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SPECIAL ISSUE The Future of Public Transportation

Is It Time for a Public Transit Renaissance?

Navigating Travel Behavior, Technology, and Business Model Shifts in a Brave New World

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Abstract

Travel behavior is undergoing a period of significant change in the United States. In 2016, public transit ridership fell in almost all major U.S. metropolitan regions. While Americans are still heavily dependent on the personal automobile for mobility, technological and societal changes are transforming how mobility is accomplished. This paper reviews the convergence of five trends leading to fundamental changes in public transportation: (1) changing generational behavior toward suburbanization and automobility; (2) new attitudes toward information communications technology; (3) shifting attitudes toward sharing and mobility on demand; (4) innovative alternatives to work and non-work travel; and (5) an increasing number of on-demand flexible route transportation options. The paper concludes with recommendations and guiding principles for public agencies to consider in responding to these trends.

Introduction

Technological, mobility, and societal trends are contributing to declining public transportation ridership. In 2016, public transit ridership fell in all major U.S. metropolitan regions except for Seattle, Houston, Milwaukee, Detroit, New York-Newark, and the San Francisco Bay Area (Schmitt 2017; Bliss 2017; Walker 2017). But it is not just public transportation ridership that is changing. The nature of how Americans travel is evolving, and this evolution is beginning to reveal itself in long-standing transportation measures. While the United States has been and is still heavily dependent on the personal automobile for mobility, changes in technology, demographics, economics, and attitudes are transforming how mobility is accomplished (Shaheen, Cohen, and Zohdy 2016; Shaheen et al. 2016). Increasing congestion, fiscal austerity, and the need to maximize existing

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infrastructure use—coupled with the growth in telecommuting, goods delivery, and digital consumption—are changing mobility needs, consumption, and travel behavior (Matos and Galinsky 2014; Kolko 2017). Heightened environmental awareness, the growth of megaregions, demographic changes (e.g., rising life expectancies and an aging population), and a reduced reliance on brick-and-mortar establishments are driving fundamental transportation and modal changes across the Western Hemisphere (Regan and Picker 2017; Koettl 2016).

Mobility on Demand (MOD) is an innovative transportation concept where consumers can access mobility, goods, and services on-demand by dispatching, or using shared mobility, courier services, automated (or self-piloted) aerial vehicles and drones, and public transportation solutions. The most advanced forms of MOD passenger services incorporate trip planning and booking, real-time information, fare payment, artificial intelligence, and predictive analytics into a single user interface. Passenger modes facilitated through MOD can include bikesharing, carsharing, ridesharing, ridesourcing/transportation network companies (TNCs), scooter sharing, microtransit, shuttle services, public transportation, and other innovative and emerging modal technologies (see Figure 1). The commodification of transportation and the increasing availability of on-demand mobility is transforming how Americans view automobility and the way Americans travel in a variety of ways.

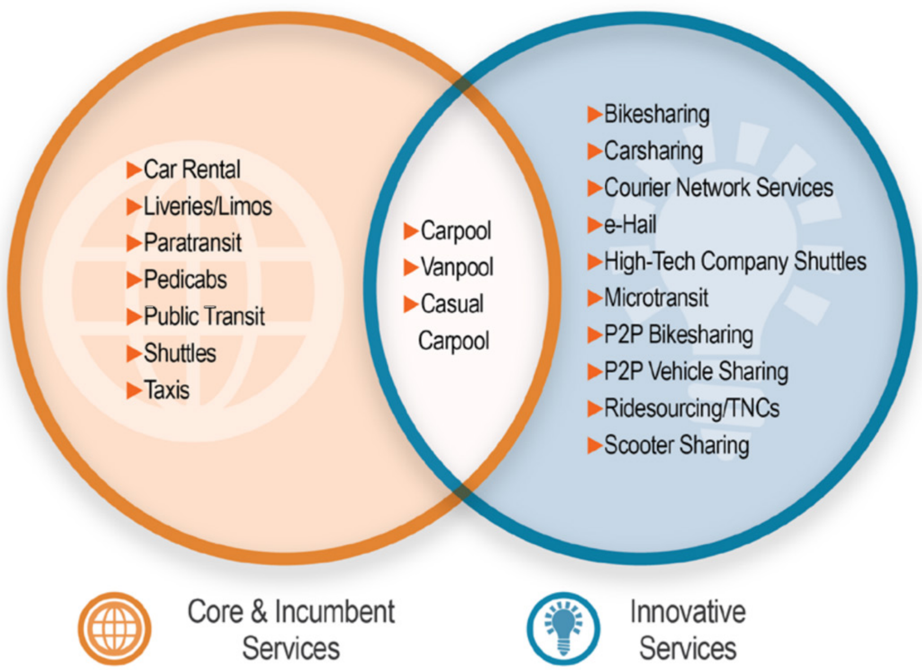

FIGURE 1.
Mobility on Demand Passenger Service Ecosystem

The convergence of a number of trends will lead to fundamental changes in public transportation in the coming years. Five key trends include:

1. Changing generational behavior toward suburbanization and automobility
2. New attitudes toward information communications technology
3. Shifting attitudes toward sharing and mobility on demand
4. New alternatives to work and non-work travel
5. Increasing number of on-demand flexible route transportation options

Today, policy makers and public transit agencies should consider the individual and collective impacts of these trends on public transportation, ridership, system design, and first mile/last mile connections. Each of these trends is discussed in greater detail below.

1. Generational Behavior Toward Suburbanization and Automobility

Suburbanization of metropolitan America has been one of the great underlying trends impacting transportation in the United States during the 20th century. While early suburbs were often built around railroad and streetcar lines, post–World War II suburbanization has become primarily an auto-driven phenomenon. Contrary to the current popular notion that the United States is becoming urbanized (i.e., a reversal post-war suburbanization) and the population is growing within American downtowns, the U.S. population is still trending toward suburbanization, overall. By the year 2000, more than half the U.S. population lived in the suburban neighborhoods of cities (Berger et al. 2013). According to the 2010 census, almost 75% of all households resided in single-family or mobile homes. Furthermore, except for the largest metropolitan areas, the central business districts (CBDs) of U.S. cities that have a population of greater than one million had low or negative growth as residents moved outward in search of suburban living. As residents have moved outward, jobs have followed. Growth in employment centers has been occurring outside of CBDs and in various nodes within suburbs. Between 1998 and 2006, the share of total employment within three miles of a city's CBD had decreased for 95 of the 98 most-populated metropolitan areas (Kneebone 2009). Frey (2012) found that the suburbs generally grew faster than the primary city from 1990 to 2010. Thus, even though there have been well-documented media descriptions of revivals in housing and residential construction within the downtowns of many American cities, growth in the suburbs has still been faster through 2010. A consequence of auto-oriented suburbanization has been increased driving for nearly all types of travel. Kahn (2000) found that suburban households drove 31% more than their urban counterparts.

Data show that in almost all metrics, millennials are driving less than their predecessors who once occupied their current age group of 18 to 33, and boomers are driving more than their predecessor cohort. Having grown up in an era of technological advancement, millennials are much more likely to take advantage of technology to substitute unnecessary travel. This includes a greater tendency to work from home, conduct shopping online, and engage in socializing online instead of in person (Polzin 2014; Patten and Fry 2015). Further, surveys of innovative mobility services, such as carsharing, have shown them to be largely used by people between the ages of 20 and 40 (Martin and Shaheen 2010). Millennials were also hard hit by the U.S. recession in 2008, as many were just entering the workforce. So more of them who are in their 20s have been deferring marriage and home ownership until after completing further education or work (Patten and Fry 2015; Polzin 2014). This would, for now, lead to a delayed (if at all) move to residing in a suburban area, where there would be greater dependence on a personal vehicle. These are some possible reasons why driver-licensing rates are at an all-time low among those aged 16 to 29 years (Schwartz 2014). A study of Dutch couples between 2011 and 2013 found that when controlling for other factors such as level of urbanization, employment, and household income, couples who enter parenthood are more likely to become car owners and less likely to exit vehicle ownership. The authors suggest that delayed entry into parenthood might lead to later entry into vehicle ownership and an increase in lifetime childlessness may lead to an overall decline in vehicle ownership (Oakil et al. 2016). A key question for policy makers and public transit agencies is whether millennials will resume historic patterns of suburban living and auto dependency while progressing through life milestones (Naughton 2017).

2. Attitudes Toward Information and Communications Technology

Millennials overall have embraced information and communication technology (ICT), particularly with the proliferation of Internet access through household broadband and mobile devices (primarily smartphones). This has allowed technology users to substitute some physical trips with "virtual trips." Telecommuting and e-commerce are examples of physical trips avoided due to technology, but the impact on public transit ridership and overall travel demand remains unclear (discussed in greater detail below). At the same time, ICT can provide access to increased mobility options. ICT can help users more easily access and navigate public transit, access carsharing and bikesharing locations, and stay connected during the trip. Another example is app-based, ride-hailing services (also known as ridesourcing or transportation network companies) such as Lyft and Uber, which connect riders to nearby drivers in real time using their mobile devices. ICT can also aid active transportation modes (e.g., walking and cycling) with turn-by-turn directions and identifying nearby points of interest.

Because ICT is quickly proliferating and evolving, little research has been done in recent years to capture its impact on travel or public transit ridership (Dutzik et al. 2014). Blumenberg et al. (2012) found no correlation between the reduction of driving among millennials and their ICT use, while Mans et al. (2012) developed a framework for determining potential ICT impacts on travel. The framework concluded that ICT will impact travel in multiple and complex ways (e.g., an online shopping purchase may merely replace a shopping trip with a delivery trip), and it is therefore difficult to model any significant impacts. Data remain scarce to draw further conclusions. The most recent National Household Travel Survey did not take into consideration the latest ICT developments, including smartphones and social media. As ICT will only continue to grow and evolve, timely research is needed to better capture attitudes toward ICT and its impact on public transit ridership and modal choice.

3. Attitudes Toward Sharing and Mobility on Demand

The sharing economy has grown alongside emerging ICT systems, which facilitate the sharing of assets that would have otherwise been used by one individual or household. Within the personal transport realm, MOD is burgeoning and evolving to meet the needs of cities and travelers whose attitudes have begun to shift toward sharing. The most direct evidence of shifting attitudes toward sharing is the increased use of MOD services. Key benchmarking data on shared modes include the following:

- As of January 2017, there were 21 active carsharing programs in the United States with over 1.4 million members (Shaheen and Cohen, forthcoming). In April 2011, Zipcar, a carsharing company providing short-term (e.g., hourly) vehicle rentals, raised $174 million in its initial public offering, giving it a valuation of $1.2 billion (Ovide 2011). The Avis Budget Group acquired Zipcar for $500 million in January 2013 (Tsotsis 2013).

- As of April 2016, there were 32,200 bikes at 3,400 stations across 99 cities (75 IT-based public bikesharing programs) in the United States, serving three user groups: (1) members, users with an annual or monthly membership; (2) casual users, short-term bikesharing users with 1- to 30-day passes; and (3) occasional members, users employing a key fob to pay for a short-term pass (Meddin, unpublished data).

- In January 2016, various ridesourcing services were available in 175 metropolitan areas across the United States (Cohen and Shaheen 2016). By December 2014, Uber, the ridesourcing platform that provides door-to-door for-hire vehicle services, was valued at $41.2 billion (Picchi 2015). Between mid-2012 and 2014, the company grew to more than 160,000 drivers (Hall and Krueger 2015). Just one year later, Uber was valued at $70 billion.

- As of July 2011, there were an estimated 638 ridematching services in North America, based on an extensive Internet search. This tally includes online (most have an Internet-based component) and offline carpooling and vanpooling programs. Those located in sparsely populated rural areas, which appeared to have very low use, were excluded. Institutions that have their own ridematching website but employ a common platform were each counted separately. Of the total, 401 were located in the United States, 261 were in Canada, and 24 programs span both countries (Chan and Shaheen 2011).

While a number of social, environmental, and behavioral impacts have been attributed to on-demand modes, more research is needed to understand the precise impacts of these services on public transportation. For example, a recent study of San Francisco Bay Area casual carpooling users revealed that 75% of casual carpool users were previous public transit riders and over 10% previously drove alone (Shaheen, Chan, and Gaynor 2016). Studies have examined the impact of round-trip and one-way carsharing on public transit and non-motorized travel (Martin and Shaheen 2011; Martin and Shaheen 2016). While these studies found a slight overall decline in public transit use, carsharing members exhibited an increased use of active modes such as walking.

A study of bikesharing found that shifts away from public transportation were most prominent in urban environments within high-density urban cores (Martin and Shaheen 2014). Shifts toward public transportation in response to bikesharing tended to be more prevalent in lower-density regions on the urban periphery. This early study of North American bikesharing indicates that public bikesharing may serve as a first mile/last mile connector in smaller metropolitan regions with lower densities and less robust transit networks. The findings also suggest that in larger metropolitan regions with higher densities and more robust public transit networks, public bikesharing may offer faster, cheaper, and more direct connections compared to short distance transit trips. In addition, public bikesharing may be more complementary to public transportation in small and medium metropolitan regions and more substitutive in larger metropolitan areas, perhaps providing relief to crowded transit lines during peak periods.

Although research is limited, several studies suggest ridesourcing may compete with public transit (bus and rail), although it can also serve the first mile/last mile solution (Schaller 2017; Henao 2017; Rayle et al. 2016). More research is needed to further understand this dynamic. Location-specific variations—including urban density, public transit service and availability, socio-demographics, and cultural norms—contribute to these modal shifts, and they are likely to result in impact differences.

4. Alternatives to Work and Non-work Travel

Innovative transportation modes coupled with revolutions in ICT are transforming the way we perform daily tasks, including our travel behavior. Mobile technology has changed the pattern of modern life at home and work (Baillie and Benyon 2008). New technologies have reduced the need for brick-and-mortar retail consumption and workers to be physically present in an office. With technological advances, such as the Internet, mobile phones, personal digital assistants, and more recently smartphones and tablets, people now have access to a wide range of services from almost anywhere. Alternatives to work, such as telecommuting, may reduce the need for work-related trips, while reducing congestion from private automobiles and public transit ridership.

Telecommuting is an alternative arrangement in which an employee can work remotely from a centralized workplace (e.g., home, cafe, library, and shared workspaces). This is accomplished by using available ICT, such as telecommunications and personal computers. Nilles (1975) is often cited as having first coined the term *telecommuting*, which is also known as *telework*, *teleworking*, *home-working*, and *working remotely*. Telecommuting can vary in its frequency (sometimes or all the time) and location (home or elsewhere). Because there is no uniform definition of telecommuting, it has been difficult to compare research studies (Baruch 2001).

Past studies have noted the travel impacts of telecommuting policies have been difficult to measure and compare (Nilles 1988; Mokhtarian 1991). Although employers may have programs to encourage telework, they often do not monitor or survey their employees. Moreover, the term *telecommuting* has not been consistently defined, and previous research has noted little reliable data on trends (Mokhtarian et al. 1995). The availability of data describing teleworking, at least through the American Community Survey journey-to-work data, has since become more abundant. One of the earliest analyses of teleworking studied over 100 employees at a firm in Los Angeles who began to telecommute to a satellite center, a location remote from the main office to which telecommuters travel for accessing computing technology and telecommunications (Nilles et al. 1976). This pilot program reduced the one-way commute distance by 65% without increasing other non-commute trips.

The U.S. Department of Transportation (USDOT) conducted annual telephone surveys to create projections of telecommuting trends from 1992 to 2002 (USDOT 1993). Back then, the USDOT forecasted that between 5.2% and 10.4% of the American workforce (7.5 to 15.0 million) would be telecommuting in 2002. When the frequency of telecommuting (part-time or full-time) is taken into consideration, the forecast ranges from 1.0% to 8.3% of the workforce telecommuting on a given day in 2002. In 2011, Lister and Harnish estimated that 45% of the U.S. workforce had occupations compatible with at least part-time telework (Lister and Harnish 2011). This study further estimated that telecommuting grew by 61% between 2005 and 2009. More research is needed to understand how the ongoing (and future) growth of telecommuting may adversely impact public transit ridership or shift public transit demand (from peak commuting to non-work trips, for example).

The same technologies that have ushered in telework growth have also brought changes in non-work travel. Non-work travel continues to be influenced by e-commerce and e-services, such as grocery delivery, goods delivery, and telemedicine. E-commerce continues to grow in terms of overall activity and percent of total retail activity. The U.S. Census reported quarterly retail sales for the first quarter of 2015 were $80.26 billion, representing 7.0% of all retail sales (Bucchioni et al. 2015). This share is currently at an all-time high and shows the increasing role that e-commerce is playing in overall retail activity.

While there is a wide body of literature on the impacts of e-commerce growth on brick-and-mortar retail, there is little consensus on whether e-commerce is having a negative, neutral, or complementary effect (Mokhtarian and Salomon 2002; Tonn and Hemrick 2004; Ferrell 2005; Cubukcu 2001; Worzala et al. 1999; Sim and Koi 2002). The retail sector is diverse and changing quickly with a wide array of business models across built environments and online marketplaces. Subscription e-commerce firms are focusing on the on-demand delivery of products when and where they are needed, rather than focusing on monthly delivery cycles (Fugere 2015). Horizontal versus vertical integration of e-commerce is also impacting retail consumption trends. Simply stated, horizontal e-commerce businesses sell products from a variety of categories (e.g., Amazon and Walmart), whereas vertical e-commerce businesses (e.g., Wayfair) are market specialists. Thus, the degree to which e-commerce may reduce travel demand (and demand for public transit) will likely be influenced by how the retail sector continues to evolve. Most recent trends, such as Walmart's acquisition of Jet.com and Amazon's acquisition of Whole Foods, suggest that retail may be moving toward the hybridization of e-commerce and brick-and-mortar. The growth of e-shopping may also lead to the growth of goods delivery vis-à-vis courier services, robots, drones, and other emerging delivery technologies. This may allow public transit riders to substitute shopping trips for deliveries. More research is needed to fully understand the role of e-commerce and goods delivery on public transit ridership and the broader transportation network.

5. Growth of On-Demand Flexible Route Transportation Options

While many transportation options have existed in parallel to established public transit networks, including jitneys, dollar vans, paratransit, and shuttles, historically these services have been inefficient and costly to operate due to their heavy dependence on manual operations. Recent technology innovations are enabling an array of on-demand ride services (defined below) where drivers and passengers can link up using smartphone applications. In many cases, passengers can compensate drivers and service providers for fuel, parking, and other trip expenditures through these applications.

- *Ridesourcing services* (also known as transportation network companies or TNCs) provide prearranged and on-demand transportation services for compensation, which connect drivers of personal vehicles with passengers. Smartphone applications are used for booking, ratings (for both drivers and passengers), and electronic payment.
- *E-hail* allows a user to reserve a taxi through a smartphone, track the location and status of the cab until it arrives for pickup, and make an online payment (similar to services offered by Uber and Lyft).
- *Microtransit* refers to privately owned and operated shared transportation systems, usually made up of vans and buses, that can have fixed or flexible routes and fixed timetables or on-demand scheduling.
- *Digital ridematching* facilitates formal or informal shared rides between drivers and passengers with similar origin-destination pairings using a smartphone or web-based application.

This growing suite of on-demand mobility options are raising awareness to innovative alternatives that facilitate both first mile/last mile connections and compete with public transportation. Some of these services operate much like classic forms of fixed-route public transportation but with enhanced information technology that allows for on-demand or dispatch operations and/or crowdsourced routes that are created based on demand. Other service models include a variety of on-demand flexible routing, typically within a predefined geofenced zone. For example, microtransit service provider Via allows users to request rides in real time and pick up other travelers going in a similar direction at a dynamically generated location within minutes of dispatch.

Ridesourcing services have also begun similar operations using a concept known as *ridesplitting*, which involves splitting a ridesourcing/TNC-provided ride with someone else taking a similar route. Lyft and Uber match riders with similar origins and destinations together, and they split the ride and the cost. Recent examples of ridesplitting are Lyft Line and UberPOOL. These shared services allow for dynamic changing of routes as passengers request pickups in real time. Broadly, these services leverage advanced algorithms and smartphone technology to vastly improve the operational efficiency of flexible route and on-demand services.

In the future, these flexible route and on-demand options will offer a number of opportunities and challenges for public transit. Public transportation is increasingly confronted with a competitive environment where mobility consumers seek the best possible “mobility experience." In other words, travelers no longer "need" to take public transit or higher occupancy modes. Public agencies have to focus on users and customer experience, so travelers want to take public transportation. Competition from other modes means that public transit agencies cannot afford bad experiences. The Federal Transit Administration (FTA) has developed the Mobility on Demand Sandbox, an ongoing research initiative to study ways innovative technologies can be leveraged to support personalized mobility, multimodal, integrated, automated, accessible, and connected public transportation systems. The MOD Sandbox allows for use of on-demand information, real-time data, and predictive analysis to provide travelers with transportation choices that best serve their needs and circumstances (FTA, n.d.). The goal of the Sandbox program is to leverage technologies that allow for a traveler-centric approach that provides better mobility options for everyone. This research initiative enables FTA to measure project impacts and assess how existing FTA policies and regulations may support or impede these innovative transportation service models (FTA, n.d.). Results of this research initiative are expected to be completed in 2019.

Conclusion

In the future, automation could be the most transformative trend to impact regions and public transportation since the automobile. Automation will likely result in fundamental changes to public transportation by altering the built environment, costs, commute patterns, and modal choice. Reduced vehicle ownership due to shared automated vehicles (SAVs) could result in changes in parking needs, particularly in urban centers. The repurposing of urban parking has the potential to create new opportunities for infill development and increased densities. While SAVs may compete with public transit ridership, infill development could also create higher densities to support additional public transit ridership and allow for the conversion of bus transit to rail transit in urban cores. However, the growth of telecommuting and AVs also make longer commutes more practical, which could shift consumer preferences in favor of suburban and exurban living. If workers do not have to commute every day, and if those commutes are less expensive and more productive, today's time cost of commuting (and congestion) may be notably reduced. As such, concerns that the introduction of AVs could reduce demand for public transit and may encourage increased vehicle use are real. But just as AVs have the potential to reduce driving costs, automated transit vehicles have the opportunity to reduce operating costs and the potential to pass these savings on to riders in the form of lower fares. Reduced operational costs and lower fares could make public transit more competitive than other modes and result in increased ridership.

Looking to the future, technology will be both a key enabler and a "multi-modal multiplier" for public transit operators. Technology can dramatically multiply the effectiveness of public transportation, allowing existing services to become automated and to right-size transit vehicles based on demand and predictive analytics. Public transit has the opportunity to leverage innovative technologies, real-time data analytics, and algorithms in a variety of ways to improve the traveler experience, enhance operations (such as managing crowdsourced and flexible routing), provide predictive analytics to more accurately forecast and respond to demand, and improve operational responses when natural or manmade hazards impact usual transportation operations. Digitization of public transportation with real-time analytics, mobile applications, sensors, and satellite navigation will enhance the customer experience and allow travelers to be more informed, agile, and mobile in their modal decisions. As public transportation undergoes a dramatic transformation, it is helpful for public agencies to consider several guiding principles:

- *Public agencies should embrace public and private collaboration*. Public-private partnerships can lead to a stronger, more robust transportation network that bridges first mile/last mile connections, fills service gaps, and enhances overall understanding of traveler needs and potential service gaps. In particular, a growing number of public transit agencies are exploring opportunities to offer flexible demand-responsive services, especially in areas where ridership is sparse. However, the process of building dispatching software and user interfaces to implement such services requires significant time and specialized resources (Lazarus et al. 2017), while many private sector transportation technology companies have created reliable on-demand dispatching software and service models that can be applied to public transit operations. Public-private partnerships are one tool public transit agencies can employ to improve access to transit and reduce agency costs in areas where ridership is too low to support fixed route or timetable public transit services (Lazarus et al. 2017).
- *Vehicle automation will likely change the nature of conventional public-private relationships in transportation, which have been around for decades.* As vehicle automation changes the costs of both public and private services, the nature of public-private partnerships will change based on geographies, densities, and existing infrastructure (Lazarus et al. 2017). Some public transit agencies may opt to provide more flexible demand-responsive service in smaller vehicles themselves, while others may opt to pursue such systems through partnerships. The emergence of such shared automated vehicle services could ultimately reflect a quasi-public transportation system. The ultimate nature of these hybrid systems and mix of public-private interactions will likely vary from city to city depending on the context (Lazarus et al. 2017).
- *Public agencies should collect data and establish data repositories to evaluate impacts and system performance*. Public agencies should consider developing data partnerships with the private sector and may consider requiring data reporting for this purpose.
- *Transportation should be accessible and equitable*. People are entitled to reasonable access to transportation services. Public agencies should always consider environmental justice and ensure they meet the basic transportation needs of all travelers.

By leveraging best practices and technology from the private sector, public transit has the opportunity to present itself as a competitive alternative to private vehicle ownership today and private automated vehicle ownership tomorrow. By using technology to employ flexible route services and on-demand or dispatch operations, public transit has the opportunity to increase market share and reduce inefficiencies. Big data and predictive analytics present new prospects for public transit to pre-position assets to better meet rider demand, reduce wait times, and improve fare box recovery. In the future, public transit must reinvent itself as a convenient, customer-focused, on-demand alternative to private vehicle use. "Innovative transit" strategies need to become an integral part of urban planning, public policy, and ultimately a public transit renaissance.

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