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Coordinated Operation of Shared Micro-mobility for a Sustainable City Transportation System

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Micro mobility policies and lack thereof

Existing Policies

At present day, there are little to no policies around the use and implementation of micro-mobility in many cities. At the national level, there are no specific guidelines that outline how micro-mobility parameters should be implemented in a city. The National Transportation Board has left it up to metropolitan districts to decide on how to gauge the decision to install micro-mobility systems in their cities. However, best practice guidelines have been identified by the National Association of City Transportation Officials (NACTO) and the U.S. Department of Transportation Federal Highway Administration (FHWA).

The U.S. Department of Transportation Federal Highway Administration (FHWA) provides a Shared Mobility Primer as a practical guide for local governments and public agencies as they seek to implement emerging services or manage existing shared services. The FHWA suggests to public agencies that the government should be consulted in the process of integrating shared mobility. The government should play a role in considering health, safety, consumer protection, taxation, insurance, parking and rights of way, signage and advertising, multimodal integration, planning processes, data sharing, data privacy and standards, and accessibility (*Shared Mobility Current Practices and Guiding Principles*, n.d.).

Before cities allow micro-mobility services into their community, they must establish a legal framework for their operations (*General Provisions – Shared Micromobility Playbook*, n.d.). The national standards state that policies should include provisions on the right to operate, the right to revoke permits, the right to deny, appeals process, transfer of permits, state and federal laws, indemnification, commercial liability, and insurance bonds. These general provisions have not been defined at the national level, but Transportation for America urges that government agencies must play a role in defining these regulations.

Within the realm of considering health, safety, and consumer protection, local governments are suggested to investigate helmet laws, insurance laws, pricing regulations, and access laws. Micro mobility sharing users are required to wear helmets while riding, however, this regulation has been loosely followed due to lack of availability of helmets.

Local governments should also make efforts towards regulating pricing related to shared mobility. This includes regulating the payment method, promotion of special discounts, and surge pricing. By regulating the pricing, can help increase the accessibility and equity of using these services depending

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on the members of the community. To further protect accessibility for users, agencies should also investigate methods to promote access for special needs populations and mandate ADA access to prohibit discrimination. It is also important to consider parking and access to the right of way, especially when considering between docked and dockless options.

During the planning process of micro-mobility program implementation, local governments should make clear on the common goals that can be achieved through introducing the program to their community. Some goals include reducing vehicle miles traveled (VMT), mitigating congestion, and achieving climate action targets. In addition, encouraging public involvement helps to reduce opposition and get the community engaged with the new program.

In recent times, data privacy has been a rising concern. Therefore, it is important to identify data standards and balance data sharing and privacy among individuals, companies, and agencies. Many agencies currently make data publicly available for download which typically contains the rider type, vehicle identification, weather information, and the availability of vehicles at stations. However, any real-time data and personal information on the rider remains anonymous. Nonetheless, safety concerns still exist and local governments should be attentive to matters regarding data to avoid cases such as the Citi Bike software glitch where sensitive personal and financial information was exposed.

Communities seeking to implement a shared mobility program should also be cautious of accessibility and equity issues. Many studies have shown that mobility sharing tends to be more common amongst the well-educated population. Contrastingly, low-income users struggle to access credit and debit cards that would allow them to pay and utilize the shared vehicles. Some programs. Such as the Capital Bikeshare program in Washington D.C. made an active effort to consider this population and partnered with financial institutions to help their users establish bank accounts. Local governments should consider similar alternatives when proposing an equitable micro-mobility system.

Some cities that have already implemented micro-mobility systems have struggled to establish appropriate regulations. In Auckland, safety and appropriate regulation were major concerns. Safety was compromised as helmet use was not obligated and regulation was not properly mandated as scooters were constantly left in areas outside of the designated zones. In Dubai, scooters were initially intended to be used for casual trips around parks and tourist areas. However, after the launch of the program, it was found that people were using the scooters for personal trips and in unexpected areas. Some cities such as London and San Francisco are taking “pro-active” approaches to develop frameworks around emerging micro-mobility, while others such as Singapore and Stockholm are taking a “reactive” approach where they establish regulations after experiencing the flaws of the system. Some cities have completely eliminated the idea of implementing micro-mobility, such as Toronto, out of overwhelming concerns regarding aspects of incorporating the system into their community.

As data and privacy have become a rising concern as more companies enter the public realm, NACTO released a document³ defining the best practices for the access and management of mobility data. In collaboration with the International Municipal Lawyers Association (IMLA), NACTO states that a

³ <https://nacto.org/2019/05/30/managing-mobility-data/>

common framework for sharing, protecting, and managing data should possess four principles: public good, protected, purposeful, and portable (*NACTO_IMLA_Managing-Mobility-Data*, n.d.).

Analysis Framework to compare benefits and problems associated with shared micro-mobility

We have identified the factors associated with the adoption of shared micro-mobility-

- a) User Preferences
 - White
 - male
 - Higher average income and education
 - Live/work in an inner city
- b) Demographics
- c) Usage rates
- d) Geospatial visualizations
- e) Safety
- f) Redistribution options
- g) Technological innovation

The major factors motivating the adoption of micro-mobility from other modes are-

- a) Convenience
- b) Perceived usefulness
- c) The value proposition is competitive with other transport options.

Safety

One major concern when implementing bike-sharing services is how to ensure the safety of new users. In New York City, the Citi Bike program finds that out of the 134 million cycling trips within a year, there are about 17.2 million average cyclist fatalities and year and 392 million cyclists either killed or severely injured within a year⁴. Most crashes in this study that led to cyclist fatalities fall into three main categories: traveling adjacent to a motor vehicle (29%), traveling at a right angle to the vehicle (27%), and motor vehicle turn crashes (21%). In addition, a majority of cyclist accidents were observed to occur at intersections. NYC DOT draws from this data that a key way to improve cyclist safety across New York City is to invest in bicycle infrastructure. This includes improving the bicycle network by installing one of the three types of bicycle facilities, protected bicycle lanes, conventional bicycle lanes, or signed/marked routes, in areas that experience high bicyclist collision rates⁵.

Fishman, Bikeshare: A review of Recent Literature mentions that Bike users are less likely to wear a helmet than a private bike rider Study has found that US bikeshare riders are four times less likely to wear a helmet than private bike riders. Also, another study in New York City found that 85% of Citi Bike users do not wear a helmet.

Currently, many bike share programs require that all users wear a helmet while riding. However, most programs do not provide helmets which leads to many riders neglecting this requirement.

⁴ <https://www1.nyc.gov/html/dot/downloads/pdf/bike-safety-study-fullreport2017.pdf>

⁵ <https://doi.org/10.3390/su12229505>

Modal Competition

A primary concern regarding the implementation of shared micro-mobility revolves around the potential modal competition that adding the system will introduce. A goal of introducing micro-mobility programs is to increase the usage of sustainable modes of transportation. However, some research finds that there is a conflict between shared micromobility and other means of sustainable transportation. Bike-sharing programs are typically introduced as a substitution or addition to public transit.

In a study on the effect of bike sharing on the New York City (NYC) bus ridership, the bike sharing system, Citi Bike, a significant decrease in bus ridership along routes near bike sharing (). To study the relationship between micro-mobility and the public transportation system, Campbell and her team studied the current bus service in NYC. At the time of the study, the sharing network in NYC is the densest in the United States. As bicycling increased, NYC invested more into bicycle infrastructure introducing improved bike lanes, bike signage, and signals, and a new bikeshare system. Campbell used a regression methodology to estimate the effect of bike sharing on bus ridership based on the geographic coverage of bike sharing. From the research, they found that the location of bike-sharing docks and treated routes along the bus routes caused a 3.3% decrease in unlinked bus trips. However, in this study, the introduction of a new bike-sharing system and the improvement of bicycle infrastructure were evaluated together when measuring the effects on bus ridership. Therefore, it is not clear the direct impact the new bike share system solely had on ridership. The study also focuses on the decline in daily ridership and does project long-term behavior.

In the efforts towards promoting modal integration, many bike share stations are located near transit stops to provide convenience between using the two modes of transportation.

Ultimately, the goal is to introduce a shared micro-mobility program that supplements current public transportation systems. Many agencies have looked towards utilizing micro-mobility to resolve the first mile / last mile predicament.

There are constant efforts to propose a bike-sharing system that serves to replace vehicle trips. However, studies have found that the impact of private vehicle trips is relatively low while bike sharing is predominantly used instead of walking and public transport.⁶

According to a variety of user surveys, bike sharing did not have a significant impact on the modal shift from private vehicles.

- London BCH, UK – 2% car trips substituted (Fishman et al., 2014)
- Velo'v, Lyon, France – 7% (Fishman et al., 2013)⁷
- Capital Bikeshare, Washington DC, US – 7%
- Nice Ride Minnesota in the twin cities of Minneapolis-Saint Paul, US – 19.3%

⁶ Fishman; Bikesharing: A review of evidence on impacts and processes of implementation and operation. [Fishman; Bikeshare: A synthesis of literature](#)

⁷ Fishman; Bike share: Impact on Car Use

- Melbourne Bike Share, Australia – 19%
- CityCycle Brisbane, Australia – 21%

LDA Consulting Capital Bikeshare 2016 Member Survey Report found the following-

- Modal Substitution
 - o 55% drove car less often
 - o 65% used taxi less
 - o 60% reduce ride hailing
 - o 58% reduce Metrorail
 - o 55% less bus
 - o 35% decreased walking trips
- Modal Substitution
 - o 35% transit
 - o 39% walking
 - o 5% drive
 - o 2% taxi / ride hailing
 - o 3% personal bike
- Reduced driving miles – 20%
- Modal Incorporation
 - o 71% used Capital Bikeshare occasional to access bus stop/station
 - o 15% used at least 6 times a month
- Mode Choice
 - o 56% of respondents chose bikeshare because fastest or easiest way to reach destination
 - o 15% for exercise
 - o 7% cheaper
 - o 8% destination was too far to walk

The following table is taken from bike sharing scheme paper⁸-

Trip type replaced by bicycle-sharing in selected cities

Type of Trip Replaced	Bicing Barcelona	BIXI Montreal	Vélib' Paris	Vélo'v Lyon
Bus or Metro	51%	33%	65 %	50%
Car or motorcycle	10%	2%	8 %	7%
Taxi		8%	5 %	
Walk	26%	25%	20 %	37%
Bicycle	6%	28%		4%
New Trip		4%		2%

Sources: Buis, J , 2008; Curran, A, 2008; Bachand-Marleau, J , 2010.

⁸ [Bicycle Sharing Scheme:](#)

Santa Monica Shared Mobility Pilot Program found that micromobility trips are coming from the following sources- 49% car and 39% walking

Energy Use and Emissions

Notable benefits of incorporating micro-mobility systems into city transportation systems include reduced congestion and carbon emissions due to the reduced demand for private vehicle trips and reliance on fossil fuels (Hern, Scientometric Review of Powered Micromobility, <https://doi.org/10.3390/su12229505>).

As riders trade in their private vehicles for an open-air ride, they are likely to be exposed to air pollution. The study found that there is little impact on the typical rider's exposure to air pollution. However, there are also higher ventilation rates as bicyclists ride which balances the impact. As we project further into the future, it is important to keep in mind that as more users abandon their personal vehicles, less air pollution will be produced and a rider's air pollution exposure will continue to decrease.

LDA Consulting Capital Bikeshare 2016 Member Survey Report found that the total annual VMT reduced due to the bike share program implementation was 9,912,000 annual miles

Public Health

The implementation of micro vehicles can help encourage public health benefits as these alternative modes of transportation encourage exercise over sitting in a private vehicle.

In addition to physical health, research suggests that riding micro vehicles can improve psychological health from the sense of enjoyment derived from riding.^{9,10}

According to a study published by Woodcock on the London BSP, there are three main issues regarding bike sharing: physical activity, crashes, and exposure to air pollution. The team used trip data to model the health impacts of the program via comparison to a scenario without bike sharing. Overall, an increase in physical activity occurred and these benefits would increase as the age study group increased. Contrastingly, the study also found that younger riders were more likely to experience crashes. As younger riders get into crashes, older riders have a harder time recovering from these crashes.

⁹ Woodcock, J., & Goodman, A. (2014). Hard evidence: Do bikeshare schemes lead to more head injuries among cyclists? Retrieved from <http://theconversation.com/hard-evidence-do-bikeshare-schemes-lead-to-more-head-injuries-among-cyclists-30135>

¹⁰ Woodcock, J., Tainio, M., Cheshire, J., O'Brien, O., & Goodman, A. (2014). Health effects of the London bicycle sharing system: Health impact modelling study. *BMJ*, 348. doi:10.1136/bmj.g425

Opportunities for Cooperative and Synergistic Management

Modal Integration

As mentioned before, a primary issue with introducing a new bike-share system is the potential to introduce modal competition. However, agencies have the power to instead use SMM to enhance transportation systems sustainability by evaluating modal shift behaviors of the community to determine the best locations for docking stations and types of vehicles to provide.

Safety

As agencies prepare to incorporate bike-sharing systems, there are many ways to preemptively mitigate the amount of safety issues.

Some proposed theories to be further explored surrounding bike sharing and safety include making bicycles more visible and recognizable, making the equipment heavier to enact slower and more stable riding, encouraging cautious behavior amongst bike-sharing riders, and possibly requiring a deposit for rented bicycles.¹¹

According to a new report from the Mineta Transportation Institute (MTI), users of bike-share bikes over personal bikes experience lower collision and injury rates (*Bikesharing and Bicycle Safety*, 2017). MTI analyzed data from bike share programs in San Francisco, Washington DC, and Minneapolis. This is due to several factors. First, the design of bike-share bicycles tends to be heavier and possess wider tires, causing the bicycles to be studier, enacting slower travel, and ensuring stable riding. In addition, the bicycles are typically designed to be more visible and recognizable to make the bikes able to be easily spotted by cars.

Bike-share paths are often routed through denser, slower-traveling areas. By consciously planting bike-share stations along roads with lower average speeds and higher pedestrian traffic, vehicles are less likely to collide with bicyclists.

Bike-share users tend to be new riders or infrequent riders. Therefore, they ride much more cautiously and defensively than an owner of a personal bicycle.

A major obstacle that bike-share programs constantly face is the commonality of bike-share users to wear bike helmets. While wearing a helmet surely decreases the intensity of injury should an accident occur, there are also studies that suggest wearing a helmet should not be required and may hinder bike-share programs.

Business Vitalization

According to the data from the Capital Bikeshare 2016 Member Survey Report, 32% of Bikeshare members said they were either more likely or somewhat more likely to patronize establishments that were accessible by Capital Bikeshare.

¹¹ (*A Study of Bikesharing and Bicycle Safety* | US Department of Transportation, n.d.).

Accessibility

E-scooter/e-bike use survey done in Santa Monica found the following factors as barriers to the adoption of micro-mobility-

1. Expense – 16.7%
2. Difficult to locate – 45.2%
3. No bike lanes – 54.1%
4. Don't feel safe, scooter – 17.6%
5. Don't feel safe, bikes – 4.9%

Regional Coordination

The Santa Monica Mobility Program survey¹² data finds that one of the highest barriers to shared vehicle use is that 45.2% of users find the bicycles difficult to locate. One way to provide a more accessible bike-share program and improve regulation is for cities to coordinate regions to manage mobility services. Actively managing these services through contracting or permitting processes with associated rules/regulations as well as through right-of-way management is critical. Stabilize context within Metro Bike Share and Breeze operations.

Case Studies

In the following section, we present the case studies of micro-mobility adoption at different cities in the United States.

City of Santa Monica

In 2017, the City of Santa Monica became ground zero for a disruptive force that's been hailed as both the future of mobility and the "herpes of urban transit (Fonseca, n.d.) ([Fonseca](#)).” Bird and Lime launched hundreds of scooters. To manage the chaos of scooters provided by Bird and Lime, and the new Lyft and Jump, Santa Monica launched their Share Mobility Device Pilot Program in September 2018. The goals and objectives of the program include diversifying mobility options, reducing emissions, maximizing user awareness of safe and legal behaviors for operating shared mobility devices, creating an enforceable framework for managing shared mobility services, maintaining flexibility, protecting public health and safety, and more. The City made efforts to invest in infrastructure by installing additional parking and pick-up zones and improving public safety with 299 citations and 929 violations. The City provided Operators with invoices for the Annual Operator and Annual Device Feeds. It was detailed in the Pilot Program Administrative Regulations that Operators must provide the necessary technology to track devices, determine device utilization, enhance customer service, and educate users about safe riding and the rules of the road. The City assigns the responsibility of providing state-of-the-art shared mobility technology

The City of Santa Monica's Breeze Bike Share has maintained a 500-bike fleet that provides 87 stations, 4 drop zones, 10 on-street kiosks, and 942 on-street racks.

¹² [Southern California Association of Governments](#)

Problems Identified

- Safety
 - Unsafe riding and irresponsible parking. It was resolved through police enforcement.
- Riding without license
- Riding on sidewalk
- Running red lights
- Riding without helmet
- Parking
 - Designate parking and pick-up zones
 - Promote education campaigns to promote responsible riding and parking

Bay Area

Bay Wheels allows users to make point-to-point trips using shared bicycles, including hybrid electric bikes. Can be docked at a station or a city bicycle rack¹³. The users can use Clipper Card to unlock bikes.

Equity

The requirement for at least 20\$ stations to be located in low-income communities promotes equitable distribution of services¹⁴. Bikeshare for All subsidized membership program makes membership accessible to low-income individuals. Determined by anyone who qualifies for Muni Lifeline Pass, CalFresh, or PG&E's CARE utility program. Cash payment is accepted and a credit card is not required. Through the Bikeshare for All program, low-income or unbanked users are able to obtain a prepaid card that will give them the flexibility to purchase a prepaid card at retail locations such as drug stores and grocery stores or online.

System Planning and Station Siting

Strategically spaced bike share stations every 2 to 3 blocks throughout the service area so that stations are within a five-minute walk of one another. Derived this idea from other cities in Europe and North America that have shown this method maximizes utility and customer satisfaction. Factors considered when determining idea locations include topography, job density, transit connections, bike rack requests, proximity to the bikeway network, and general support of station neighbors.¹⁵

Multi-modal Connectivity

Prioritized station siting to complement regional transportation connections like BART, Caltrain, ferries, and the TransBay Terminal.

Public Involvement

¹³ <https://mtc.ca.gov/our-work/operate-coordinate/traveler-services/bay-area-bike-share>

¹⁴ <https://www.sfmta.com/getting-around/bike/bike-share>

¹⁵ <https://www.lyft.com/bikes/bay-wheels/expansion>

Held SFMTA Engineering Public Hearings when making plans on system planning and station siting. Locations provide convenient options for residents, commuters, and visitors making short trips to and from these facilities to places of employment and residences and to social and recreational destinations. SFMTA held a Question-and-Answer Session for the permit application on June 7th, 2019. Many forms of contact were provided on the launch website and on the current website. Contacts included a representative from SFMTA, JUMMP service, and LimeBike support.

Data Sharing

Real-time station and bike data is provided through the Bay Wheels' data webpage¹⁶. Users are also able to view detailed historical trip data. Each trip is anonymized but data can be viewed.

Portland, OR

The Portland Bureau of Transportation (PBOT) launched its first e-scooter pilot in 2018 with the intention to reduce traffic congestion, prevent fatalities and series injuries, expand access, and reduce air pollution ([PBOT scooters](#)). From this pilot, they assessed that many of these goals were accomplished, however, the city experienced problems with improper parking and sidewalk riding. The City of Portland launched their own Shared Electric Scooter Pilot in the midst of the recent coronavirus pandemic with Bolt, Lime, Razor, Shared, and Spin permitted to operate their e-scooter fleets. At the beginning of the global pandemic, Portland's scooter ridership was already declining. In addition, the restricted use of scooters to combat the pandemic and ensure safety during the protests resulted in ridership leading to an all-time low. Portland's bikeshare system, BIKETOWN, serves to provide a lifeline for essential trips and safe, physically distant outdoor recreation.



Figure 1: Replacement of Car Trips and Low Carbon Modes from Adoption of E-Scooter¹⁷

2018 E-Scooter Findings Report

¹⁶ <https://www.lyft.com/bikes/bay-wheels/system-data>

¹⁷ https://www.portland.gov/sites/default/files/2020-09/pbot_escooter_report_final.pdf

PBOT looked to implement new transportation technology in an efforts to help meet Portland's transportation needs. The City assessed whether introducing e-scooters would help reduce traffic congestion by shifting trips away from private motor vehicle use, prevent fatalities and serious injuries on Portland streets, expand access to opportunities for underserved Portlanders, and reduce climate pollution. For this study, PBOT required participating companies, Lime and Bird, to share data including real-time availability, trip origins and destinations, routes, and safety information. After evaluating the data and feedback from the community, PBOT found that Portlanders overall responded positively to the introduction of e-scooters, accomplishing the majority of the initial goals. However, Portland did also observed challenges with illegal sidewalk riding, incorrect scooter parking, and equitable access.

Policy Implemented

As e-scooters proved effective in helping Portland meet its transportation improvement goals, Portland added to its 2035 Transportation System Plan that the City should aim to balance various modes of transportation to meet the identified goals. This includes evaluating e-scooters alongside other forms of mobility such as e-bikes, car sharing, and ride-hailing services.

The pilot program established administrative rules and a permit to regulate the framework. According to state law, riders were required to wear a helmet and prohibited from riding on sidewalks. PBOT also requires companies to receive a permit to operate. Upon receiving a permit, each company was responsible for deploying a minimum of 100 scooters daily in East Portland and educating riders on safety procedures and proper parking.

Framework

Promote scooters by increasing prices, decreasing available e-scooters, and lowering the novelty of e-scooters. They found that users mostly use e-scooters during peak hours (5-7 pm) and during the weekends. Their operating principles are- a) Prioritize offering e-scooters to serve short trips – less than 1 mile b) Invest more into infrastructure to promote safety.

Environmental Impacts

Portland looked towards new mobility methods to aid in accomplishing the mission of decreasing transportation emissions as labeled in their 2035 Comprehensive Plan. Therefore, e-scooters were introduced into the transportation system to provide an attractive option that reduces car use and discourages car ownership while decreasing city congestion and greenhouse gas emissions.

Stakeholder Cooperation

Engaged the community by providing feedback forms and organizing focus groups. Worked with community-based organizations including Disability Rights Oregon to provide video promoting safe scooter riding.

- Coordinate with Forth Mobility to coordinate safety workshops with companies and
- Multnomah County Health Department to study scooter-related industries
- Portland State University to research the impact of e-scooter operations.
- To increase equitable access, worked with Transportation Wallet for Residents of Affordable Housing to promote ridership for low-income citizens.

- Coordinate with City Council offices to ensure responsiveness to constituent concerns and communicate with companies to ensure compliance with regulations and work towards meeting city goals.

Problems and Resolutions

- Education
 - o Sidewalk riding poses a danger for pedestrians and people with disabilities
 - o Improper parking blocks access for pedestrians and people with disabilities
 - o Users ride in parks and other prohibited areas
- Citations
 - o Sidewalk riding poses danger
 - o Improper parking blocks access
 - o Users ride in parks
- Reporting Issues
 - o Improper parking blocks access
- Geofencing Technology
 - o Users ride in parks
- Seated e-scooters
 - o Not everyone is physically able to ride an e-scooter
- Incentives
 - o Sidewalk riding poses a danger
 - o Improper parking blocks access
- Dedicated E-scooter parking
 - o Improper parking blocks access
- The climate impacts of e-scooter operations are unknown
 - o Life cycle analysis
 - o Operational Vehicle Miles Traveled

Future Plans

- Congestion and Climate
 - o Relationship to transit and driving trips
 - o Environmental impacts
 - o Service area boundaries
- Safety
 - o Education
 - o Geofencing and speed governing
 - o Parking
 - o Infrastructure
 - o Custom service and reporting
- Equity
 - o Access across the city
 - o Pricing
 - o Low-income plans
 - o Increasing use by underserved communities

- Equitable hiring
- Employment

Washington D.C

Washington DC is the home of the country's largest bike-share system.¹⁸

They have solar-powered stations with three-speed bikes under the Capital Bikeshare (CaBi). The program started with SmartBike DC. However, the program was criticized for low usage and a limited number of bike stations. The program served as a proof of concept for the bike share system.

At the time that Washington D.C. launched its bike share program, only Minneapolis and Denver contained bike share programs within the country. European cities have had bikeshare systems for a couple of years now and this is an area that America is late on. One large contributor to this is that bike share programs are very expensive to start.

Capital Bikeshare had a capital cost of about \$5 million and an operations cost of about \$2.3 million at the start of its launch. These costs were largely covered by the city while recouping revenue monthly from membership and usage fees. Maintenance included checking and repairing bikes every week. In addition, a team oversaw balancing bikes – moving bicycles from full stations to empty stations.

Austin, TX

Many Austinites prefer or rely on modes of transportation other than their own private vehicle. Taxicab service is not consistently meeting demand. Transportation Network Companies (TNCs) recently innovated in transportation services that use an online-enabled application or platform to connect passengers with drivers.¹⁹

Future Research Opportunities

Fishman, Bikeshare: A Review of Recent Literature included the following research directions in the adoption of micro-mobility behavior.

- a) A better understanding of whether awareness of behavior drivers differs in the presence of bike share users.
- b) Develop standard, justifiable tools to measure the impacts of bike share in terms of climate change, congestion, air and noise quality, and health and time savings.
- c) Finding comparable methodology for quantifying benefits of bike share.
- d) Develop more efficient methods of fleet rebalancing.

¹⁸ <https://www.zdnet.com/article/dc-unveils-countrys-largest-bike-share-program/>,
<https://www.washingtonpost.com/wp-dyn/content/article/2008/04/18/AR2008041803037.html>
<https://washingtoncitypaper.com/article/385026/r-i-p-smartbike-good-riddance/>
<https://ggwash.org/view/29892/many-unsung-heroes-made-capital-bikeshare-a-reality>

¹⁹ <http://www.austintexas.gov/edims/document.cfm?id=219353>