone app use the API to request rides and interact with the customer account; Uber also provides limited access to the API to third-party software developers and researchers. Uber granted SUMC's researchers access to the API for 1000 requests per hour for each of price and wait time. The API provides two key pieces of information as part of the response to queries for a theoretical ride between two locations: the wait time before a vehicle arrives at a requested location, and the estimated price, which includes a factor called the surge multiplier that reflects the relative demand for vehicles at that moment and location. Though it doesn't directly reflect the number of riders, the researchers made the assumption that changes in this factor act as a proxy for the changing level of demand over time.

By systematically querying the API around the clock with origin/destination pairs from points providing coverage of the study cities, the researchers assembled a picture of how ridesourcing availability and demand varies across time and geography."[21]

"To determine how Uber rides corresponded with transit trips, we compared the Uber API data with transit agencies' General Transit Feed Specification (GTFS) service information. For the transit capacity side of the comparison, we started from the assumption that the transit agencies schedule service in accordance with customer demand, and used the GTFS schedule data to build estimates of service capacity at the zip code level across the day and week. The researchers gathered the transit agencies' GTFS feeds and programmatically transformed them to hourly counts of trips, vehicles and vehicle types, and maximum wait times for each stop in the system (limited, like the ridesourcing data, to the core county of each region). Using standard load

[19] Ibid, Page 33
[20] Ibid, Page 35
[21] Ibid, Pages 35,36

factors and agency-specific vehicle sizes to estimate capacity at each stop, we arrived at a measure of hourly seat-stops and headways for each stop. We then generated aggregate measures of seat stops per hour and average headways at the ZCTA level."[22]

General Transit Feed Specifications (GTFS)

As way of background, General Transit Feed Specifications (GTFS) was developed by Tri-Met and Google, and "defines a common format for public transportation schedules and associated geographic information. GTFS 'feeds' allow public transit agencies to publish their transit data and developers to use that data to write applications. The feeds are represented in a series of text files that are compressed into a ZIP file, and include information such as fixed-route schedules, routes, and bus stop data. GTFS datasets are used in a variety of types of applications, including trip planners such as Google Maps, mobile applications, timetable generation software, tools for transit planning and operations analysis, and other categories of applications . . "[23]

In addition, General Transit Feed Specification-Real Time Format (GTFS-RT) was developed by Google "as an extension to General Transit Feed Specification (GTFS) and released via Creative Commons in 2011, GTFS-RT is a software-agnostic standard that allows public transportation agencies to provide realtime updates about their fleet to the public vis-a-vis application developers and Google Maps. The GTFS-RT standard allows transit operators to provide the following:

- Trip Updates - delays, cancellations, changed routes
- Service alerts - stop moved, unforeseen events affecting a station, route or the entire network
- Vehicle positions - information about the vehicles including location and congestion level"[24]

The TTD utilizes a third party application, "Transit" for providing real time passenger information and multi-modal trip planning services for its customers. Transit was developed by a Canadian company and uses GPS trackers on all TTD's buses. Passengers can generate real-time information on the location of a bus, its estimated arrival time and details on delays. The system is free through phone vendor app stores and also available through a website for those without smart phones. Transit includes ride-hailing services, Uber and Lyft, but only as options for the trip being planned. It does not incorporate those services as a link to the nearest transit stop in those cases where the origination and/or destination is outside the transit service area. Transit is offering an enhancement, Transit+, which links ride-hailing services with public transit. The application is in beta but is being offered to communities at no cost where there is an interest and a willingness to promote the application through the agency's website, social media and/or printed material as part of their service promotions. Refer to page 27 for examples of where Transit+ is being used, including the Regional Transportation Commission, Clark Co, NV and Pinellas Suncoast Transit Authority, Pinellas Co. FL.

[22] Ibid Page 36
[23] Transit Wiki: https://www.transitwiki.org/TransitWiki/index.php/General_Transit_Feed_Specification
[24] Ibid

Broadband Infrastructure

One of the challenges facing the TTD and others in the Tahoe Basin when considering expanding online capabilities and data sharing is the remaining gaps in the broadband infrastructure. For example, the Tahoe Prosperity Center's (TPC) Connected Tahoe Project is focused on extending high speed broadband internet within the Basin. TPC is advocating for getting "Dig Once Policies enacted by each Basin County and the City of South Lake Tahoe by providing internet providers access to publicly owned rights of way. This is in addition to the mandatory installation of conduit for fiber-optic cable during road construction, similar excavation projects, or by allowing qualified broadband deployments to be installed during construction projects."[25]

In addition, the 2017 TRPA "Linking Tahoe Regional Transportation Plan" outlined the Dig Once Policy as follows:

"**The Dig Once Policy**

- Conduit is installed when digging occurs for projects, allowing easy upgrades to communication lines, increasing broad-band coverage.
- Provides opportunities for synchronization and connection of traffic signals, improving traffic flow.
- Parking management systems also benefit by encouraging installation of real-time information systems during routine maintenance or new construction.
- Challenges to delivering the Dig Once Policy include finding appropriate funding sources."[26]

Federal Transit Administration Mobility on Demand (MOD) Sandbox program

In May 2016 the Federal Transit Administration (FTA) announced the availability of $8 Million "for a new program to demonstrate and evaluate innovative approaches to integrated "Mobility on Demand" (MOD) solutions within a public transportation framework"[27] (Federal Transit Administration, *Mobility on Demand (MOD) Sandbox Progra*m, Page 1, May 3, 2016, https://www.transit.dot.gov/funding/applying/notices-funding/mobility-demand-mod-sandbox-program >. As FTA explained it in the announcement, "The MOD Sandbox Demonstration Program is part of a larger MOD research effort at FTA and the U.S. Department of Transportation (DOT) that seeks to support transit agencies and communities as they navigate the dynamic, evolving landscape of personal mobility and integrated multimodal transportation networks. FTA is interested in conducting research on new service options in combination with available technologies that enable a traveler-centric approach to transportation, and provide better mobility options for everyone. FTA's MOD Sandbox Demonstration Program will provide a platform where integrated MOD concepts and solutions – supported through local partnerships

[25] Tahoe Prosperity website: <https://tahoeprosperity.org/connected-tahoe>
[26] TRPA, Linking Tahoe Regional Transportation Plan and Sustainable Communities Strategy Horizon Year 2017-2040, page 3-28.
[27] Federal Transit Administration, *Mobility on Demand (MOD) Sandbox Progra*m, Page 1, May 3, 2016, <https://www.transit.dot.gov/funding/applying/notices-funding/mobility-demand-mod-sandbox-program >

– can be demonstrated in real-world settings. FTA seeks to fund project teams to innovate, explore partnerships, develop new business models, integrate transit and MOD solutions, and investigate new, enabling technical capabilities such as integrated payment systems, decision support, and incentives for traveler choices. FTA intends to conduct evaluations of each of the demonstration efforts to measure the program impacts and assess how existing FTA policies and regulations may support or impede these new mobility service models.

The guiding principles of the MOD Sandbox demonstrations are:

- System Integration – the MOD Sandbox Program seeks operational integration of MOD products and services with existing transit service. Examples of this include open data platforms, common user interfaces, and practices and technologies that encourage and ensure system interoperability.
- Partnership Driven –MOD Sandbox projects should demonstrate teaming efforts, from public and private sectors, with partners committed to supporting the proposed MOD project both technically and institutionally.
- Innovative Business Model – the MOD Sandbox is structured to encourage innovative business models where MOD solution providers and transit operators partner to collectively deliver better service to travelers, while mutually benefitting from the partnership.
- Equity of Service Delivery – MOD Sandbox projects will demonstrate and promote equitable mobility service for all travelers, including communities such as low income, the aging population, and persons with disabilities, including wheelchair users."[28] (Ibid, Page 1)

In 2017, the FTA awarded $8 Million to fund eleven projects under this program. The following are relevant examples of these projects:

"**TriMet**, which serves Portland, OR, will receive funds to integrate shared-use mobility options into its existing trip planning app, allowing users to plan efficient trips even without nearby transit access.

The Vermont Agency of Transportation will receive $480,000 for a statewide transit trip planner that will incorporate flexible-route, hail-a-ride, and other services in mobility apps. The online trip planner particularly benefits non-traditional rural transit users and people with disabilities, allowing universal access to transit information.

In Dallas, TX, the Dallas Area Rapid Transit (DART) will receive $1.2 million to integrate ride-sharing services into its GoPass ticketing app. The project will create an integrated, multimodal application that leverages ride-sharing services, improving access to DART stations, particularly in non-walkable areas not well served by transit."[29]

Other examples of grants awarded through the Sandbox Program include the following:

The Regional Transportation Authority of Pima County

[28] Ibid, Page 1

[29] Federal Transit Administration, *U.S. DOT Secretary Foxx Participates in White House Frontiers Conference, Announces Nearly $65 Million in Advanced Technology Transportation Grants,* May 21, 2018, Page 1

The Regional Transportation Authority of Pima County, which includes Tucson, Arizona, who "will receive funding for the 'Adaptive Mobility with Reliability and Efficiency' project, integrating fixed route, subscription based ride-sharing and social carpooling services into an existing data platform to provide affordable, convenient and flexible service. The project augments transit by addressing first mile/ last mile issues and congestion mitigation by incorporating shared ride-on-demand services, integrated open payment systems and advanced traveler information systems."[30]

Valley Metro, Maricopa County, Arizona

The following is an excerpt from Valley Metro's FTA grant announcement and provides an example of a plan to integrate mobile phone applications and link them to travel modes. The challenges and goals the program addresses appear to be similar to those being encountered by the TTD. Chief among them are the challenges in solving the 'first and last mile' segments of an individual's effort to use a transportation mode other than with a private auto.

"Valley Metro is the regional public transportation agency in Maricopa County, Arizona providing coordinated, multimodal transit options to approximately four million residents of the Phoenix metropolitan region. With a core mission of developing a regional and fully integrated transit network, Valley Metro plans, develops and operates the regional bus and light rail systems and alternative transportation programs for commuters, seniors and people with disabilities. Valley Metro will develop a mobile application for all major smartphone devices that will integrate mobile ticketing and multimodal trip planning to provide fast and reliable transit and local travel information.

The proposed Valley Metro Mobility Platform will build upon RidekickTM, Valley Metro's existing mobile application, by adding features not currently available to users. The envisioned Mobility Platform will enable users to receive real-time travel information, purchase tickets for both public and private transportation modes, and utilize an optimized trip planning service through the integration of non-Valley Metro operated services such as Uber, Lyft, GR:D Bike Share, Zipcar, etc.

With the formation of public-private partnerships (P3s), the mobile application will let riders choose specific travel itineraries based on travel time, mobility preferences and proximity to transit options, as well as trip cost estimates. The enhanced integration will improve the level of connectivity throughout the transit network, thereby decreasing the first/last mile challenge facing public transportation users and allowing users to smoothly complete their trip from their point of origin to final destination. This mobile application will allow Valley Metro and private transportation services to utilize technology to provide a multimodal travel planning service with the simplicity of a mobile interface and single payment system.

The application will be free to download on all major mobile device operating systems including, but not limited to, the iOS (iPhone and iPad) and Android OS (Samsung, LG, HTC, etc.). Users will be able to create personalized accounts suitable to their needs and will be able to track travel patterns, use a single payment system for public/private transportation modes, as well as receive

[30] Federal Transit Administration, *Fiscal Year 2016 Mobility on Demand (MOD) Sandbox Program Projects,* May 18, 2017 as updated, page 1< https://www.transit.dot.gov/research-innovation/fiscal-year-2016-mobility-demand-mod-sandbox-program-projects>

electronic discounts for local events such as basketball games, concerts, movie theaters, restaurants, etc.

These application features will be available to anyone with a connected mobile device, but most importantly, the application will provide personalized travel options established in the user's account settings, including travel or accessibility features for people with disabilities. Valley Metro will use an open data platform design to allow other public transportation agencies to use the application; however, they will be able to adjust the features and functionality of the application to meet the needs and requirements for their respective service area and clients.

The Mobility Platform will be implemented in two phases. Phase I includes improvements to Valley Metro's RidekickTM application to include mobile ticket purchasing using wireless capabilities and multimodal booking options with GR:D Bike Share. In addition, non-fare payment services such as incident reporting capabilities will also be integrated in Phase I. Phase II will expand mobile ticket purchasing options to include transportation network companies (TNCs) such as Lyft, Uber, Zipcar and others. Additional features to be deployed as part of Phase II will include opportunities for businesses to provide combined event and transportation ticket purchasing in a single payment.

CHALLENGES PROJECT IS DESIGNED TO ADDRESS

The current RidekickTM mobile application limits users' ability to plan multimodal trips. Currently, if a passenger wanted to know all the potential travel options in their immediate vicinity, as well as utilize and pay for one of those services, they would need to visit multiple applications on their smartphone. For example, riders need to access RidekickTM for bus and rail schedules, Uber or Lyft for transportation network company choices, and Social Bicycles for GR:D Bike.

A fundamental component of improving the mobile application is to include a trip planning tool that includes a combination of public and private transportation alternatives. The new mobile application would not only provide a greater volume of travel options, but also provide users with personalized information about the environmental and economic benefits of each travel route. For example, someone querying the application would get a trip cost estimate, amount of CO2 saved from using alternative mobility options versus automobile travel, calories burned, and amount of gas money saved displayed with each travel option. Beyond this, the application would provide a single, integrated payment system for all trips. Additionally, the new added convenience of mobile ticketing would be accompanied by real-time trip tracking for Valley Metro bus and light rail services, both of which are currently not available.

ANTICIPATED OUTCOMES, BENEFITS, IMPACTS

The development of the Mobility Platform will enable real-time travel and trip planning functions for public transportation riders, which are currently not available on the RidekickTM application. The Mobility Platform will consolidate all trips using public and private transportation choices to allow riders more flexibility when choosing their travel mode. Users will be able to see the cost of gasoline saved, amount of CO2 saved from using alternative modes of travel, as well as route travel-time comparisons. The Mobility Platform will also provide riders a universal payment system for all public and private transportation choices, thus

enhancing connectivity, integrating sustainable transit solutions, such as car sharing and vanpool travel choices, as well as providing real-time travel data for riders throughout the Phoenix Metropolitan Region. Providing real-time trip information will save riders' time, thereby improving system efficiency and helping address perceived wait times. The mobile ticketing element also provides a sustainable solution as it will reduce the need for passengers to use fareboxes or ticket vending machines which, in turn, reduces paper-based and card-based tickets."[31]

Mobility on Demand: Example of plan to integrate mobile phone applications:

Vermont MOD:

"Building off previous investments in data creation and research, the Vermont Agency of Transportation (VTrans) and its partners are applying for funds to create and implement a tool that fills a well-known gap in transit public information: an online trip planner for both "fixed" and "flexible" transit services. The public transportation industry has seen a boom in third-party mobile applications for transit riders. These applications are designed for both standard web browsers, and as mobile apps for smart phones with internet access. One of the most important features of these applications is the presentation of information from multiple agencies within the same interface.

Rural transit operators provide a variety of services that help tailor transit to their areas including flag stops, deviated-fixed routes, general service area dial-a-ride, and other forms that work better in rural areas. That means trip planners built for urban areas do not present all the options that rural residents have. These flexible modes of transit are not only for rural areas though. They are also common models to provide extra service to persons with disabilities. Some business models have also sought to bring flexible transit services, such as Bridj or Ollie, to larger cities to provide trips more efficiently than public transit, and cheaper than taxis.

VTrans' goal is to develop a trip planner that provides access to mobility options while also building on a platform that can be adapted, utilized, and scaled elsewhere. This proposed trip planner will include itineraries that utilize both fixed and flexible modes of public transit. The final deliverable of this project is a mobile and desktop-accessible statewide trip planning website application. Any user will be able to define an origin and destination within the state and receive transit itineraries including those that can be found in Google, but also services like flag stops, deviated fixed routes, and dial-a-ride. Just like the Google Maps trip planner, this web application will provide information on what trips are possible, but not book actual trips for riders."[32]

Tri-County Metropolitan Transportation District of Oregon (TriMet) MOD:

[31] Ibid, with link to: *"MOBILITY ON DEMAND (MOD) SANDBOX" Valley Metro Rail, Inc. (Phoenix, AZ) Mobility Platform*"< https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA%20MOD%20Project%20Description%20-%20Valley%20Metro.pdf >,Page 1,2

[32] Ibid with link to: "MOBILITY ON DEMAND (MOD) SANDBOX VERMONT AGENCY OF TRANSPORTATION (VTrans) Vermont Statewide Transit Trip Planner – Fixed and Flex" <https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA%20MOD%20Project%20Description%20-%20VTrans.pdf> page 1,2

"TriMet's OTP SUM project will create a complete open platform for the integration of transit and shared-use mobility options. The open data, software and user interfaces, responsive on both web and mobile, will help Portland area 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. TriMet's project includes the development and expansion of two core data frameworks that current and future collaborative OTP initiatives can be built upon, producing replicable software and results for communities across the country. These two foundational core project elements are to:

- Extend the Open Trip Planner code base to support the integration of transit trip planning with shared-use mobility modes, such as bike share and transportation network companies (TNCs), as well as updated real-time transit information.

- Implement a fully functional and comprehensive open geocoder built off the existing Mapzen Pelias geocoder. Geocoding, or address locating, is a primary requirement for trip planning. A non-proprietary and non-restrictive option for address locating would substantially lower the barrier to entry for many transit systems to offer trip planning and can achieve significant cost savings for transit agencies, government agencies, and the public."[33]

These preceding examples echo the strategies identified in myriad studies completed for the TTD. For instance, recommendation "G2 – Multi-Modal First Strategies" of the "Linked Tahoe Corridor Connection Plan" states the following:

- "Insure that pedestrian facilities are incorporated in new development and redevelopment that address the "last mile" to/from transit service.
    - o Tactics/actions:
        - Identify and prioritize significant "last mile gaps"
        - Reach agreement with partner agencies approving development that projects will be reviewed for opportunities to address these gaps

- Prioritize public investments in new pedestrian facilities to address "last mile" gaps.
    - o Tactics/actions:
        - Circulate the list of significant "last mile gaps" to partner agencies
        - Reach agreement with partner agencies that capital improvement programs in pavements and sidewalks will be reviewed for opportunities to address these gaps"[34]

In June, 2018, the National Transportation Library released plans for how "independent researchers will evaluate Mobility on Demand public transportation projects. . . . Researchers will assess each of the 11 MOD Sandbox Program projects based on performance measures provided by the project partners, as well as an independent evaluation. Each report will address

[33] Ibid with link to: *MOBILITY ON DEMAND (MOD) SANDBOX Tri-County Metropolitan Transportation District of Oregon (TriMet) OTP Integration of Transit with Shared-Use Mobility Real-Time & Data Enhancement,* Page 1,2 <https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA%20MOD%20Project%20Description%20-%20TriMet.pdf>
[34] Stantec, *Linking Tahoe – Corridor Connection Plan,* Page 102, August 2017

the project evaluation approach and process and data collection and analyses."[35] (Federal Transit Administration, *Mobility on Demand (MOD) Sandbox Progra*m, Page 1, October 12, 2018 <https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program>, Booz Allen Hamilton was awarded a contract for these evaluations and their work is still being conducted.

In addition to addressing the "first and last mile" challenges referred to above, once a passenger is utilizing a public transit link, it becomes equally important to constantly improve the system's performance, including increasing operating speeds in order to reduce the overall duration of the passenger trip .

The TTD and Tahoe Regional Planning Agency (TRPA) recognizes and supports the importance of increasing system speed as noted in the 2017 "Linking Tahoe: Regional Transportation Plan and Sustainable Communities Strategy" under the section titled "Transit Priority Access" as follows:

"Making transit faster, cheaper, and more convenient is key to increasing ridership and reducing vehicle miles traveled. One method to achieve this is by creating roadway restrictions in targeted locations that only allow transit, bike, emergency, and local traffic during peak periods. These types of projects dramatically reduce vehicle miles traveled and GHG emissions, needing first broad coordination among partner agencies. Transit signal priority which allows buses to start moving before cars at signalized intersections is on the constrained list and is a first step. Adaptive management strategies that hold cars to let buses pass or provide transit only lanes will occur later with additional project funding and partner consultation."[36]

The report continues its discussion regarding proposed technological improvements:

"This plan will continue to deliver technological improvements that provide real-time information using smartphone applications on bus arrival, road conditions, and parking availability and dynamic pricing to residents, commuters, and visitors. Signals along the South Shore will be optimized to better address peak demand visitation and provide safe and equitable access to bicyclists, pedestrians, and those with special needs. Transit signal priority will also be introduced on the South shore to make transit a more convenient and attractive option for commuters and visitors. Changeable message signs and traffic monitoring equipment will become more common on the Nevada side of the Region to enhance safety, manage congestion, and understand travel demand. Maintenance equipment will be upgraded to preserve the environment and enhance efficiency of maintenance activities. Alternative fuel infrastructure and public fleets will begin rapid deployment through implementation of the Plug-in Electric Vehicle Readiness Plan. Partners will collaborate to identify subsidy programs for partnerships with ridesharing companies to fill gaps where transit or active transportation cannot accommodate traveler needs. Additional technology projects such weather variable speeds signs, a region-wide transportation trip planning tool, and information kiosks at activity centers are desired but require newly identified funding."[37]

[35] Federal Transit Administration, *Mobility on Demand (MOD) Sandbox Progra*m, Page 1, October 12, 2018 <https://www.transit.dot.gov/research-innovation/mobility-demand-mod-sandbox-program>

[36] (TRPA, Linking Tahoe Regional Transportation Plan and Sustainable Communities Strategy Horizon Year 2017-2040 Page 3-12

[37] Ibid, Page 3-28

Other transit related technological improvements in various stages of development are also referred to in the report as follows:

"Communication improvements, optimizing intersection functionality, and increasing electric and zero-emission vehicle use help meet the regional goals of environment, safety, operations and congestion management, and system preservation." "Optimizing intersections, addresses congestion management and safety by improving traffic flow, movement predictability, and accessibility. Examples of intersection improvements include signal timing and coordination, signal queue-jump for buses, bikes, and pedestrians, bicycle signal detection, emergency response signal override, and pedestrian hybrid beacons. Technology also preserves the environment through using best available technologies in equipment, construction, and vehicle type."[38]

In addition, technologies associated with transit and its role in congestion mitigation and increasing the transit mode split is emphasized in "Linking Tahoe – Corridor Connection Plan" (LTCCP) with the following excerpts:

"G3. Manage Congestion-Strategies
• Increase amenities for transit riders (NextBus, WIFI, seating, bus stops, lighting and safe connectivity).
    o Tactics/Actions:
        − TTD Implement Real Time Bus Arrival technology to emulate TART system
        − TTD/TART Construct large capacity bus shelters complete with NextBus arrival information, level boarding, off-bus fare collection, CCTV, seating, and trash receptacles
• Operational and limited capacity improvements to address congestion
    o Tactics/Actions:
        − TTD/TART Install queue jump priority systems for transit vehicles at key signalized intersections
        − All Agencies Work with legislators to require drivers to yield to buses re-entering the roadway from bus stops"[39]

Within the LTCCP and TMP, a clear emphasis was placed on increasing the transit mode split from the current levels of less than 2% to 5%, 10% and 20% incrementally over the next decade. It was also recognized that the visitors to the Tahoe Basin represents a large percentage of the trips generated in the area. Specifically, the LTCCP stated that recreational travel over commuter travel needs to be an important focus: "Since the proportion of these commuter trips compared to those of visitors or residents is miniscule, the focus of transit service enhancements will be directed to capturing the recreational visitor, both outside the Basin where possible and from their lodging destinations on sidewalks, bikeways or at transit stops. Since most of all travel into and within the Basin is visitor and recreational based, further study and evaluation is necessary to more fully understand how to transfer a significant portion of these travelers to active transportation options including transit."[40]

[38] Ibid, Page 3-24
[39] Stantec, *Linking Tahoe – Corridor Connection Plan,* August 2017, Appendix A, Page 5
[40] Ibid, Page 25

Regional Transportation Commission, Clark County, NV (RTC South)
In November 2018, the RTC, Clark County announced the launch of Transit+ trip planning application which is currently in beta and is an enhancement to the Transit App that has been utilized at the RTC for a number of years. Transit+ is a multimodal trip planning platform that includes ride-hailing services such as Uber and Lyft for those portions of a trip that transit service does not cover. The RTC representative reported that customers have successfully utilized the new program and are pleased with its performance. Recently, of the 6-7 thousand uses of the RTC on-line trip planning tool, 16 percent, or 100 people a day, use the Transit + multimodal trip planning feature. Although RTC has a trip planning program accessible through their website, it does not incorporate the ride-hailing services like the Transit+ application does. The RTC's contact regarding this application is Jesse Diaz, Government Affairs, Media and Communications at 702-676-1595, DiazJ@rtcsnv.com.

Pinellas Suncoast Transit Authority (PSTA), Pinellas County, FL
The PSTA also utilizes the Transit+ trip planning application as described above but also uses Google Map-based trip planner which incorporates a $5 subsidy for using the ridehailing service, Uber for part of their trip. An analysis of the utilization rate of the new Transit + application has not been made as of this time. The PSTA contact regarding this application is Jacob Labutka, 727-540-1977, Jlabutka@psta.net.

Recommendations:

- Virtually all of the technological advances reviewed in this paper will require that individuals with smart devises, vehicles with GPS capabilities and traffic management/control devices in the Tahoe Basin have access to effective and robust hardline fiber and wireless broadband communications network. This would include the I-80 and Highway 395 corridors. The "Dig Once" policy within the Basin is an excellent example of the type of initiative that needs to be fully programmed and implemented.

  The TTD should consider taking the lead in planning, promoting and where appropriate implementing the broadband network with sufficient capacity and reliability to support the many technological initiatives.

- Implement technologies associate with operational efficiency initiatives such as queue jumping, signal prioritization and coordination, as outlined in the LTCCP.

- The TTD should consider partnering with Transit to implement their "Transit+" trip planning enhancement. Currently Uber and Lyft are offered as an alternative to public transit and not part of a coordinated trip. Transit+ does incorporate Uber/Lyft as a connection to transit services. The application is referred to by the company as "transit-oriented ridehailing". Contact should be made with Transit's Communications Lead, Stephen Miller, at partners@transit.app.

- The TTD should review the evaluation reports as they become completed by Booz Allen Hamilton on the relevant MOD Sandbox programs for applicable lessons learned and the development of best practices.

Transit Automation Grant Programs

Much of the Federal Transit Administration's (FTA) transit bus automation research is funded by the Public Transportation Innovation Program (FTA Section 5312) – revised under the Fixing America's Surface Transportation Act (FAST). Attached, as Exhibit C, is the fact sheet for Section 5312.

FTA is expected to announce in early 2019 the continuation of the Mobility on Demand (MOD) Sandbox program which is designed to enable transit agencies to innovate in order to provide better transit service. There is also an element of the program which focuses on integrating mobility payments.

FTA funding may be allocated on a discretionary basis. Grant opportunities are posted on http://www.grants.gov/ under the CFDA Number 20.514. Interested parties may subscribe on that website to receive notification of all FTA research opportunities by entering 20.514 where it requests the CFDA Number.

The Federal Highway Administration also has competitive grants available to fund advanced transportation and congestion management technologies under its Advanced Transportation and Congestion Management Technologies Deployment Program. Funds have been authorized through 2020. Eligible projects include the following:

- advanced traveler information systems;
- advanced transportation management technologies;
- infrastructure maintenance, monitoring, and condition assessment;
- advanced public transportation systems;
- transportation system performance data collection, analysis, and dissemination systems;
- advanced safety systems, including vehicle-to-vehicle and vehicle-to-infrastructure communications;
- technologies associated with autonomous vehicles, and other collision avoidance technologies, including systems using cellular technology;
- integration of intelligent transportation systems with the Smart Grid and other energy distribution and charging systems;
- electronic pricing and payment systems; or
- advanced mobility and access technologies, such as dynamic ridesharing and information systems to support human services for elderly and disabled individuals. [23.U.S.C. 503(c)(4)(E)]

Additionally, there may be opportunities for agencies to participate in peer exchanges and communities to share lessons learned and best practices. There has also been significant state and local investment in automation, and additional state funding may be available.

Recommendation:

Subscribe on www.grants.gov to receive notification of all FTA research opportunities by entering 20.514 where it requests the CFDA Number. These funds may be issued on a discretionary basis, therefore it is important to stay apprised of emerging grant opportunities.

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<https://www.transitwiki.org/TransitWiki/index.php/General_Transit_Feed_Specification>

TRPA, *Linking Tahoe Regional Transportation Plan and Sustainable Communities Strategy Horizon Year 2017-2040*, page 3-28

TRPA, Linking Tahoe Regional Transportation Plan and Sustainable Communities Strategy Horizon Year 2017-2040, pages 3-12, 3-24, 3-28, Appendix A, page 5

WSB & Associates, Inc. AECOM, *MnDOT Autonomous Bus Pilot Project Testing and Demonstration Summary*, June 27, 2018, Page 6)
<http://www.dot.state.mn.us/automated/bus/finalreport.pdf>

EXHIBIT A

Society of Automotive Engineers (SAE)

Levels of Automation

Automated driving levels and definitions include the following:

Level 0 – No Automation: The human driver does all the driving.

Level 1 – Driver Assistance: An advanced driver assistance system (ADAS) on the vehicle can sometimes assist the human driver with either steering or braking/accelerating, but not both simultaneously.

Level 2 – Partial Automation: An advanced driver assistance system (ADAS) on the vehicle can itself actually control both steering and braking/accelerating simultaneously under some circumstances. The human driver must continue to pay full attention ("monitor the driving environment") at all times and perform the rest of the driving task.

Level 3 – Conditional Automation: An Automated Driving System (ADS) on the vehicle can itself perform all aspects of the driving task under some circumstances. In those circumstances, the human driver must be ready to take back control at any time when the ADS requests the human driver to do so. In all other circumstances, the human driver performs the driving task.

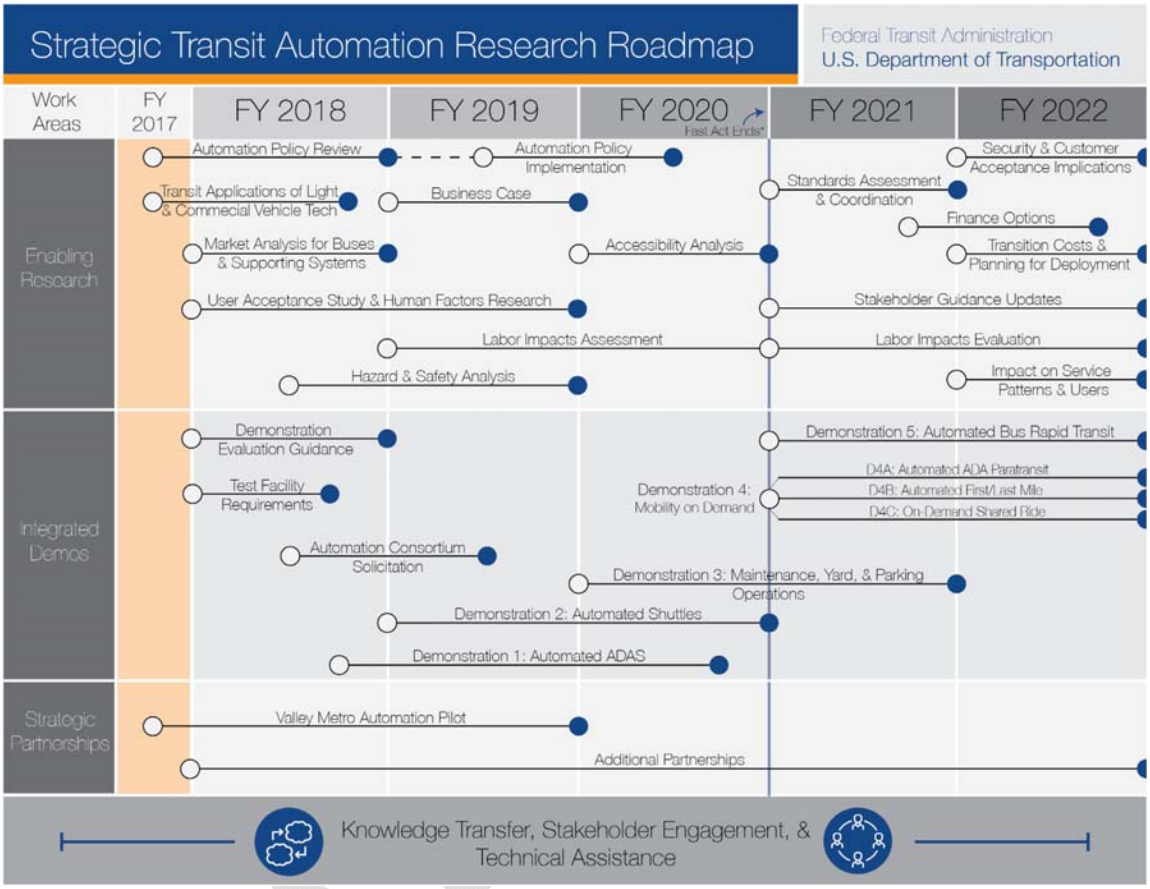
Level 4 – High Automation: An Automated Driving System (ADS) on the vehicle can itself perform all driving tasks and monitor the driving environment – essentially, do all the driving – in certain circumstances. The human need not pay attention in those circumstances.

Level 5 – Full Automation: An Automated Driving System (ADS) on the vehicle can do all the driving in all circumstances. The human occupants are just passengers and need never be involved in driving.

Source: National Highway Traffic Safety Administration

Exhibit B

Strategic Transit Automation Research (STAR) Roadmap



Source: Federal Transit Administration

EXHIBIT C

Federal Transit Administration

FACT SHEET

PUBLIC TRANSPORTATION INNOVATION Section 5312

Source: Federal Transit Administration

U.S. Department of Transportation
Federal Transit Administration

FACT SHEET:
PUBLIC TRANSPORTATION INNOVATION
Section 5312

	FY15/ MAP-21	FY16 (millions)	FY17 (millions)	FY18 (millions)	FY19 (millions)	FY20 (millions)	TOTAL (millions)
Research, Development, Demonstration, Deployment, & Evaluation	$7.5	**$20.0**	**$20.0**	**$20.0**	**$20.0**	**$20.0**	**$100.0**
Low or No Emission Vehicle Component Testing	-	**$3.0**	**$3.0**	**$3.0**	**$3.0**	**$3.0**	**$15.0**
Transit Cooperative Research Program	$3.0	**$5.0**	**$5.0**	**$5.0**	**$5.0**	**$5.0**	**$25.0**
5312 PROGRAM TOTAL*	**$10.5**	**$28.0**	**$28.0**	**$28.0**	**$28.0**	**$28.0**	**$140.0**

**Amounts above are funded from the Highway Trust Fund. Additional funds authorized from the General Fund are subject to annual appropriations and not included above.*

PROGRAM PURPOSE: To advance innovative public transportation research and development.

Statutory References: 49 U.S.C. Section 5312 / FAST Section 3008

Eligible Recipients: Federal Government departments, agencies, and instrumentalities of the Government, including Federal laboratories; State and local governmental entities; providers of public transportation; private or non-profit organizations; institutions of higher education; and technical and community colleges.

Eligible Activities:

Research: Activities shall focus on (A) providing more effective and efficient public transportation service, including services to seniors; individuals with disabilities; and low-income individuals; (B) mobility management and improvements and travel management systems; (C) data and communication system advancements; (D) system capacity, including train control; capacity improvements; and performance management; (E) capital and operating efficiencies; (F) planning and forecasting modeling and simulation; (G) advanced vehicle design; (H) advancements in vehicle technology; (I) asset maintenance and repair systems advancement; (J) construction and project management; (K) alternative fuels; (L) the environment and energy efficiency; (M) safety

improvements; or (N) any other area that is important to advance the interests of public transportation.

Innovation and Development: Activities shall focus on (A) the development of public transportation research projects that received assistance that were successful; (B) planning and forecasting modeling and simulation; (C) capital and operating efficiencies; (D) advanced vehicle design; (E) advancements in vehicle technology; (F) the environment and energy efficiency; (G) system capacity, including train control and capacity improvements; or (H) any other area that is important to advance the interests of public transportation.

Demonstration, Deployment and Evaluation: A demonstration, deployment, or evaluation project that receives assistance shall seek to build on successful research, innovation, and development efforts to facilitate (A) the deployment of research and technology development resulting from private efforts or Federally funded efforts; or (B) the implementation of research and technology development to advance the interests of public transportation.; or (C) the deployment of low or no emission vehicles, zero emission vehicles, or associated advanced technology. A comprehensive evaluation must be conducted within 2 years from the date a demonstration or deployment project receives assistance; to evaluate the success or failure of the project and to describe any plans for broad-based implementation of the innovation promoted by successful projects.

Low or No Emission Vehicle Component Testing (Low-No Testing): At least one institution of higher education shall be competitively selected to operate and maintain a facility to conduct testing, evaluation, and analysis of low or no emission vehicle components intended for use in low or no emission vehicles. The institution(s) shall have: (I) the capacity to carry out transportation-related advanced component and vehicle evaluation; (II) laboratories capable of testing and evaluation; and (III) direct access to or a partnership with a testing facility capable of emulating real-world circumstances in order to test low or no emission vehicle components installed on the intended vehicle. Component testing is voluntary, however, a low or no emission bus model must still comply with Section 5318 Bus Testing.

Transit Cooperative Research Program (TCRP): Through a cooperative agreement, the National Academy of Science will administer a public transportation cooperative research program. An independent governing board will continue to recommend public transportation research, development and technology transfer activities.

What's Changed?

- The 5312 program is authorized for funding from both the Highway Trust Fund and General Fund. In addition to the amounts in the chart above which are authorized from the Highway Trust fund, FAST authorized an additional $20 million from the General Fund, which is subject to annual appropriations.
- The creation of a voluntary Lo-No Testing Program for components, which is separate and apart of the Bus Testing Program (Section 5318). This program also requires FTA to publish a performance report on the assessments conducted.
- TCRP, formerly authorized in Section 5313, is now included in this section and is now funded by the Trust Fund as opposed to the General Fund.
- Annual Research Report on projects, evaluations, and benefits is posted to FTA's website rather than submitted to the Congress.

Funding:

Federal Share: The Government share of the cost of a project carried out under this section shall not exceed 80 percent. However, for the Lo-No Testing, the Government share is 50 percent.

Non-Government Share: The non-Government share of the cost of a project carried out under this section may be derived from in-kind contributions For the Lo-No Testing, the remaining 50 percent is to be paid from the fees established and collected.

Additional Information:

- Departmental Coordination: FAST requires FTA to submit its comprehensive annual modal research plan to the Assistant Secretary for Research and Technology for review and approval prior to expending funds.
- Small Business Innovation Research (SBIR): Pursuant to the Small Business Innovation Development Act of 2000 (P.L. 106-554), a portion of the 5312 funds must be set aside for the Department's SBIR program to address high priority research that will demonstrate innovative, economic, accurate, and durable technologies, devices, applications, or solutions to significantly improve current transit-related service including transit vehicle operation, safety, infrastructure and environmental sustainability, mobility, rider experience, or broadband communication.

For Additional Information on FTA and the FAST Act, please visit: www.fta.dot.gov/fast.html