A New Way to Go

The Transportation Apps and Vehicle-Sharing Tools that Are Giving More Americans the Freedom to Drive Less

U.S. PIRG Education Fund

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Executive Summary

America is in the midst of a technological revolution … and a big shift in our transportation habits.

Over the last 15 years, the Internet and mobile communications technologies have transformed the way Americans live and work. During that same period, growth in vehicle travel slowed and then stopped, with Americans today driving about as much on average as we did in 1996.

Both changes have taken place most rapidly among young Americans, who have been the earliest and most enthusiastic adopters of new technologies, as well as the new social networking tools that are the foundation of the emerging "sharing economy." They have also been the group that has reduced its driving the most, with the average American between 16 and 34 years of age driving a startling 23 percent less in 2009 than in 2001.

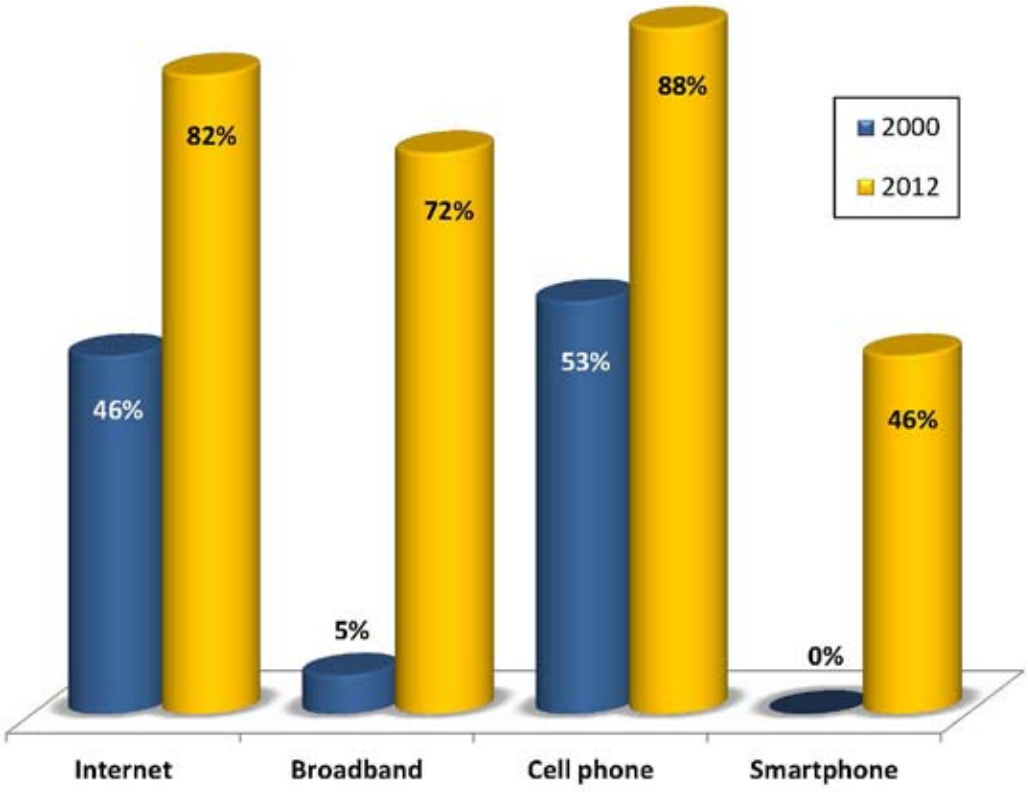
Could these developments—the rapid spread of mobile, Internet-connected technologies, the emergence of social networking, and the recent decline in driving—be related? And what does the future hold?

Early evidence suggests that **new innovations in technology and social networking are beginning to change America's transportation landscape**. New transportation services are providing people with an abundance of new options, helping to overcome barriers to the use of non-driving forms of transportation, and shifting the economics behind individuals' travel choices. Collectively, they are also opening up the opportunity for more Americans to adopt "car-free" and "car-light" lifestyles with dramatically less driving.

America is in the midst of a technological revolution.

- Between 2000 and 2012, the percentage of adults who use the Internet increased from 46 percent to 82 percent. The percentage of adults who own a cell phone increased from 53 percent to 88 percent. The share of Americans with access to high-speed Internet at home increased from 5 percent to more than 70 percent. And roughly half of Americans now own smartphones, which did not exist in their modern form in 2000.

Figure ES-1. Market Penetration of Major Technologies in 2000 versus 2012[1]



- These technologies are changing how Americans live and work. Participation in telework and e-commerce has increased dramatically in the last decade. Meanwhile, social networking has helped unleash an emerging "sharing economy."

- Young Americans have consistently been the first to adopt and test the capabilities of these new technologies and practices. As of September 2012, young adults were six times more likely to have a smartphone than people in their grandparents' generation, and twice as likely as those between 50 and 64 years of age.

Advances in the Internet and mobile communications technologies have unleashed a wave of new technology-enabled transportation services.

- ***Carsharing*** – Classic roundtrip carsharing services, such as Zipcar and City Carshare—as well as newer one-way services such as car2go—enable subscribers to access cars located in their neighborhoods and on their college campuses, providing participants with the mobility benefits of access to a car without having to bear the burden of owning one. As of 2012, more than 800,000 Americans were members of carsharing services (sharing a combined fleet of more than 12,000 vehicles). Newer peer-to-peer carsharing networks enable individuals to rent out their own unused vehicles to people looking for a car.

- ***Bikesharing*** – Six years after the launch of the first modern bikesharing system in the U.S., more than 30 cities now have programs where subscribers can access bikes by the minute or by subscription at kiosks located on city streets. In just its first season, New York City's Citibike program enlisted more than 70,000 annual members, with riders traveling more than 4.5 million miles.

- ***Real-time transportation information*** – The majority of U.S. transit systems now make scheduling information publicly available, enabling developers to produce a variety of new smartphone apps to help riders navigate urban transportation systems. Smartphone-based tools enable riders to find the best route for their trip, track the progress of trains and buses in real time, and even, in some cases, pay their fare.

- ***Ridesharing*** – A variety of new services across the country pair ordinary people with open seats in their cars with individuals who need a ride. Using the Internet and smartphones to facilitate rides enables those seeking shared rides to tap a broader pool of potential matches.

- ***Taxi hailing and transportation network services*** – New services enable people to hail taxis or livery vehicles, or to arrange rides with ordinary drivers (e.g., Lyft and Sidecar) via smartphone, making it easier and often less expensive to hire a ride.

- ***Multi-modal tools*** – New apps and tools also enable individuals to plan trips using several modes of transportation, facilitating efficient, seamless, door-to-door journeys.

Technology-enabled transportation services have the potential to change Americans' transportation behaviors.

- Technology-enabled services can *eliminate traditional barriers* that prevent Americans from taking public transit or sharing rides and vehicles.

- The array of new services can make it easier for households to *reduce the number of vehicles they own*—a step that generally leads to steep reductions in driving.

- Technology-enabled services can *expand the availability of transportation choices* in places and markets where they are not currently available.

- Access to mobile technology also enables riders to *use their time riding on trains or waiting for buses more productively*. This provides shared transportation with a market advantage over driving, since the use of mobile technology is increasingly understood as being incompatible with the safe operation of a car.

While many of these new tools are in their infancy, several have already been shown to reduce vehicle ownership and driving.

- Each carsharing vehicle replaces nine to 13 privately-owned vehicles, and the average carsharing participant reduces his or her driving by 27 to 56 percent. About 25 percent of carsharing participants sell a vehicle after joining while another 25 percent forgo vehicle purchases they otherwise would have made.[1]

- A study of the Chicago transit system, which gradually introduced a real-time bus location information

system from 2006 to 2009, found that introducing real-time information increased weekday bus ridership.

- Approximately 40 percent of bikeshare members report reducing their driving, according to a 2011-2012 survey of members of four North American bikeshare services. A 2013 survey of members of Washington, D.C.'s Capital Bikeshare program found that one quarter reported having reduced the number of miles they drove since joining the service. Five percent of members reported having sold a personal vehicle since joining the service, with 81 percent of those members reporting that joining Capital Bikeshare was a factor in the decision. The total reduction in vehicle travel by Capital Bikeshare members was estimated at 4.4 million miles.

The cumulative impact of new transportation services on vehicle ownership likely exceeds that of the individual services.

- By providing more choices and flexibility for individuals to meet their transportation needs, these new tools can make it convenient to adopt "carfree" and "car-light" lifestyles.

- Households that reduce the number of vehicles they own often dramatically reduce the number of miles they drive. Because many of the costs of owning a car are perceived to be fixed, vehicle owners perceive the cost of driving an additional mile to be artificially low. New services such as carsharing shift the cost of driving from fixed to per-mile costs, providing an incentive for users to drive less and allowing many households to reduce their overall spending on transportation.

- Information technologies make it easier to ensure seamless connections between various modes of transportation, expanding the number and types of trips that can be completed effectively without a car.

Cities, states and the federal government should take a series of immediate steps to unlock the potential of technology-enabled transportation services to provide Americans with more and better transportation choices, while integrating new technologies into transportation planning and policy. Specifically, governments should:

- **Use information technology** to facilitate the development of technology-enabled services by providing open access to transit scheduling and operations data, providing real-time transit information at stations, bus stops and elsewhere, ensuring wi-fi and/or cellular network access on all transit vehicles, and creating multimodal connections with emerging transportation services.

- **Modernize regulations** to accommodate carsharing, bikesharing, ridesharing, and other transportation services in ways that unlock the tremendous potential of these services while ensuring strong protection for consumers and residents.

- **Embrace a multi-modal future.** Transportation planners should seek to integrate new technology-enabled services and existing transportation services into systems that provide efficient, seamless, door-to-door connections**.** Officials should incorporate new transportation tools into all aspects of transportation planning and decision-making, while breaking down outdated mode-specific

"silos" in transportation agencies and financing. Governments should make strategic investments in tools to integrate and maximize the benefits of new transportation innovations, while also investing in the basic infrastructure—such as transit lines and improved facilities for bicycles and pedestrians—that provides individuals with high-quality transportation choices.

- **Extend the use of technology-enabled tools to new communities.** Local and state governments should expand access to technology-enabled services to areas beyond the major cities in which they have taken root, surmount economic and other barriers to the use of those alternatives, and explore the potential uses of Internet and mobile communications technologies in expanding access to high-quality public transportation in areas that currently do not have the population density to sustain such service.

- **Learn and adapt** by tapping the rich information offered by new technologies to improve the quality of transportation services. Local, state and federal officials should also invest in research to explore the impact of recent technological changes on future expectations of demand for driving.

Public officials should also ensure that plans for future transit and road capacity investments adequately reflect the emergence and potential of new technology-enabled tools to reduce driving. Governments should cancel plans for highway expansion projects that no longer make sense amid recent trends toward reduced driving and the emergence of new technologies.

Introduction

Most Americans want to drive less.[2] For some, it's a matter of economics. Transportation is the second-largest household expenditure, after only housing, and ahead of food, clothing, education and health care.[3] Owning, maintaining and fueling a car is a significant drain on household budgets, especially when times are tight.

For others, the desire to drive less stems from fatigue with the daily grind of commuting. Commuting by car is a stressful experience, one that can have a negative impact on overall well-being.[4] Traffic congestion and unpleasant commutes are among the major reasons that an increasing number of Americans find driving to be a chore.[5] At the same time, Americans are increasingly coming to recognize that time behind the wheel cannot also be spent staying connected with others via cell phones or the Internet—at least not safely.

For still others, driving less is a way to improve their health, or the health of the planet. Bicycling and walking are increasingly seen as important ways to stay active and healthy. Meanwhile, more than 40 percent of American drivers age 18 to 34—and more than 35 percent of all other age groups—report that their concern for the environment leads them to drive less.[6]

Cutting back on driving isn't easy, though, especially given the transportation and land-use decisions local, state and federal governments have made since World War II. For decades, American communities have been built on the self-fulfilling assumption that people will drive wherever they need to go, leaving many of us dependent on cars for even the most basic daily tasks. Carpooling, public transportation, bicycling and walking are important and viable options for millions of Americans, but nine out of 10 American households feel the need to own at least one car.[7]

The rapid advance of the Internet, mobile communications technologies and social networking—and the technology-enabled transportation services they are spawning—has the potential to expand the share of American households with the freedom to live without a car, or to live with fewer cars than they own today. These new tools give Americans a broader array of convenient, flexible transportation choices—enabling them to drive when

and where they need to, share rides where they can, and take full advantage of the particular benefits of public transportation, bicycling and walking.

Many of these new services are still in their infancy, while others are well on their way to becoming important fixtures of the nation's transportation system. Local, state and federal officials should take immediate steps to facilitate the growth of these services, while integrating emerging transportation technologies and tools into our planning and decision-making for the future.

America's Technology and Social Networking Revolution

America is in the midst of a technological revolution. Over the last two decades, American life has been transformed by the rapid spread of the Internet, broadband, and mobile communications technologies. More recently, technological advances have unleashed the potential of social networking—a new form of online social organization that expands the ability of people to share ideas and goods with people with similar interests and needs.

Young people have consistently been the first and most enthusiastic adopters of both new technologies and new forms of social media.

Transportation is among the many aspects of American life being reshaped in real time thanks to technology. To appreciate those changes—particularly among young people—it is first necessary to grasp the broad sweep and rapid speed of America's technological and social networking revolution.

From Dial-Up to iPhone: America in the 2000s

By the turn of the 21st century, America had already been through a period of rapid technological and social change that brought the popularization of the personal computer, mass access to the Internet and mobile communications, and a host of other changes.

Since then, however, the pace of technological change has, if anything, accelerated. In the late 2000s, the smartphone emerged as a powerful new technology that put location-aware, Internet-connected, mobile communications technology in the hands of millions of Americans. Consumers have been adopting smartphones at a pace 10 times faster than they started using the personal computer in the 1980s, twice as fast as they signed up for dial-up Internet in the 1990s, and three times faster than they signed up for social networking services in the last decade.[8]

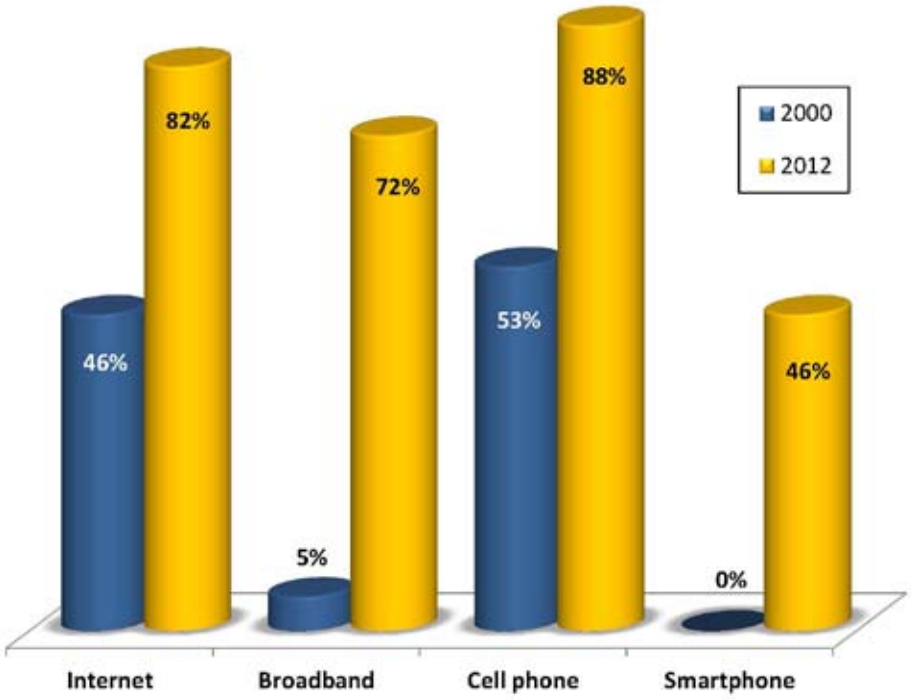
The past decade has seen the rapid penetration of new technologies into the marketplace.

- **Internet use:** In 2000, less than 50 percent of adults in the United States regularly used the Internet.[9] By 2012, 82 percent of American adults did.[10]
- **Cell phone ownership:** In 2000, just over half of adults owned a cell phone.[11] By June 2013, 91 percent of adults did.[12]
- **Broadband access:** In 2000, only 5 percent of Americans had access to a high-speed Internet connection in their home. By 2012, more than two-thirds of Americans did.[13]
- **Smartphones:** In 2000, the modern smartphone did not exist. By June 2013, more than half of American adults owned a smartphone.[14]
- **Location-aware devices:** In 2000, devices that used global positioning system (GPS) satellites were just beginning to emerge into the marketplace. GPS capability is now a standard feature of smartphones used by tens of millions of Americans, as well as a key technology in all facets of transportation.[15]

Young Americans Have Been the First to Embrace New Technologies

Adoption of new mobile communications devices is increasing across all income levels, races, ages, and education levels.[17] But young Americans have consistently been the first to adopt new technologies and to integrate them into their lifestyles.

Figure 1. Market Penetration of Major Technologies in 2000 versus 2012[16]



- **Internet use:** Young Americans were the first to embrace the Internet. In 2000, young people were five times more likely to use the Internet than people in their grandparents' generation.[18] Internet use is now nearly universal among young people, with nearly 95 percent of young adults between the ages of 18 and 29 using the Internet on a daily basis.[19]

- **Smartphone adoption:** As of September 2012, just over five years after the introduction of the Apple iPhone, two-thirds of young adults (18-29 years old) owned some variety of smartphone.[20] Young adults were six times more likely to have a smartphone than people in their grandparents' generation, and twice as likely as those between 50 and 64 years of age.

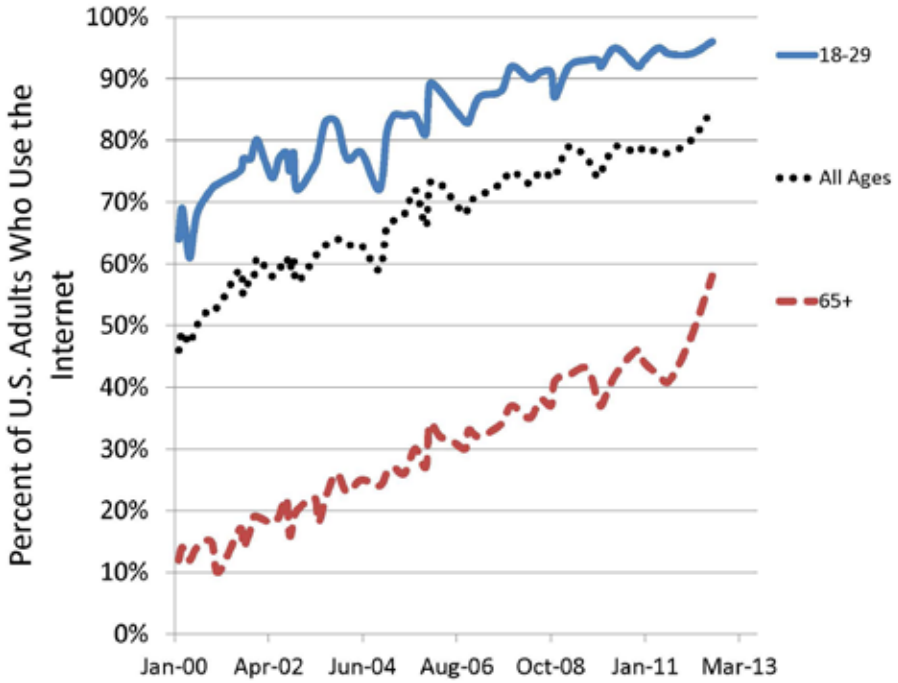
- **Texting:** In a 2011 Pew Research Center survey, 18-24 year olds reported sending or receiving an average of 110 text messages per day. These youth text message at double the frequency of 25-34 year olds, and more than 20 times the rate of adults older than 64.[21]

Social Media and the Sharing Economy

Social networking barely existed a decade ago. Today, Americans collectively spend approximately 24 billion hours per year on social networking.[23] More than 40 percent of Americans are daily Facebook users.[24]

Social media has facilitated the emergence of a growing "sharing economy," which has been defined as "an economic model based on sharing, swapping, bartering, trading or renting access to products as opposed to ownership."[25]

Figure 2: Young Adults Almost Universally Use the Internet, at Rates Well Ahead of Their Elders[22]



Wikipedia, for example, has become a dominant reference source by crowdsourcing information. Entertainment ecosystems have blossomed around widespread swapping of pictures, videos or songs. Meanwhile, growing from roots in Web-based services such as Craigslist and eBay in the 1990s, the arrival of smartphones and social networking has kicked the sharing economy into overdrive, allowing ordinary people to sell or share unused items or excess capacity.[26] People can find eager takers for a summer cottage, spare bedrooms, power tools, designer gowns, farm produce, a babysitter, or seats in a car—yielding additional cash and sometimes the benefits of human interaction.

New technology tools have made it easy to disseminate information about available opportunities, to sort among competing offers and to better trust that anonymous strangers will behave civilly to protect their online reputations. For example, where a person might once have tried to organize a carpool with a few friends from work or posting flyers in coffee shops, today Americans in some cities can arrange ridesharing with hundreds of "friends" or even trusted strangers at the click of a button.

Young people were the first to embrace social networking and have been among the earliest participants in various aspects of the sharing economy.

By 2006, nearly half of young adults (18-29 years old) who used the Internet were participating in a social networking service—three times the rate of Internet users as a whole. By 2010, more than 90 percent of college students used social networking on a daily basis.[27]

Young people have also been the first adopters of new social media platforms. For example, as of the end of 2012:

- 27 percent of Internet users aged 18 to 29 used Twitter, compared with 16 percent of all Internet users;
- 28 percent used Instagram, compared with 13 percent of all Internet users;
- 13 percent used Tumblr, compared with 6 percent of all Internet users.[28]

Members of the Millennial generation (those born between 1983 and 2000) are also among those most attracted to the sharing economy, second only to members of Generation X (those born between 1965 and 1982).[29] According to one recent summary of trends in the sharing economy, "Millennials [are] more likely to feel positive about the idea of sharing, more open to trying it, and more optimistic about its promise for the future."[30]

Technology Is Changing Our Transportation Needs

A variety of interactions that were once primarily conducted in person are now increasingly taking place online, as powerful new technologies change the way Americans work, shop, relax and connect with one another.

- **Telework:** In the last decade, the number of Americans working from home at least one day per week increased by more than 40 percent, as measured by the U.S. Census Bureau.[31] By 2010, 9.5 percent of all workers worked from home at least part of the time.[32]
- **E-commerce:** Shopping online is becoming an increasingly important part of the American economy. Retail sales happening online have increased five-fold in the last decade.[33] About 5 percent of all retail sales now happen online.[34] Purchases via mobile devices, in particular, are growing

at a rate of more than 80 percent per year.[35]

America's technological revolution has reshaped the nation's life. Industries that had seemed invulnerable little more than a decade ago—from the recorded music industry to newspapers to the postal service—have had their business models upended. The ways in which Americans work, shop and socialize have changed dramatically. Those changes have been especially rapid among the youngest Americans.

Transportation has not been immune to the massive changes unleashed by the growth of the Internet and mobile communications technology. The next section discusses the potential of these new technologies to disrupt existing arrangements in ways that reduce dependence on the automobile.

Technology-Enabled Transportation Services: What They Are and Why They Matter

America's technological and social networking revolution is changing every aspect of American life—and transportation is no exception. One of the most important changes has been the emergence of a variety of new technology-enabled transportation services, which take advantage of mobile communications technology and social networking tools to provide new transportation choices to Americans.

By empowering Americans with additional transportation choices and enhanced ways to navigate these choices, new, technology-enabled transportation services could reduce the need for many Americans to own a personal vehicle, thereby resulting in a significant reduction in vehicle travel.

The Impact of Technology on Transportation Choices

Technological changes can affect transportation choices in a variety of ways. Over the past several decades, transportation experts have studied how advances such as the Internet—and technology-enabled choices such as telecommuting—have changed transportation behaviors.

The primary focus of those studies has generally been on whether Internet-connected technologies result in more or less travel. In some cases, technology substitutes for travel—as when a telecommuter reduces the number of days on which he or she drives to work, or a person swaps a trip to the store for a purchase via an online retailer.

The ability to stay connected en route is a key advantage of public transportation, with an increasing number of transit agencies providing wi-fi and other forms of mobile connectivity to riders. Credit: Matt Johnson.

A 2004 review of 20 studies from around the world on the impact of telecommuting found that on days employees worked from home, they took 27 to 51 percent fewer trips, and logged 53 percent to 77 percent fewer miles traveled.[36] Other research suggests that telecommuting very likely reduces overall vehicle travel.[37]

A study of the inclusion of wi-fi on Amtrak trains in California's Capital Corridor estimated that the addition of the service increased the number of trips by 2.7 percent, with the greatest impact being on new riders.

In other cases, however, technology generates new travel—for example, by making it easier for individuals to find cheap air flights online, to discover new destinations that require travel, to avoid traffic jams by taking more circuitous routes, or to engage in consumer-to-consumer transactions that require additional travel. In general, technology has been seen by researchers to substitute for travel in the short run and stimulate travel in the long run.[38]

The availability of Internet connections on a mobile, on-demand basis has the potential to influence transportation choices in important new ways.

Smartphones, for example, provide travelers with access to voice and text communications, information and entertainment *en route*, enabling time spent waiting for buses or riding on trains to be used more pleasantly or productively than before. The ability to stay connected while in travel is an important selling point of public transportation ridership relative to automobile driving, especially considering the increasing alarm of transportation safety officials about the perils of distracted driving. (See "Staying Connected," page 16.)

Preliminary results from recent research suggest that users who perceive public transit as providing an opportunity to multitask may be more likely to choose transit over driving.[39] A study of the inclusion of wi-fi on Amtrak trains in California's Capital Corridor estimated that the addition of the service increased the number of trips by 2.7 percent, with the greatest impact being on new riders.[40]

Both of these possible impacts of technology on transportation—the ability of telecommunications to substitute for work, shopping or recreational visits that might otherwise occur by car, and the ability of mobile Internet technologies to enable productive use of time on public transportation—are of critical importance and have the potential to affect how and when people choose to travel.

In this report, however, we focus on the implications of what we call **technology-enabled transportation services**—services that assist travelers or enable new economic models for transportation, and that are made possible by the Internet and/or mobile communications. More specifically, we focus on those services related to modes of transportation other than driving in a personal vehicle.

How Technology Can Enable "Car-Free" and "Car-Light" Lifestyles

New, technology-enabled transportation services have the potential to reshape America's transportation system. Individually, these services have the potential to reduce or eliminate key barriers to the use of non-driving modes of transportation. Collectively, they may make it easier for households to construct viable "car-free" or "car-light" lifestyles that are less dependent on privately owned vehicles. And they may

expand access to non-driving alternatives to groups of people who do not currently have access to them by making those alternatives less expensive, more efficient or both.

Reducing Barriers to Non-Driving Modes

There are numerous barriers that have traditionally prevented people from using non-driving modes of transportation. Public transportation use, for example, is often limited by:

- Perceptions of security;
- Lack of timely and accurate information about the service;
- The availability and convenience of the service—including concerns about reliability and wait times.[41]

Mobile, Internet-connected technology has the potential to address each of these barriers. Security concerns may be alleviated by the ability of riders to photograph and report incidents by cell phone. Real-time trip planning and vehicle tracking applications can overcome information barriers and address concerns about reliability and wait times. (See page 24 for more information on these new tools.)

In the past, for example, transit users needed to consult confusing paper maps and timetables to plot their trips. In a 2005 study, 180 people—made up of a mix of transit users and non-users—were tasked with using paper system maps and timetables to plot a transit trip. Only 52.5 percent of those taking part were able to plan their trip successfully.[42] Today, in many cities, an individual could undertake the same task—with far greater accuracy—by simply plugging an address into a mobile app or an Internet site such as Google Maps. The benefits of these services are even more profound when they enable users to construct trips that use several transit lines or multiple modes of transportation—trips that would have been exceedingly difficult to plan without automated tools.

Survey research by Latitude, a consulting firm, suggests that providing information about transportation options via the Internet and mobile technologies can give people the same sense of mobility and freedom that comes with owning a car.[43] The researchers concluded that "new forms of information access enable choice; they can aid with smart planning and in-the-moment decision-making, reduce users' frustrations, and soften preconceived notions about the downsides of more sustainable transit options when compared with driving."[44]

In short, technology-enabled transportation choices can help people target and overcome barriers that might previously have deterred them from taking public transportation, sharing a ride with a friend (or a trusted stranger), or biking or walking to their destination.

Reducing the Need for Vehicle Ownership

Most Americans face a stark choice when it comes to transportation: either buy or enter into a long-term lease of a car, and obtain reliable, 24-hour access to automobile mobility, or forgo buying a car and risk not having access to one at all. Even many people who might generally be willing and able to travel by means other than driving face certain situations—such as the need to travel in the rain, or carry packages, or take the occasional long-distance trip—in which access to a car is desirable.

It is no surprise that, under those circumstances, the vast majority of Americans have felt the need to own a personal vehicle—despite the tremendous burden vehicle ownership places on household budgets. According to a 2010 poll conducted for Transportation for America, nearly three-quarters of Americans surveyed said they had "no choice but to drive as much as I do."[45]

Staying Connected: Mobile Technology Makes Time Spent on Transit More Valuable

Americans increasingly feel the need to stay connected with email, social networks and the Internet wherever they go. The increasing importance of mobile connectivity to Americans has the potential to shift traditional conceptions of how individuals value their time—making time spent connected to mobile technologies while waiting for a bus or riding a train more valuable than it might previously have been.

The use of mobile technology on public transportation has become extremely common. An annual observational survey of Chicago-area commuter rail riders found that the percentage using portable electronic devices *en route* increased from 26 percent in 2010 to 48 percent in 2013.[50] More than half of the riders on Amtrak's Acela high-speed rail service in the Northeast use laptops, tablet computers, or other electronic devices at any given time during travel.[51] Surveys conducted by researchers in Great Britain have found that 80 percent of business travelers riding on trains worked during their journey, with those who worked spending 57 percent of their time working.[52]

Drivers also attempt to remain connected while at the wheel. Surveys show that about two-thirds of drivers have used a cell phone while driving. On the order of one in 10 drivers is using a cell phone at any given time.[53] More than 10 percent of drivers responding to one survey reported texting while driving.[54]

It is becoming increasingly clear, however, that driving and mobile connectivity simply don't mix. Studies of this behavior show that cell phone use increases crash risk. Texting while driving recently supplanted drunk driving as the number one cause of teenage driving deaths.[55] Hands-free devices do not appear to offer any conclusive safety advantage.[56] A large scale study conducted by the American Automobile Association, following similar findings by the Texas Transportation Institute, found that even with "hands-free" technology, communications technologies such as texting, cell phone calling or dictation are highly dangerous.[57]

Some states have outlawed talking or texting on hand-held devices while driving.[58] Additionally, the National Transportation Safety Board has recommended banning cell phone use while driving—including with hands-free devices.[59]

While it is possible that the advent of autonomous vehicles (see page 33) may make it easier for drivers to remain connected while driving, the full penetration of those vehicles is at least a decade away and likely longer. For the time being, the ability to stay connected while in transit is a market advantage for non-driving modes in relation to those where drivers must spend time focusing on the road ahead.

New technology-enabled services reduce barriers to non-driving modes of transportation and provide a greater range of transportation choices—potentially giving many Americans the freedom to construct viable lifestyles that do not include car ownership. By creating more alternatives to car ownership, these new services can change how people consider driving among other transportation options.

The High Fixed Costs of Vehicle Ownership Encourage Driving

The economics of vehicle ownership tend to artificially encourage Americans to drive more than they would otherwise. The vast majority of the costs of driving are incurred in large lump sums that are not directly tied to the number of miles driven. They are what economists call "fixed costs." Vehicle owners must purchase, finance or lease the vehicle, pay for insurance, and secure a place to store the vehicle. These costs tend not to change much regardless of how far the car is driven.[46]

When most automotive costs are fixed and the remaining marginal costs for each mile of additional driving are small, people are artificially encouraged to drive more. An individual may choose to drive to a destination rather than take transit because he or she perceives the marginal cost of the additional vehicle trip to be near zero (perhaps limited only to the cost of fuel), while the transit trip will require payment of a round-trip fare. Even when the alternative trip is also cost-free (as in biking or walking), the presence of an auto in the driveway represents a constant invitation to maximize its use.

Research validates that people who own cars are likely to use them more frequently and other modes of travel far less frequently.[47] In sum, once a person becomes a car owner, economic incentives encourage him or her to use their vehicle as much as possible.

Shared Transportation Changes Economic Incentives

Technology-enabled services such as carsharing upend these economic incentives in ways that can reduce automobile travel. Instead of purchasing a car for personal use, participants in carsharing services buy access to a car through their annual membership. Typically, this results in carsharing participants receiving the benefits of car access, but at a significant overall cost savings.

Carsharing and ridesharing services shift many of the costs of vehicle travel from fixed, upfront costs associated with ownership to variable costs that are determined by the number of miles driven. The fewer trips an individual makes via car, the less he or she has to pay. This creates an incentive for users to consider alternative means of making trips—such as public transportation, biking and walking—or to avoid some discretionary trips by vehicle that were once perceived to be nearly "free" but now bear a per-trip cost.[48]

Participants in carsharing services tend to reduce the number of vehicles they own. (See page 18.) Even though consumers perceive the per-trip cost of carsharing trips to be higher, eliminating the cost of vehicle ownership often leads to dramatic overall transportation cost savings.[49]

Carsharing and ridesharing programs can easily provide Americans with access to cars when they need them, providing attractive alternatives to car ownership and shifting economic incentives in ways that reduce driving. At the same time, tools such as real-time transit information and bikesharing can also contribute to changing decisions about vehicle ownership by expanding the number of viable alternatives to driving. The cumulative impact of the emergence of a variety of technology-enabled transportation services on vehicle ownership and driving is therefore likely to be far greater than the impact of any individual new technology-enabled tool.

A Field Guide to the Transportation Technology Revolution and its Impacts on Driving

Technology-enabled services are helping Americans get where they are going more quickly, easily, safely and affordably. Automobile drivers were among the first to benefit from the technological revolution, enjoying the ease and security of in-car GPS navigation and real-time traffic information delivered via roadside signs, GPS devices and smartphones. More recently, however, there has been an explosion of new technology-enabled transportation services and information tools that make it easier for Americans to travel by means other than a personal vehicle.

This section provides a brief "field guide" to these technology-enabled options and enhancements as of mid-2013. It covers: carsharing (both fleet-based and peer-to-peer), ridesharing, taxi and transportation network services, bikesharing, multi-modal apps, and tools to enhance public transit, such as navigation apps, real-time vehicle location information, and mobile ticketing.

Carsharing

Until recently, having reliable access to a car required owning or leasing one. Either option required a significant commitment of money (in the form of up-front costs for obtaining and insuring the vehicle) as well as a place to park it. Carsharing gives individuals access to the mobility benefits of a car without requiring them to own one.

History and Background

Carsharing made its inroads in the United States in 1998, about a decade after it took root in Europe, as emerging technologies such as the Internet and wireless data transmission enabled consumers to reserve cars for daily or hourly rentals online and gain remote access to their vehicles with a radio frequency identification (RFID)-enabled card. In recent years, new models of carsharing have emerged in which consumers can rent vehicles for one-way trips across town or even rent out their own vehicles for use by other individuals.

Carsharing has emerged from a small, niche option into a big business. By 2012, the largest carsharing firm, Zipcar, had

767,000 members in 20 major cities and at 300 university campuses.[60] According to Susan Shaheen and Adam Cohen of the Transportation Sustainability Research Center at the University of California, Berkeley, membership in carsharing services increased 44 percent from 2011 to 2012, rising to about 800,000 Americans, sharing a fleet of approximately 12,000 vehicles.[61] Consulting firm Frost & Sullivan expects the number of people joining carsharing services in North America to rise to 15 million by 2020.[62] A RAND Corporation report found that, with policies supporting carsharing, participation could reach 4.5 percent of U.S. drivers—with a maximum potential of more than 12 percent of all drivers.[63]

Variants

There are two types of carsharing in the United States: fleet-based services (both round-trip and one-way) and peer-to-peer networks.

Fleet-Based

The fleet model of car sharing is by far the most prominent in North America. There are two types of fleet-based carsharing services in the United States: round-trip and one-way. Round-trip services require users to return a vehicle to its original location when their trip is complete, while one-way services enable users to leave the car parked anywhere within a designated zone.

Classic round-trip carsharing is the model followed by long-standing services such as Zipcar and City CarShare. Round-trip carsharing services station vehicles in designated parking spots throughout a city, often within walking distance of dense residential or commercial areas. Members of a carsharing service use the Internet or a smartphone application to locate and reserve available cars nearby. Members can open the car doors using a card containing an RFID chip that the car can recognize, or by using a smartphone app. Cars are available for use 24 hours

Indianapolis will become the first American city with an electric vehicle sharing service—a business model pioneered by Paris' Autolib program (above). Photo: Mario Roberto Duran Ortiz, via Wikimedia, under Creative Commons license.

a day, with rentals by the day or by the hour.

One-way carsharing is newer to the United States and is exemplified by car2go, a service run by car giant Daimler, which offers two-seat "Smart" cars for rental by the minute, allowing users to pick up a car and leave it at any legal parking space near their destination, as long as it is within a region covered by the service. The service operates in seven U.S. cities, including Seattle, where 18,000 members signed up for the service in its first 90 days in 2013.[64] In France, a similar service called Autolib allows users to rent electric cars at one of a number of curbside charging stations (similar to bikeshare stations, see next page) and return them to any station with an available parking space.[65] In June 2013, the French company that created Autolib announced its first rollout of the service in the United States, with a 500-car program to be launched in Indianapolis in 2014.[66]

Round-trip and one-way carsharing services fill different transportation needs. Round-trip services, with their hourly or daily rental rates, appeal primarily to drivers making longer trips, including those that go beyond city boundaries. One-way services, with their by-the-minute rates, are designed to facilitate short-hop trips within cities, akin to those made in taxis or via bikesharing.

Major car rental companies see a future in the market for on-demand carsharing, possibly signaling a convergence between traditional car rental and on-demand car sharing services. For example:

- Avis, one of the largest rental car companies in the United States, bought Zipcar in 2013.[67]

- Hertz has plans to equip its entire North American fleet of 370,000 cars with hourly rental technology during 2013.[68]

- Enterprise bought startup carsharing services Mint and WeCar, along with Philadelphia's PhillyCarShare.[69] In May 2013, Enterprise also purchased Chicago's nonprofit iGo carsharing service.[70]

As these major players move into carsharing, more people are likely to be exposed to the technology, increasing public acceptance and use of carsharing services.

Peer-to-Peer Carsharing

Since 2010, a new model for carsharing has emerged in the United States. Peer-to-peer carsharing uses an Internet-based service to match ordinary individuals interested in renting their cars with willing renters. As of May 2012, there were 10 peer-to-peer carsharing services active in North America and three more planned.[71]

Major examples include RelayRides, GetAround, and JustShareIt. These services allow personal car owners to rent their cars to other drivers on an hourly, daily, or weekly basis at rates they set themselves. While the main role of the companies offering these services is to act as a "matchmaker," they all provide additional support services designed to ensure that the transaction between two strangers comes off without a hitch. Each of these services provides car owners with independent insurance and drivers with 24-hour roadside support.[72] They also enforce standards for the safety of vehicles and pre-screen would-be renters.

New variations on peer-to-peer car sharing continue to emerge. A company called FlightCar now rents the cars of those traveling out of town from major airports to incoming passengers. The company lures vehicle owners with the prospect of free airport parking and a free car wash—which are provided regardless of whether the car is rented—and attracts renters with low rental rates.[73]

According to an international survey, participants in peer-to-peer car sharing arrangements are typically young urbanites. The average user is 35 years old. Users own smartphones at double the rate of the average population, and they more frequently use social media tools like Twitter.[74]

Impact on Driving

Research into the impact of carsharing in North America has found that each carshare vehicle removes between nine and 13 privately owned vehicles from the road, as carsharing members sell off vehicles or forgo vehicle purchases.[75] A 2008 survey of North American carsharing members found that about 25 percent of members sold a vehicle, while another 25 percent did not purchase a vehicle they would otherwise have considered purchasing were it not for carsharing.[76] Carsharing membership was associated with a reduction in miles driven of 27 percent (observed impact) and 56 percent (full impact, including the effect of forgone vehicle purchases).[77] The total reduction in driving attributable to carsharing has been estimated at 1.1 billion miles as of early 2013.[78]

Carsharing participants also increase their use of non-driving transportation modes. One year after joining, Zipcar members in Baltimore reported taking fewer driving trips and driving fewer miles.[79] Fourteen percent reported biking more, 21 percent reported walking more, and 11 percent reported using public transportation more.[80]

Similarly, San Francisco's non-profit City CarShare reports that its members increase their use of transit, walking and biking by up to 49 percent after joining.[81] Researchers at the University of California at Berkeley studied the service in 2003, finding that 18 months after joining:[82]

- 30 percent of households sold one or more cars;
- 67 percent avoided purchasing a new car;
- Overall automobile travel among members dropped 47 percent, while use of transportation alternatives, including walking, biking and transit, increased.

Researchers at the University of California at Berkeley anticipate that future growth in carsharing services in the United States is likely to consist of households that already own a vehicle—which could increase the rate at which carsharing services reduce overall automobile ownership and car travel.[83]

A 2008 survey of North American carsharing members found that about 25 percent of members sold a vehicle, while another 25 percent did not purchase a vehicle they would otherwise have considered purchasing were it not for carsharing.[76]

Bikesharing

People traveling in and around cities often find themselves needing to make trips that are too long to be made comfortably on foot and are not well served by existing transit. Taking a taxi may be an option, but it is often expensive.

Bicycling offers a quick, flexible—and often fun—transportation solution for these intermediate-length trips. To make these trips by bike, however, one must have a bike available. Bikeshar-

ing programs overcome this barrier by making bicycles available for one-way or round-trip rental at stations throughout an urban area.

History and Background

The first bikesharing programs emerged in Europe in the 1960s. The idea was simple: bikes would be left throughout a city and anyone could pick them up and ride them to their destination, where they would be left for the next user. These early bikesharing programs—along with somewhat more sophisticated coin-operated systems in the 1990s—fell victim to theft and vandalism, as there was no way to track the locations of the bicycles or to enforce accountability on those who used them.[84]

In 2005, the first modern bikesharing program was launched in France. Modern bikesharing programs use communications technology to rent bikes to members, who pay membership and usage fees. Bikes also are often fitted with "location aware" technology. These additions help to prevent bike theft as well as facilitate system management.

The first bikesharing program taking advantage of modern communications technology launched in the United States in 2007.[85] By 2013, more than 30 such services existed across the country.[86] Bikesharing services are now operating in numerous cities, including Boston, Chicago, Denver, Des Moines, Honolulu, Miami Beach, New York, San Antonio, Washington, D.C., and the San Francisco Bay area.

Capital Bikeshare in Washington, D.C., is one of the largest bikesharing programs, serving nearly 35,000 annual

Washington, D.C.'s Capital Bikeshare program was one of the first—and most successful—modern bikesharing programs in the United States. Capital Bikeshare members have reported reducing their driving by roughly 4.4 million miles since the program began. Credit: Mario Roberto Duran Ortiz, via Wikimedia, under Creative Commons license.

Table 1. Participation in Selected U.S. Bikeshare Systems[89]

City	Program	Year Began	Annual Members	Cumulative Miles Traveled
Washington, D.C.	Capital Bikeshare	2010	34,985 (as of May 2013)	4.1 million (as of March 2013)
New York City	Citibike	2013	71,760 (as of 8/16/13)	4.5 million (as of 8/16/13)
Boston	Hubway	2011	8,100 (as of July 2013)	1.2 million (as of July 2013)
Chicago	Divvy	2013	4,000 (as of August 2013)	325,000 (as of August 2013)

members. (See Table 1, page 23.) During its first year, ending in September 2011, the program facilitated 1 million rides—doubling initial projections.[87] The program has since expanded into nearby Washington suburbs.

In May 2013, New York launched its Citibike bikesharing program. In the program's first four weeks, more than 100,000 people signed up for annual or casual membership in the program, biking more than 1 million miles.[88] A month later, Chicago launched its new "Divvy" bikeshare service. Both services—like most urban bikeshare systems in the United States—are supported in part by revenues from advertising on bicycles and docking stations.

Impact on Driving

Bikesharing can reduce driving by providing an alternative to the use of a car for specific trips and by providing an additional transportation option that reduces the need for vehicle ownership.

Modern bikesharing programs are in their infancy in the United States—the oldest is just six years old—meaning that there has been little time for study of their impacts on driving. Several bikesharing services, however, have conducted surveys of their members that shed some light on the degree to which those services are altering transportation decisions.

A 2011-2012 survey of members of four North American bikeshare services found that 40 percent reported driving less as a result of bikesharing. About 5 percent of bikeshare members reported having sold or donated a personal vehicle since joining bikesharing, with about 55 percent of those respondents stating that bikeshare played a very important or somewhat important role in their decision.[90]

A 2013 survey of members of one of the oldest modern bikesharing programs—Washington, D.C.'s Capital Bikeshare—found that one quarter reported having reduced the number of miles they drove since joining the service. Five percent of members reported having sold a personal vehicle since joining the service, with 81 percent of those members reporting that joining Capital Bikeshare was a factor in the decision. The total reduction in vehicle travel by Capital Bikeshare members was estimated at 4.4 million miles.[91]

Officials in Boston estimate that 13 percent of all trips taken in the first two years of the city's Hubway bikeshare system replaced trips that would otherwise have been taken by car, translating into a total of more than 87,000 averted car trips.[92] A similar survey of members of Madison, Wisconsin's B-cycle system found that 28 percent of bike trips replaced trips that would have been taken by car.[93]

The provision of open data on transit operations has resulted in a variety of new tools to supply transit information to riders. Here, a screen with real-time bus arrival information is shown in the window of a Seattle department store. Credit: Seattle Department of Transportation

Transit Apps

Navigating public transportation once required consulting maps and timetables, and carrying exact change, tokens or passes. To daily transit users, these tasks quickly became second nature. But for novice users—or even some experienced transit riders making trips on unfamiliar routes or in new cities—they often presented a barrier to transit use.

In recent years, the arrival of real-time navigation, route planning and payment apps has equipped even novice transit users with the tools they need to navigate a city's public transportation network. It has made it easier for people to expand the number of routes and neighborhoods where they feel comfortable taking transit, or for rail riders to explore and learn unfamiliar bus systems. With smartphones and GPS technology, riders can even track the progress of a train or bus toward their location or destination in real time.

History and Background

In the 1990s, the spread of vehicle location technology and the emergence of the Internet opened up new possibilities for travelers to access information about transit service. Transit agencies began to make system maps and schedules available online and to use the Internet and text messaging to share information about system problems and delays. In addition, some transit agencies began to provide real-time arrival information through the use of electronic signs at transit stops.[94]

The true potential of technology to help riders navigate public transportation began to be tapped in 2005, when Google launched the first online transit mapping and scheduling application. Google Transit Trip Planner originally provided transit trip planning functionality for the Portland, Oregon metropolitan area.[95]

"This was something that no one had heard of before," said Bibiana McHugh, director of Information Technology at Portland's TriMet transit agency. "People loved it. We watched the usage go up and up and up."[96] In June 2006, Google integrated the service into Google Maps.[97] By the end of 2006, five additional transit agencies provided usable data online, expanding Google's transit planning service to Honolulu, Pittsburgh, Seattle, Tampa and Eugene, Oregon.[98] By June 2008, transit agencies in more than 50 cities around the world had signed on.[99] By early 2013, Google published schedules for transit services in about 500 cities around the world.[100]

The availability of open-source transit data—including, increasingly, real-time vehicle location data—led to an explosion of new mobile transit apps. Transit agencies were surprised as software developers who were riders began requesting data and creating web-based tools.[101] As more transit riders began to take advantage of real-time information, transit agencies began experimenting with new ways to use mobile

technology to help transit riders, including through mobile ticketing, the first U.S. applications of which began in 2012.

Variants

Trip Planning and Navigation Apps

Transit agencies supply two kinds of information to users: static and real-time. Static information essentially provides data from bus schedules and maps to users in a more convenient and user-friendly format. But while static information shows when the bus is supposed to arrive based on a schedule, real-time information shows where the bus actually *is*, using GPS systems to communicate to users the current status of the transit system.

The advent of the smartphone meant that riders didn't just have access to trip-planning and scheduling information at their home computers, but also in waiting areas and on transit vehicles themselves. In 2008, Google incorporated transit planning functionality into its Google Maps application for mobile devices.[102] This made it possible for users to plan trips and refer to information while on the go. It also meant that if they missed a connection or got off at the wrong stop, they could easily reroute. Because smartphones are location-aware, people could also get transit directions to a destination from their current location without having to know where they were.[103]

The provision of static transit information via electronic means is increasingly becoming the nationwide norm—85 percent of transit agencies supply schedule and/or routing information electronically. More than two-thirds of all agencies provide their data for Google Transit directions and 60 percent have trip planners on their websites. Roughly two-thirds of all agencies also make information available to third-party developers for the creation of apps and other tools for transit users.[104]

Increasingly, transit agencies are also supplying real-time information on the location of transit vehicles. More than 60 percent of the transit agencies with the technology to track their vehicles now supply real-time arrival information to the public.[105]

The availability of real-time schedule and navigation information and smartphones fueled an explosion of new apps created by third-party developers. In Portland, Oregon, developers have built more than 50 applications using TriMet data.[106] "Some of the apps are so clever," McHugh says. For example, a college student made an app called iNap to allow him to sleep on the bus. The application tracks where the bus is and alerts the user when his or her stop is approaching.[107]

In addition to Google Maps, more than 200 transit planning applications now exist, ranging from applications focused on a single transit agency to applications that cover hundreds of cities across the world.[108]

Real-Time Arrival and Departure Information

In the 1990s, U.S. transit agencies began experimenting with ways to keep track of service performance on bus and train lines in real time. By installing GPS devices and connecting buses to a communication network, agencies could begin to provide riders with instant information about how long it would be before their bus or train arrived to pick them up. Initially, this information was made available through electronic signs at bus stops and stations, then via the Internet, and finally via smartphone.

NextBus was one of the first services to capture this information and make it available to transit riders. The service—available for more than 100 transit agencies as of early 2013—helps keep riders informed about when their bus or train will arrive through a website, smartphone applications, text messages or phone call alerts.[109]

Portland, Oregon, San Diego and San

Francisco were the first cities to publish real-time system performance data online in a standardized format, open and available for anyone to use. In 2011, Google and other third-party developers began incorporating this data into transit route planning services to provide users with the most up-to-date information possible about travel times and schedules.[110]

"Real-time information revolutionized the experience of riding the bus in Boston," says Joshua Robin, Director of Innovation at the Massachusetts Bay Transportation Authority (MBTA). "It really changes how

Tapping the Potential for Transit Service in Rural Areas

While new technology-enabled transportation services and tools are starting to make an impact in major cities, the biggest payoff may turn out to be in less densely populated areas. Technology-enabled services have the potential to improve the transit-riding experience for rural and suburban users and to improve efficiency in ways that expand the number of areas where transit service can be provided cost-effectively.

The Berkshire Regional Transit Authority in mostly rural western Massachusetts serves an area the size of Rhode Island with buses that typically run at hourly intervals. Much of the agency's resources are dedicated to paratransit minibuses that respond to requests to pick up the disabled, elderly or injured for appointments and do not follow a fixed route.

Gary Shepard, the authority's administrator, sees the potential for new technologies to help him customize and target the routing and timing of transit vehicles. Shepard sees potential in "deviated route" service, in which drivers of regular fixed-route buses would have the flexibility to respond to paratransit requests en route. Doing so would save the agency lots of money, he said, since paratransit trips are expensive—and saving money would allow him to run more routes or to improve the frequency of service throughout the county.

Information technology and improved communications could also make it possible to schedule and coordinate transit schedules to pick up paratransit passengers more easily, and to reduce the steep costs of paratransit no-shows by having telephone systems call back a rider to verify a pickup request that had been made on a previous day.

In addition, the benefits of real-time arrival information are likely to be greater for riders of rural transit systems, which experience less-frequent service, than for users of urban systems. A mobile app that might enable a transit rider along a frequent route in Boston to save 10 minutes by arriving just in time for his or her bus might save a similar rider an hour in Berkshire County.

Technology-enabled transportation options may make other non-driving modes of transportation possible in areas that are not dense enough to support traditional transit service. Transit agencies that support ridesharing, for example, often do so to provide some measure of service to outlying areas that may not be dense enough to support fixed-route transit service.[115]

people relate to the bus," he said.[111]

One transit planning application called NextTime stands out as particularly innovative. NextTime uses real-time bus location coupled with the location-aware capability of the smartphone, notifying a user when to leave his or her current location, wherever they are, in order to meet a selected bus at the nearest stop on time.[112] With this service, transit users can greatly minimize the hassles of transit use—waiting for a long time at a stop, or failing to catch the bus at all. Effective use of the application can greatly increase the perceived reliability of transit as a means to get around effectively. The app currently works with transit systems in Boston, San Francisco and Washington, D.C.

In addition to using data provided by transit agencies, smartphones can also "crowd source" data from riders themselves. Some applications pull information from Twitter postings made by users on messaging channels established for a service line. Other applications use data generated by other smartphone users. For example, an application called Tiramisu draws information from the universe of all Tiramisu users about where their bus is, how fast it is moving, and how many open seats it has.[113] A similar service called Moovit launched in late 2012, recruiting more than 400,000 users in its first two months.[114] These types of services depend on having a dense network of users in order to provide quality information.

Ticketing

"For 100 years, transit agencies have had to basically issue their own currency—tokens, passes, fare cards, and the like," according to Joshua Robin, Director of Innovation at Greater Boston's MBTA transit agency. Maintaining this parallel system was both expensive for transit agencies and cumbersome for riders, who needed to understand and master the process of paying for their trip.

Relying on cash payments is little better, slowing the progress of buses as riders fumble for payment, burdening drivers with the need to issue transfers, and forcing riders to bring exact change or risk overpaying for their trip.

Electronic ticketing via smartphones has the potential to reduce the hassle, delay and cost of paying transit fares by seamlessly linking fare payments to a credit card account or other digital payment method. These services use smartphones as both the vending machine for fares and as the ticket itself. These services reduce lines at traditional ticketing locations, simplify the process of boarding, and reduce the need for riders to carry cash or have correct change.

The simplest services work like airline e-tickets. For example, Amtrak launched a national e-ticket program in 2012—delivering tickets purchased online by e-mail. However, the newest services are taking the form of user-friendly smartphone apps.

Ultimately, according to the MBTA's Robin, mobile ticketing will enable users to use transit services in a more seamless way, increasing convenience. "Being able to simply walk through a fare gate or board a bus with [the smartphone] you already have in your pocket will really change the experience," Robin says.[116]

Robin led the deployment of the nation's first mobile ticketing program for transit, which launched on MBTA commuter rail service in November 2012. In its first three months, the app generated $1 million, accounting for 10 percent of all commuter rail ticket sales.[117] Sales have been steadily increasing over time.

"It took off wildly," Robin says. "It is the most successful thing we've done in years with commuter rail."[118]

The MBTA chose the mobile ticketing option for three reasons. First, technology had advanced to the point where mobile ticketing was possible. From user surveys, the agency knew that its riders were rapidly

adopting the smartphone. As of late 2012, more than three-quarters of MBTA riders owned a smartphone—up from two-thirds in just one year.[119]

Second, mobile ticketing saved the agency money. Hundreds of MBTA commuter rail stations are open to the outdoors, and installing vending machines for the existing "CharlieCard" smartcard payment system at all stations would have cost more than $50 million. The mobile ticketing program, by contrast, had no up-front cost. Instead, the third-party vendor that designed the program is paid 2.8 percent of each ticket purchase. The MBTA does not anticipate passing that cost onto transit riders.[120]

Finally, the mobile ticketing program was very quick to deploy, taking about six months from design to launch. "If you think about transit projects you've heard of, usually it takes about six months just to formally say you're going to actually do a project you've all agreed to do," Robin said in an interview with *The Atlantic Cities*.

Boston's MBTA enables commuter rail riders to purchase tickets online, reducing fare collection costs and making payment far more convenient for riders.

Transit agencies in New York City, Portland, Oregon, and New Jersey are developing similar applications in response to demand from transit riders.[121]

Impact on Driving

Transit apps affect vehicle travel by reducing information barriers, reliability concerns and other hurdles to the use of public transportation. Survey research and observations by transit agency officials suggest that real-time transit information is a valuable amenity to transit riders and one that can increase transit ridership.

- A study of ridership on the Chicago transit system, which gradually introduced a real-time bus location information system from 2006 to 2009, found that introducing real-time information increased weekday bus ridership on the order of 2 percent.[122] While that impact appears small, it is likely greater today, as convenient smartphone-based tools were only beginning to become available by the end of the study period.

- A survey of users of the University of Maryland's campus shuttle service found that real-time data increased ridership on the service by 23 percent.[123]

- A study of Seattle-area bus users who used real-time performance information through a service called OneBusAway found that 90 percent reported that the service reduced the amount of time they spent waiting for the bus, with an actual reduction in wait time averaging 2 minutes. Real-time information was also responsible for a reduction in *perceived* wait times of about 13 percent.[124] More than 30 percent of respondents reported that the service induced them to ride the bus more often.[125]

- A survey of bus riders on a New York City bus line found that, just six months after providing real-time information, more than half of all riders had used the information, with more than half of those riders consulting the real-time information on every trip. Riders who used the real-time information reported that they perceived spending less time waiting for the bus than non-users, even though the amount of time they actually spent waiting was the same.[126]

- Boston's transit agency, the MBTA, has cited the availability of real-time transit information for buses as one of the reasons why the agency set 15 monthly ridership records in a row from 2011 into 2012. In a June 2012 press release, General Manager Jonathan Davis said "We're absolutely convinced that the widespread availability of real time bus data is making public transit a more convenient option for commuters. More than 100,000 smartphone users have downloaded apps that provide arrival time information for more than 180 MBTA bus routes."[127]

In addition, researchers from Massachusetts Institute of Technology surveyed riders the day before and the day after the MBTA installed digital train arrival countdown signs in several subway stations in the summer of 2012. Because of the signs, customer satisfaction with the overall train service went up by 15 percent, and riders' perceived wait times went down by several minutes.[128]

Ridesharing

Catching a ride with a friend or a coworker has long been a way for Americans without cars—or those simply looking to save on gas or share company on the ride to work—to get where they are going. With the emergence of mobile technology, ridesharing can be arranged easily and with less advance planning. Moreover, with hundreds or thousands of users, the chance of finding a driver or passenger who is "going your way" is dramatically increased.

History and Background

Once upon a time, a person looking to share a ride might have had to call through a list of friends by telephone, consult a bulletin board at work, or take the risk of hitchhiking. Despite those challenges, carpooling was once an extremely common way for Americans to get to work. As recently as 1980 (in the midst of the second oil crisis), roughly 20 percent of working Americans shared rides to work. By 2010, however, that share had been cut in half, to 10 percent, as a variety of factors, including the increased prevalence of more complex commutes that often involve side trips, worked to discourage carpooling.[129]

New technological tools create the potential for Americans to share rides in ways that weren't previously possible. In the 1990s, Internet-based rideshare matching services began to help commuters organize carpools between their homes and places of work such as office parks. Now, newer services are streamlining ridesharing and expanding the pool of potential riders.

Variants

Ridesharing services pair those needing a ride with those going in the same direction. As with peer-to-peer carsharing services, ridesharing services play the role of matchmaker, but also provide tools—such as reputation or report card systems that enforce accountability among drivers and riders (similar to the accountability mechanisms that have long been successfully used by eBay)—to facilitate safe and effective transactions.

Ride Matching

Some new technology-enabled services improve upon the online ride matching services launched in the 1990s by streamlining the creation of carpools and pairing drivers and riders for trips that are planned in advance. As of 2011, there were just over 400 ride matching services in the United States.[130]

Zimride is an example of such a service.[131] This service started by facilitating carpooling within individual university communities. The business then expanded to working with companies and other large institutions—eventually expanding to 130 college and corporate campuses—followed by a long-distance ridesharing option available to anyone.[132]

Zimride allows users to post a planned trip, selling seats in their vehicle. The service requires users to log in through Facebook, and it enables people to post profiles about themselves and to leave feedback about drivers and riders. The Zimride website and smartphone app help drivers and riders get in touch with one another and facilitate payment. From 2007 to mid-2012, Zimride recruited more than 360,000 members and enabled nearly 200 million miles of carpooling.[133]

On-Demand

On-demand ridesharing is the newest form of ridesharing, allowing drivers and riders to arrange shared rides in real time. Services such as Carma (formerly Avego) use location-aware mobile devices, enabling drivers to locate nearby passengers and pick them up.

On-demand ridesharing services act as third-party platforms to facilitate connections between drivers and riders, ensure the safety and security of the transaction through driver background checks, reputation systems and other means, and often to collect payment.

Impact on Driving

Ridesharing tends to reduce vehicle travel by using spare capacity in existing vehicles to serve travel demand. Not every trip shared is an auto trip completely avoided—some trips served by on-demand ridesharing services might require drivers to travel out of their way to pick up riders, thereby requiring them to log more miles at the wheel.[134] Other trips may take the place of a bus or walking. The key determinant of the impact of ridesharing on driving will likely be the level of participation in the services. Attracting more participants will both make on-demand ridesharing more efficient (by increasing the likelihood that drivers and riders will share origins and destinations) and maximize the potential impact on vehicle ownership.

Taxi Hailing and Transportation Network Services

Taxis have long been a transportation backstop for those without access to a vehicle. Taxi service in many cities, however, is quite expensive and taxis aren't necessarily available immediately when and where you need them. New technology-enabled services make hailing a car more convenient and have opened the door to alternatives to traditional taxi services.

Variants

Taxi Hailing and Livery Car Services

Several new services help riders hail traditional taxis using smartphones. These services include ZabKab, Flywheel, TaxiMagic and Hailo, each of which has a different reach, geographic area of operation, and target market.

The smartphone app Uber allows users to have a livery sedan and driver come pick

them up, either at a designated location and time, or wherever they happen to be at that moment. The app enables users to pay with a click of a button, without the hassle of needing cash—or even a credit card—on hand. The smartphone app can even inform the rider where his or her pickup car is in real time. The service also recruits traditional taxi cabs to participate in some cities. It operates in Boston, Chicago, San Francisco, Sacramento, Washington, D.C. and Toronto.[135]

Transportation Network Services

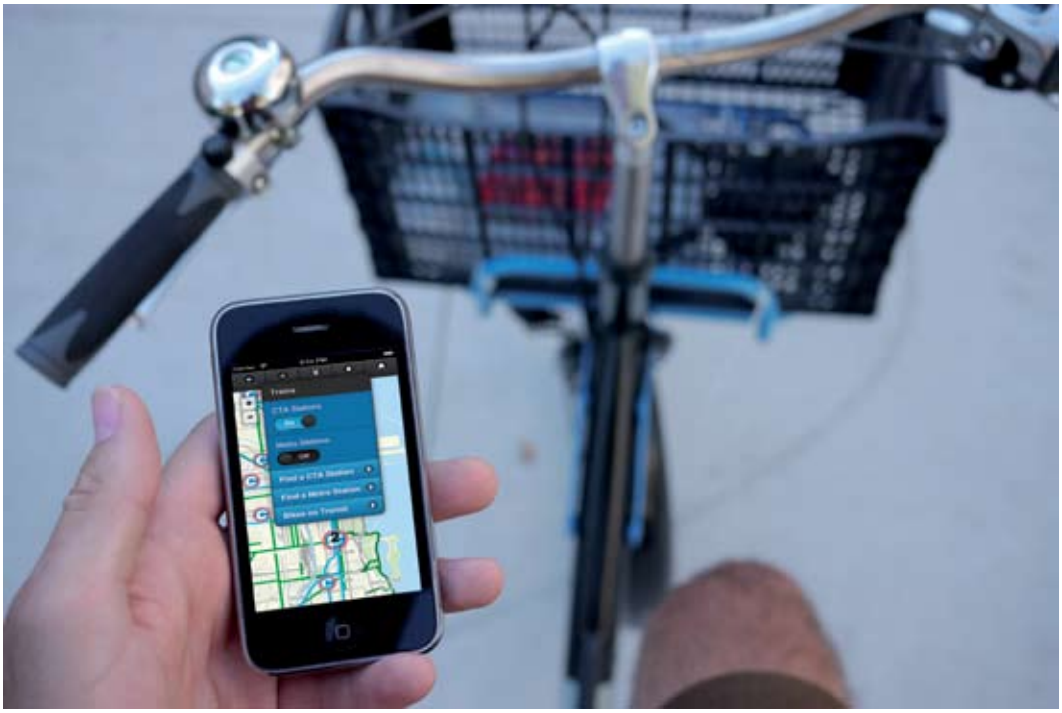
New services such as San Francisco-centered Lyft and Sidecar allow riders to arrange rides in real-time with ordinary drivers who provide a ride in exchange for payment. These services have spread to numerous U.S. cities in recent years, with Lyft reporting that it now facilitates more than 30,000 rides per week.[136]

Impact on Driving

Taxi and transportation network services can have mixed impacts on driving. To the extent that the services are used to substitute for trips that might occur by transit, on foot, or in a shared ride, they may increase driving. However, by providing reliable, affordable on-demand access to a vehicle, these services may give individuals greater comfort in moving toward a "car-free" or "car-light" lifestyle.

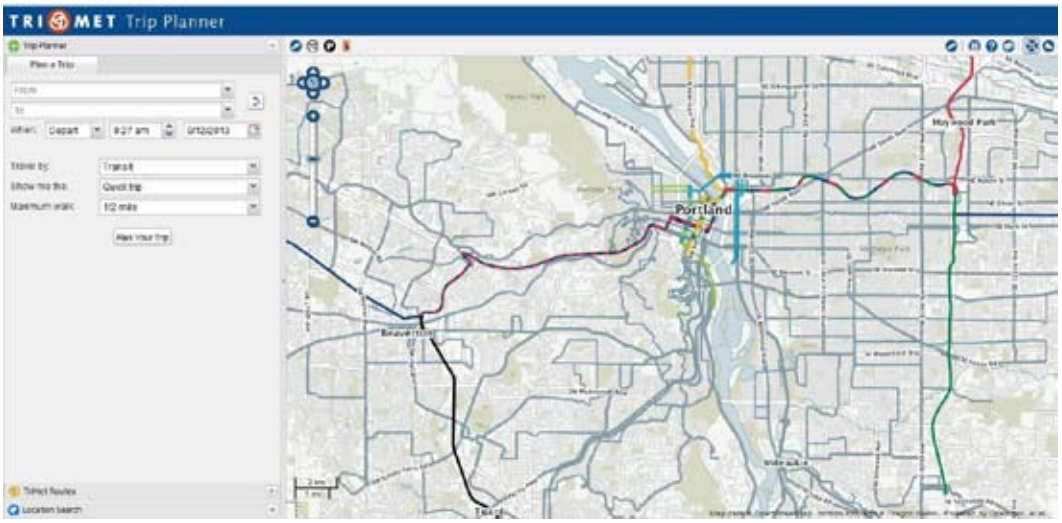
Multi-Modal Apps

In addition to technology-enabled carsharing, ridesharing and bikesharing services, and new technology options to help make public transportation easier to use, a number of new apps are being developed that knit the entire transportation experience



Mobile apps can help travelers make connections between different modes of transportation. This mobile app helps Chicago-area bicyclists navigate bike routes and trails and find local bikeshare stations, and displays the location of transit stations. Credit: Steven Vance, Chicago Bike Guide, www.bikechi.com.

Figure 3: Portland TriMet's Multi-Modal Trip Planning Tool Helps People Get from Point A to Point B, by Foot, Bike, Bus, Train, and/or Carsharing[140]



together—taking a multi-modal approach to helping people get places in the fastest, cheapest, most convenient way possible. This is particularly important because specific services may only be convenient for people under certain circumstances, when they are traveling to certain neighborhoods, or in certain weather. The broader the spectrum of overlapping choices available to travelers—and the easier it is to find the best potential option—the easier it is for people to consider a car-free or car-light lifestyle.

Portland's TriMet transit agency, for example, introduced a multi-modal trip planning tool on its website in 2011. The tool enables users to plan trips that could include a mix of walking, cycling, buses, trains, bikesharing and carsharing. It even allows cyclists to choose routes based on personal preferences such as speed, availability of bike trails or bike lanes, or minimizing hill climbing.[137]

Bibiana McHugh, Director of Information Technology at TriMet, says multi-modal planning is crucial for commuters, who sometimes need extra guidance about how to travel the last mile from their transit stop to their place of work.[138] She has also been working with Zipcar and car2go to put information into the planner about where carsharing vehicles can be picked up.

Because the trip planning tool is open-source, other developers have begun to build on TriMet's work to create multi-modal trip planning tools in cities around the country. As of February 2013, such tools are being deployed in Florida, Tennessee, Washington D.C. and New York City—as well as in 11 other countries around the world.[139]

Other app developers have taken on the challenge of helping consumers navigate the wide array of new transportation options available. RideScout is a mobile app that aggregates information about all of the various transportation options available in a given city. A RideScout user simply enters in his or her destination and is provided with a menu of real-time transportation options—including transit, taxi service, carsharing or ridesharing.[141]

What about Self-Driving Cars?

The advent of autonomous (self-driving) vehicles has been touted as a possible counterweight to the role that mobile technology currently plays in encouraging alternatives to driving. If drivers can use the time currently spent behind the wheel working or relaxing and be assured of getting to their destination safely and with the minimal investment of time—all potential outcomes of a "driverless car" future—wouldn't they drive more? And wouldn't we therefore need more and bigger highways to accommodate them?

It is far too early to tell what form a transportation network based on self-driving vehicles would take. Fully autonomous vehicles are not expected to hit the road in significant numbers until 2025, though their full impact may not be felt for another decade or two into the future, when autonomous vehicles become the norm on American roads rather than the exception.[142] A system based on autonomous vehicles could, paradoxically, open up new opportunities for greater sharing of vehicles and rides that might look a lot like public transit. Systemic changes could also make non-driving forms of transportation more attractive and allow for reduced auto infrastructure.

In a world with self-driving cars and spreading acceptance of ridesharing and carsharing, it is not hard to imagine a system in which a fleet of shared automated cars is available to be summoned on demand. Some trips could be served by individual vehicles (as is currently done with carsharing), others in small shared vehicles (as with ridesharing) and still others by high-capacity vehicles (as with transit). Such a system could reduce the need for private cars (which typically sit idle approximately 90 percent of the time) and reduce the need for parking infrastructure—enabling much of the space currently used for warehousing vehicles to be used for other purposes, such as housing, parkland, bicycle lanes, wider sidewalks and new commercial buildings. Such a system might allow for the more intensive use of urban space and safer non-motorized travel—expanding the ability of individuals to travel safely on foot or on bike.

Regardless of whether automated vehicles are primarily personal or shared, those vehicles may eventually be able to travel much more closely together at speeds that are optimal to reduce congestion—enabling current road capacity to serve more passengers and diminishing the need for new road capacity.

The transition to autonomous vehicles will not happen overnight, and the potential implications are far from certain. It is, however, certainly premature to assume that autonomous cars would lead to an increased need for new highways or that the prospect of autonomous cars in the future can justify current investment in more auto-focused infrastructure today. In fact, the reverse may be true.

Policy Recommendations

The past decade has seen tremendous changes in technology and transportation. New, technology-enabled transportation options—from real-time information about transit service to new models of carsharing, ridesharing and bikesharing—have begun to spread rapidly across the country.

These new technologies and tools provide more Americans with the freedom to reduce their driving and embrace car-free or car-light lifestyles. But the full potential of these tools will only be realized if policymakers take appropriate steps to integrate them into the transportation system. Far from just standing back and waiting for hackers and venture capitalists to transform how people get around, governments at every level should seize the opportunity to maximize the benefits of new transportation services and address the challenges they present.

Opportunities for Immediate Action

There are many cities and metropolitan areas across the United States that are beginning to reap the benefits of technology-enabled transportation services. A few simple, relatively inexpensive steps can help get these new services off the ground. Specifically, local and state governments should:

- Provide open access to scheduling and operations data for public transportation, facilitating the development of real-time transit apps that can improve the transit experience.

- Ensure the availability of wi-fi and/or cellular networks on all transit infrastructure (as well as electrical outlets and recharging facilities on vehicles and in transit stations, where possible), enabling riders to stay connected while in travel and access information about their trips.

- Create multi-modal connections with emerging transportation services by

providing space for bikesharing stations and parking for carsharing and ridesharing vehicles at transit hubs, and by engaging in cross-promotion partnerships in which, for example, bikesharing is promoted by transit agencies and vice versa, with discounts or other benefits used to encourage participation.

- Consider public bikeshare and transit app development to be eligible for government funding designed to reduce traffic congestion and reduce air pollution, such as the federal Congestion Mitigation and Air Quality (CMAQ) program.

In the medium-term, local, state and federal agencies should do the following:

Modernize Regulations to Accommodate New Transportation Services

Technology-enabled transportation services are being created faster than local, state and federal regulations can adapt to them. In some cases, this has left innovative transportation services in an unregulated no-man's land—putting the public at risk and creating profound regulatory uncertainty that discourages new service providers from entering the marketplace or making larger investments. In other cases, new transportation services are burdened by regulations designed decades ago for far different purposes.

Several new transportation alternatives—such as livery vehicle hailing application Uber and transportation network service Lyft—have run into legal difficulty or been forced to cease operations in particular cities because they run afoul of local or state regulations. Some cities and states, meanwhile, subject carsharing services to the high levels of taxation imposed on rental cars—taxes that were originally designed as easy sources of revenue that primarily affected tourists, but are now increasingly levied on local residents who rent cars by the hour.[143] A 2011 DePaul University study, for example, found that the average level of taxation on an hourly car rental in a set of major markets approached 18 percent—more than double the general sales tax rate in those same cities.[144]

Everyone—public officials, consumers, providers of innovative transportation services, and providers of incumbent transportation services—stands to benefit from clearing up the regulatory uncertainty that has dogged many new transportation services. Local governments should follow the recommendation of the U.S. Conference of Mayors to create local task forces to "review and address" regulations related to the sharing economy.[145] This does not necessarily mean that regulation on technology-enabled transportation services should be reduced, but rather that regulations should be updated to maximize the benefits and minimize the dangers of these new services. Organizations of state officials, as well as federal agencies, think tanks and academic researchers should quickly engage the question of how best to regulate these services in ways that protect consumers and transportation system users yet encourage innovation. Ideally, model ordinances could be developed to assist local governments in regulating these services.

Federal and state officials should also ensure that employer commuter benefits provided in the form of ridesharing or bikesharing are equitably treated under tax law.[146] There is no reason to subsidize employee-owned automobile parking at a place of work, but not support other ways of getting there that reduce car commuting.

Expand Access to Real-Time Information and Tools

The availability of real-time public transportation information by smartphone has revolutionized the transit-riding experience. In addition to making open sharing of transit scheduling and operations data a nationwide standard (see "Opportunities for Immediate Action" above), transportation agencies should seek out new opportunities to share real-time information within and across modes and without artificial proprietary restrictions on data.

Some cities have begun to make real-time transit information available in ways that facilitate intermodal connections—for example, by showing the time until the arrival of the next bus or train to downtown at airport luggage carousels. Transportation agencies could provide real-time information about bus or train arrivals on highway signs prior to park-and-ride lots, or supply information on the availability of carsharing or bikesharing vehicles at transit stations, at designated intermodal hubs, or via the Internet.

The recent experience with real-time transit information also demonstrates the importance of maximizing the provision of open data and the use of open-source code. Transportation agencies should avoid contractual arrangements that limit the availability of critical operations data to the public or that limit the ability of developers and other transportation agencies to use or build off of newly developed tools.

Public officials should also explore opportunities to limit the ability of "non-practicing entities" (popularly known as "patent trolls") to stand in the way of technological innovations that benefit transit users. In recent years, transit agencies and independent developers that produce real-time vehicle information apps have faced threats of patent infringement litigation from a Luxembourg-based firm. Many settled out of court.[147] The firm has agreed to stop suing transit agencies (as a result of a lawsuit filed by the American Public Transportation Association) but similar issues may continue to dog providers of innovative transportation tools and services in the future.[148]

Finally, transportation agencies should take advantage of opportunities for electronic ticketing by smartphone, enabling riders to board transit vehicles more easily and with less hassle.

Use New Technologies and Services to Address Transportation Problems

Technology-enabled services can be powerful solutions to transportation challenges. They should become part of the standard tool kit of transportation agencies. To take advantage of that potential, government agencies should:

- *Integrate technology-enabled transportation tools into traffic management plans.* Colleges and universities across the United States have been among the leading adopters of services such as carsharing and ridesharing, recognizing their potential to reduce traffic on and around campus and reduce demand for expensive and space-consuming parking lots and structures. Often, these services are incorporated into long-range campus transportation plans and they are provided for free or at a discount to students and staff. Local and state governments should investigate the potential for similar tools to address transportation challenges such as traffic congestion and parking availability in ways that may be more efficient and less expensive than adding highway or parking capacity.

- *Adjust planning and zoning practices to accommodate new tools.* Publicly-owned space and facilities—including space in public garages, in parking lots and along curbsides—should be set aside for shared transportation modes such as carsharing and bikesharing. Local governments should adopt parking policies that support carsharing, such as reduced parking costs for car-share vehicles at curbsides and public garages, heightened enforcement to prevent illegal parking of non-car-share vehicles in carsharing spaces, and policies that enable one-way carsharing.[149] Cities and states should consider extending incentives—such as relaxation of minimum parking requirements—to developers who make available space for shared vehicles.

- *Factor new transportation tools into capacity planning.* Several of the tools described in this report have been shown to reduce vehicle ownership or use—potentially adding to the economic, demographic and cultural forces that have limited the growth of driving in the United States over the last decade and will likely continue to do so in the decades to come.[150] As additional information becomes available about the impact of technology-enabled transportation services on driving, transportation planners should ensure that plans for future transit and road capacity adequately reflect the emergence of these tools and their potential to reduce driving. If road expansion projects have been premised on projected increases in the volume of driving that will not materialize because more people are sharing vehicles, riding transit or biking, then cancelling those makes sense and will save money. By contrast, if reduced vehicle ownership or new technological tools create the opportunity for new or expanded transit service, governments should ensure that the resources exist to take advantage of those opportunities.

Embrace a Multimodal Future

The vast potential of information technology and new technology-enabled services to improve the efficiency of the transportation system will only be realized if those new transportation options are fully integrated into a seamless, interconnected network. "New mobility" strategies seek to integrate Internet and mobile communication technologies, various modes of transportation, and smart land-use planning into convenient, sustainable systems for providing people with door-to-door access to the services they need and opportunities they wish to pursue.

The emergence of new transportation choices will lead to a decline in the number of Americans who "only" use one form of transportation, meaning that more Americans will have a stake in ensuring that connections between different forms of transportation can be made seamlessly. Even those who continue to rely only on private vehicles will benefit from attractive, efficient multi-modal connections that encourage others to use non-driving modes of transit, reducing congestion for drivers.

To facilitate a multi-modal future:

- Transportation agencies should seek to integrate public transportation, carsharing, ridesharing and bikesharing services with other transportation options in seamless networks, using designated multimodal hubs and the sharing of information on multiple platforms

to enable users to make efficient connections among modes. Several of the new transportation services profiled in this report may appear at first blush, to compete with one another. However, like the Internet itself, the availability of a multitude of options will increase resiliency of the system and the ability of travelers to move within the system. Insofar as these services and enhancements encourage more Americans to adopt "car-free" or "car-light" lifestyles, the market share for all non-driving modes of travel will increase. Transit agencies should particularly focus on exploring the potential of technology-enabled services to address the "last mile" challenge of getting people from their homes to transit stations—one of the key impediments to transit use.

- Local, regional and state authorities should break down mode-specific "silos" in transportation planning and policy to allow for true multi-modal planning and collaboration.

- Legal provisions that require gas tax revenues to be used exclusively for highways should be eliminated. Revenues from transportation taxes should be spent on the most effective solutions to transportation problems regardless of the mode—or modes—of transportation used.

Carsharing in many cities began as a non-profit enterprise, led by organizations such as Philadelphia's PhillyCarShare. Policy-makers should look for opportunities to extend the benefits of technology-enabled transportation services to areas where they may benefit the public but may not deliver the near-term profits needed to attract private investment. Credit: Gloria Bell.

Extend the Use of Technology-Enabled Tools to New Communities

Many new, technology-enabled transportation options have been generated by private enterprise (often with a healthy assist from public agencies that provide open transportation data or an injection of funding or expertise at a critical moment in time). The growth of carsharing and ridesharing services, for example, has been fueled by investments of venture capital. Bikesharing services have often been paid for, in part, by advertisers or corporate sponsors.

The engagement of the private sector has been a boon to the development of these new services—hastening the speed at which they have made their way to the marketplace, minimizing the draw on public resources, and fostering innovation. However, the cost of relying so heavily on the private sector has been that new technology-enabled services have tended to be launched first in a small group of relatively wealthy cities with dense populations of young "early adopters" of technology.

These new tools, however, have potential benefits in every area of the country and for people of all ages and economic conditions. Transportation agencies should actively identify opportunities to put these new options to use to forward their own public interest missions.

For example:

- Transit agencies serving suburban areas should experiment with integrating smartphone hailing into flex-route bus service. Flex-route services allow drivers to deviate from fixed routes to pick up riders at locations within a certain distance of the route who call ahead with a request for pickup. Smartphone applications could enable agencies to provide this service more efficiently and effectively—expanding the reach of transit into less densely populated areas.

- Government agencies should consider whether to establish their own on-demand ridesharing services or provide support for the creation of other technology-enabled transportation alternatives. It is worth noting that several carsharing systems—such as Chicago's iGo car sharing program and Philadelphia's PhillyCarShare—were originally established by non-profits, and eventually sold off to private companies once the financial viability of the concept was proven. Government agencies and non-profit organizations should take an active role in the development and operation of these services in areas where they can deliver a net benefit to the public, even when the potential for near-term profit is insufficient to draw private-sector investors.

- Government agencies and providers of new transportation services should seek to break down barriers that limit participation. For example, some new transportation services—including many carsharing or bikesharing services—are built on the assumption that participants will possess a working credit card or bank account, a condition that excludes some would-be participants. Policy-makers should work with communities facing economic, physical or other barriers to participation in new transportation services to develop novel approaches to expanding access to those services to all who wish to participate.

Increase Our Knowledge

Mobile technology provides a rich source of information on how transportation

systems are used. And unlike surveys of households, drivers or transit riders, these data are available in real time, enabling transportation decision-makers to be far more nimble in adjusting to changing trends than in the past. Recent bikeshare systems such as New York's Citibike, for example, provide publicly available data, updated daily, on ridership, membership and aspects of system operation.

These data, however, are only useful if they are collected and the resources exist to study them. Specifically, government agencies should:

- *Provide resources to study the changing relationship between technology and transportation.* While the interactions between telecommunications and transportation have been studied intensively, little of that research has been conducted since the commercialization of the smartphone and advent of the new transportation services profiled in this report. As policy-makers consider how to invest billions of dollars in transportation spending each year, it is imperative that they have the latest information about the degree to which technology is affecting transportation choices.

- *Expand research into the impacts of new transportation services.* Despite the relative newness of many new transportation services, research is beginning to show that they can be powerful tools to improve the efficiency and sustainability of the transportation system while reducing the cost of transportation to households. Additional research is needed to document the impacts of these new services and to explore the interactions between these services and new or established modes of transportation. New transportation services that receive public support (such as carsharing services that benefit from access to public parking) should be required to share data about their services with public agencies and/or researchers.

- *Improve the quality and consistency of transportation data generally.* The most recent National Household Travel Survey – the sole, comprehensive, national source of information on travel patterns by households—was conducted in 2008, one year after the introduction of the iPhone. As a result, there is no national source of information capable of shedding light on how recent technological innovations are affecting travel behavior in the aggregate. With the accelerating pace of development of technology-enabled transportation services, the United States should move toward more frequent, ideally annual, travel surveys.[151]

- *Take advantage of the potential benefits of "crowdsourced" information from transportation system users.* Some app developers have already begun to tap the ability of transit riders to report delays, service problems, equipment malfunctions, safety issues and/or seat availability—aggregating and sharing that information with other users. Transportation agencies should examine the potential for crowdsourcing to provide operational information and data to agencies and their customers.

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