Implementing a Bike-Share System

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2 BIKE-SHARE SYSTEMS

2.1 OVERVIEW

Environmental impact due to use of fossil fuels and health impact due to lack of physical activities and pollution demand implementing less costly and more environmentally friendly transportation modes. Hence, research and implementation of greener alternatives are the focus of many countries and cities worldwide. The explorations and implementations are primarily initiated by city officials and planning committees who are seeking alternatives to make their cities greener and more resilient. One such effort is to improve mobility within cities by enhancing non-motorized facilities, integrating various transportation modes, and implementing other alternatives such as ride-share, bicycle-share, etc. The information presented in this chapter is limited to bike-share.

Recently, the use of bicycles has drastically increased within cities (Firestine 2016). The underlying reason is the typical short trips that are taken by city residents. Bicycles offer the users with a chance to complete their first/last mile trips and modify the trips to meet their individual needs. The advantages brought to city residents and employees are not limited to transit stops and schedules. Additionally, cycling offers health, financial, and environmental benefits. Thus, many cities started expanding non-motorized facilities, promoting bicycle use within their jurisdictions, and developing bike-share programs.

A bike-share program makes bikes available at stations throughout a well-defined project area for shared use to individuals on a short-term basis. This provides another choice of transportation and extends the existing transportation system by providing access to destinations off of existing public transportation routes. Based on the Bureau of Transportation Statistics (BTS), as of August 2015, a total of 46 bike-share systems are being operated by one or more cities with a total of 2,655 bike-share stations in total of 65 U.S. cities (Firestine 2016).

This chapter presents the key aspects in planning, implementation, maintenance, and evaluation of a bike-share program. Use of location allocation models as a planning tool to identify the optimum number of bike-share stations for a given jurisdiction is discussed. Further, technology and infrastructure needed to develop a successful program are presented. A summary of lessons learned from already implemented programs is presented. Also, a summary of an implementation case study developed for the city of Kalamazoo in Michigan is presented.

2.2 PLANNING

Prior to launching a bike-share program, up-front planning and consideration must be made. Even though planning methods are not the same among all cities and communities, at least the following steps need to be considered when conducting feasibility studies:

- Define a goal (such as promoting physical activities, reducing traffic jams, providing access to underserved communities, etc.) Defining a goal is important to successfully perform a feasibility study, and to evaluate the impact and success of a program once implemented.
- Define initial service area by using heat maps.
    a. Identify dense areas such as areas with high population, job rates, commercial/ retail activity, and pedestrian activities; and the areas that are located at close proximities to colleges or universities, touristic attractions, recreational facilities, and hospitals.
    b. Identify number of short trips within and between these dense areas.
    c. Identify available bicycle infrastructure (bike lanes, shared-use paths, etc.)
    d. Identify social equity such as low income housing, percent living in poverty, and percent of non-English speakers.
    e. Identify areas with slope no greater than 4%
- Evaluate possibility of transit intermodality
    a. Identify connectivity with other modes of transport.
- Evaluate appropriateness of a bike share system for a jurisdiction. Surveying residents of communities is key to learning the interests, needs, and acceptance of such a program. In addition, the following information can be collected through a survey:
    a) Willingness to pay for the service
    b) Typical mode of transportation
    c) The level of knowledge about bike share systems
    d) Origin and destination of typical trips, time of day, and day of week
    e) Age of trip makers
    f) Purpose of the trips
- Define the most appropriate operation model and funding mechanism

   a) Jurisdiction owned and managed
   b) Non-profit
   c) For profit

- Define possible locations for stations: on-street, sidewalk and/or off-street.
- Select suitable equipment and bicycles.
- Estimate associated costs such as capital cost, launching cost, operational cost, and administrative cost.
- Develop marketing strategies, and
- Develop strategies to prevent theft and vandalism.

2.2.1 Stakeholder Involvement

The implementation of a bike-share program is likely to involve a variety of stakeholders. Involving them early in the process helps building support and defining goals. The likely stakeholders and their potential roles are listed below:

- Politicians: provide required resources, enact regulatory changes (if needed), and ensure cooperation between municipalities.
- Planners: ensure integration of the system with bicycle infrastructure and ensure integration of the bike-share system with public facilities.
- Transportation authority: ensure integration of bicycle infrastructure with public transit infrastructure and promote the use of bicycles to current transit users.
- Parking authority: provide space for bicycle stations.
- Traffic and roads department: coordinate construction of the stations, make change to road infrastructure, and install signage and signaling to support increased bicycle traffic volume.
- Police: maintain a safe environment for infrastructure, bicycles, and cyclists; and protect the system components from theft and vandalism.
- Community groups and NGOs: build community support, provide bicycle safety education, and promote bicycle use.
- Business associations: build support among merchants, mitigate opposition to removal of parking spaces, and find sponsors.

2.2.2 Service Area Selection

Bike-share service areas are typically located in dense areas (i.e., densely populated areas in terms of employment, commercial/retail activity, and pedestrian activities). Service areas are also located at close proximity to colleges, universities, and hospitals. Other factors that influence the selection of a service area include availability of bicycle infrastructure (bike lanes, shared-use paths, etc.), touristic attractions, recreation facilities, access to other transportation modes, number of short trips that are made by people within a specific service area, and topography. Developing a successful program requires selection of an area that attracts a large number of users and sponsors (FHWA 2012; Alta 2013).

Dense areas are often identified by using heat maps that divide the area to be analyzed into approximate square grids of 1,000 ft^2, and locate the spots where a majority of the population live, work, shop, play and take some form of a transit. Social equity is also located using heat maps. These locations are determined by spatial analysis that identifies the areas with low income housing and percentage of population living under the poverty line. The percentage of non-English speaking population is often considered when planning a bike-share program (Alta 2013). After identifying these dense areas, it is also recommended to conduct a survey. Surveys can help to determine public interests, expected support, and willingness to pay for the service. This information is critical and can help in selecting the most suitable service area. Other helpful information obtained from a survey includes the mode of transportation used and the level of knowledge about a bike-share program (DeMaio and Sebastian 2009). Further, surveys can be used to educate communities about the benefits of bike sharing.

Surveys can be used to collect information about the trips taken by a population of a community on a daily basis. These are called mobility studies. The type of data that can be collected are the purpose, origin, and destination of the trips; time of day and day of a week; the mode of transportation chosen; and the age of trip makers (Bhat and Koppelman 1999). Conducting a survey with a random representative sample of the population, and a population as larger as the budget allows, is recommended. The area of a survey should be extended beyond the dense areas, where bike sharing is most likely to be implemented. This approach helps identifying the potential users that live outside of the dense areas but travel to the area for various reasons such as work or study (DeMaio and Sebastian 2009).

2.2.2.1 Station Locations

There are three commonly used places to locate bike sharing stations (Alta 2013):

- *On-street*: The use of existing no standing/no parking areas are recommended for on-street stations. The consultation with the applicable authority is required to get approval. One vehicle parking space can park up to 8 bicycles. Safety and user's comfort need to be considered when selecting on-street stations. On-street locations are primarily considered for areas with narrow sidewalks (Figure 2-1) (Wine 2012).

Figure 2-1. On-street bike share system (Source: Transitized 2015)

- *Sidewalk*: A minimum sidewalk width of 10 ft is required to accommodate a station and meet ADA requirements. However, most cities often require maintaining at least 15 ft wide sidewalks to accommodate the space required for a station, ADA requirements, and the volume of pedestrian traffic (Figure 2-2).

Figure 2-2. Sidewalk bike share system (Source: Thevillager 2014)

- Off-street: Stations can be located in publically owned or private sites. Public sites may include plazas, transit stations, or parks. These location may have less competition for space but requires more consultation with appropriate authorities. On the other hand, private sites may be more difficult to obtain and will require to have a buy-in from the owners.

2.2.3 Station Density

Bike-share stations are typically located at approximately quarter (¼) to half (½) miles away from each other. This range is based on the distance that a person is often willing to walk to reach a station. They should also be located where the trips will most likely be taken by young adults (between 18 to 35 years old) and places with transit nodes, educational institutions, and major public facilities (DeMaio and Sebastian 2009). However, this distance will be dictated by available funding, and permitting and spacing requirements (FHWA 2012, Alta 2013).

A bike share system with a minimum of 10 stations is typically recommended to provide an effective mix of trip origins and destinations, and justification of operational costs. However, a system with a minimum of 20 stations is desired (Alta 2013). Another factor that affect the distance between stations is the density of the area. As an example, in much denser areas, the distance between stations is maintained at 1,000 ft to 1,300 ft range (i.e., 25 - 36 stations per square mile) (Alta 2013).

The number of bicycles at each station is a function of the demand. Number of bicycles per station need to be determined to ensure availability at any given time. It is also important to ensure availability of empty docks at any given time for bikes to be returned. A dock-to-bike ratio of 1.5 to 2.0 has been commonly used (Alta 2013).

Once the approximate distribution of stations is determined, following factors need to be considered to more precisely locate the stations (DeMaio and Sebastian 2009):

- Locations with high visibility (e.g., closer to a street intersection)
- Locations with high accessibility
- Locations that do not interfere with other users (e.g., pedestrians)

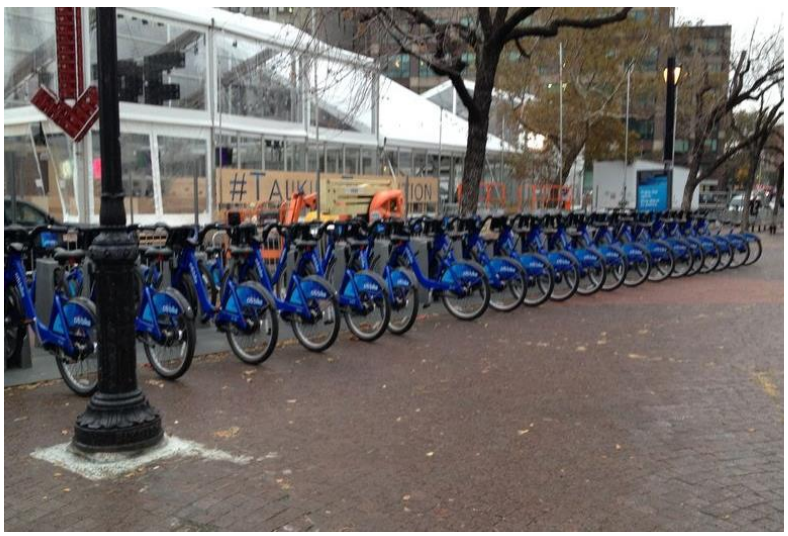

Figure 2-3. Off-street bike share system (Source: WNYC 2013)

After identifying potential station locations, getting feedback from public and future users is highly recommended. As an example, Alta (2013) used a web-based tool to gather information from the public on potential locations. The tool allowed the users to suggest alternative locations and provide comments.

2.2.4 Business Model Selection

Table 2-1 presents bike share business models, operator, operation procedures, revenue sources, benefits, and potential short-comings.

Table 2-1. Bike-share Business Model, Operator, Operation Procedure, Revenue Sources, Benefits, and Potential Short-coming

Business Model	Operator	Operation procedures	Revenue Sources	Benefits	Potential shortcomings
Jurisdiction owned and managed	An independent contractor	• Services are provided under the supervision of the local authority. • Net revenues are shared by jurisdiction and the contractor. Jurisdiction reinvests the revenue into the program. • Capital funding is provided by the jurisdiction. Equipment and infrastructure is owned by the jurisdiction. • To maximize revenues, contractors are allowed to use advertising and sponsorship. • Jurisdiction is responsible for financing the program. Contractor bears the liability.	• Federal, State, and local grants • Advertising and sponsorship (title sponsor, local businesses, Ads on bike share equipment and communication, etc.) • Membership and usage fees	• Better control over permitting and deployment of stations. • Reinvestment of revenues is controlled. • Uses private expertise to compliment agency skills.	• Funding resources may require more time. • Financially liable. • Sometimes, ads on public space is not permitted. • Contract negotiation skills are required.

Table 2-2: Bike-share Business Model, Operator, Operation Procedure, Revenue Sources, Benefits, and Potential Short-coming (contd.)

Business Model	Operator	Operation procedures	Revenue Sources	Benefits	Potential shortcomings
Nonprofit business	Nonprofit organization	• With the support of a jurisdiction, an entity is created to provide services. • Initial capital is provided by the jurisdiction. Securing additional funding is a responsibility of the nonprofit organization. • Operational costs are primarily provided by the nonprofit organization.	• Federal, State and local grants • Bank loans • Local business sponsorship • Membership and usage fees.	• Financial responsibility of a jurisdiction is marginal • Reinvestment of revenues is controlled. • Revenues are reinvested to improve the system • Public interests are better served rather than interest of advertisers.	• Deployment and expansion of a program can be slower. • Limited supervision by a jurisdiction. • Often lack the necessary expertise for start-up and operation.
Profit business	Independent contractor	• Minimal supervision by a jurisdiction. • Jurisdiction has no financial responsibility. • Public space and permitting costs are paid to the jurisdiction as a percentage of the revenue.	• Private investment • Local investment sponsorship • Ads on bikes and stations • Membership and usage fees	• Implementation and expansion can be quicker • More flexibility to changes	• Minimal supervision by a jurisdiction • Contract negotiation skills are required • Future expansions are likely in profitable areas

Sources: Alta (2013); DeMaio and Sebastian (2009); Shaheen et al. (2010); FHWA (2012)

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2.2.5 Funding Sources

Table 2-2 presents funding sources based on the business model for capital and launch, operation, and maintenance. In addition, the table presents a few comments and considerations.

Table 2-2. Funding Sources: Business Model, Capital and Launch, Operation and Maintenance, and Comments and Considerations (FHWA 2012)

Business Model	Capital and Launch	Operation and Maintenance	Comments and Considerations
Jurisdiction owned and managed	• Federal grants • State/Local grants • Sponsorships	• Membership and usage fees • Sponsorships • Advertisements	• Federal grants may provide long-term dedicated funding. However, the funding agencies will impose stricter timeframes for implementation. Delays are common. • Federal grants can only be used for capital expenses. • When sponsorships are considered, the local ordinance should be consulted to determine if advertising is allowed in public right of way. • When FHWA funds are used, outdoor advertising may be restricted.
Non-profit	• Private foundation grants • Local/national energy conservation and/or health grants • Sponsorship	• Gifts • Sponsorship • Membership and usage fees • Advertisements	
For profit	• Private funding	• Membership and usage fees • Advertisements	

The available funding sources for developing bike share systems are as follows:

- Transportation Investment Generating Economic Recovery (USDOT – TIGER Discretionary Grants 2016)
- Congestion Mitigation and Air Quality Improvement (USDOT – CMAQ 2016)
- Transportation Enhancement Activities (USDOT – TEA 2016)
- Department of Energy (DOE 2016)
- Transportation, Community and System Preservation Program (TCSP 2015)
- Centers for Disease Control (CDC 2016)
- Department of Health and Human Services (HHS 2016)

Some state and local grant opportunities may include:

- Public health grants (FHWA 2012)
- Local transportation funds (FHWA 2012)

Sponsorship or advertising models may include:

- Advertising on street furniture (Alta 2013)
- Sponsorship that involves long-term relationship where stickers, logos and/or statements are put on bike-share infrastructure (bikes, stations, and/or website) (Alta 2013).

2.2.6 Permitting Process

An approval or permission from the public and/or private right-of-way owners is mandatory to locate bike-share stations. This process will often require approval of station plans and preparation of necessary permits. The preparation and approval process can take several months. The steps to be taken are (Alta 2013):

- The station locations, design specifications, and drawings are submitted to the corresponding jurisdiction (i.e. Department of Public Works Traffic Engineer).
- Plans are reviewed and approved.
- Permits are issued.

2.2.7 Bicycle Infrastructure

In the U.S., bicycles are allowed on any street, except freeways and highways. However, when planning to locate bike-share stations, it is prudent to consider bicycle-friendly, safe, and interconnected routes to limit bicycle trips to short distances. Avoiding lengthy and circuitous bicycle routes is recommended (Shaheen et al. 2010). Implementation in communities with already existing bicycle infrastructure is highly recommended. If the community does not have bicycle infrastructure (shared-lanes, shared-use paths, paved shoulders, bike lanes or trails), implementation is not recommended unless the roads are in good condition with adequate width for vehicles to safely pass the cyclists.

2.2.8 Operational Hours and Seasonal Constraints

Operational hours depend on user's travel routines and demand patterns as well as availability of funding. Operational hours include bike service hours and customer service hours.

Typically, non-profits tend to offer service hours from 5 a.m. to midnight and customer service from 8 a.m. to 5 p.m. Operational hours are consistent throughout the week. For profits tend to offer 24-hour service, with customer service from 8 a.m. to 6 p.m. Jurisdiction owned systems also typically offer 24-hour operation (FHWA 2012). Seasonal operation is implemented in winter cities. Typically, the operation is closed during the coldest months. This results in a decrease of operational and maintenance costs (FHWA 2012).

2.2.9 Cost of Implementation

The program implementation costs include:

- *Capital cost* includes the cost of stations, kiosks, bikes, and docks (Alta 2013). Station cost depends on the size (number of bikes per station). Cost of bicycles depends on the features of the bicycles (e.g., availability of gearing systems, independent docks, GPS). The cost can vary between vendors, but typically a station cost ranges from $40,000 to $55,000 (Alta 2013).
- *Launching costs* include hiring employees, storage spaces, bike and station assembly tools, website development, IT setup, marketing, site planning and permitting, bike station assembly, and installation docks (Alta 2013). For example, the launching cost for a system with 35 stations, 350 bikes, and 595 docks is approximately $500,000.
- *Operational costs* include customer service staff salary and benefits, station maintenance (troubleshooting, station cleaning, and snow, litter, and graffiti removal), bike maintenance, bike redistribution, and other expenses (maintaining facility, purchasing tools and spare parts, maintaining IT infrastructure, and maintaining an insurance). These costs depend on numerous factors, but mostly depend on the Service Level Agreement that establishes the operating terms to be met (i.e. how long a station can stay empty, how often bikes are inspected, snow removal policy, etc.) Based on the terms, cost could range from $2,400 to $2,700 per bike per year. Rate of theft and vandalism also affect the operating cost (Alta 2013).
- *Administrative cost* includes costs associated with administering a program (program manager salaries and benefits; and public outreach) (Alta 2013).

2.2.10 Program Marketing

The success of a program depends on how well the communities are encouraged to use and promote a bike-share system. Marketing campaigns have geared their promotion towards 18 to 35 year olds, as this demographic is most likely to use the system. During marketing, it is highly recommended to highlight the health and environmental benefits of using bicycles in general (DeMaio and Sebastian 2009). If a program is marketed during the initial planning stage, more acceptance and support is often seen after launching. Early marketing creates an initial excitement and brings attention to the program. Reaching out to local elected leaders for social rides should be considered to encourage, support, and promote the initiative. During the grand opening, getting the maximum media coverage is recommended to attract the maximum number of potential users. All of these activities will help in building interest and increasing membership (FHWA 2012). Use of highly recognizable and unique brands develops a local identity.

As an example, the city of Montreal conducted a major promotion in fall 2008, before launching the program in spring 2009 (DeMaio and Sebastian 2009). The activities included:

- *Naming contest*: A public contest was conducted through the city of Montreal's website and asked residents to propose a name for the program. The winner was given a lifetime subscription to the program.
- *Demonstration*: Over the course of a month, a demonstration was held in a station and several prototypes were displayed to educate the public. Also, participants were allowed to take test rides.
- *Founding member campaign*: In order to obtain early subscriptions, the public was encouraged to become "founding members". The first 2000 people to obtain an annual subscription received prizes such as limited electronic keys for unlocking the bicycles, tickets to a museum exhibition on bicycles, and other exclusive privileges.

Other means to drive early subscription are to offer pre-sales of discounted long-term subscriptions; offer discounted or free subscription to transit pass holders; and develop collaborative programs with local institutions and business in the form of employer-based health and wellness programs, tourism related, etc., (DeMaio and Sebastian 2009).

2.2.11 User Fee

User fees account for a large percent of operational revenue. The fee structure should be designed to make short one-way trips more affordable while avoiding an all-day use. This is achieved by offering a lower price for short trips while increasing the price as the rental duration increases beyond a predefined time period. This fee structure encourages users to utilize the system as part of the transit trips, and allows the availability of bicycles to everyday users (Wine 2012).

User fees include membership and usage fees. The membership can be issued for a day, week, month, or a year. The usage fee depends on the total duration of a trip. The membership and usage fee ranges are presented in Table 2-3 (FHWA 2012, Wine 2012).

Table 2-3. Membership and Usage Fee

Membership fee		Usage fee	
Daily	$8 - $5	0 – 30 minutes	Free
Weekly	$30 - $15	30 – 60 minutes	$1 - $2
Monthly	$60 - $15	60 – 90 minutes	$2 - $4
Annual	$85 - $40	Additional 30 min.	$4 - $6

2.2.12 Additional Considerations

2.2.12.1 Weather

Severe weather conditions (snow, precipitation, etc.) affect the quality of service (FHWA 2012). The heaviest precipitation occurs from May through August. The heaviest snowfall occurs from November through March. As roads and sidewalks are not often cleaned quickly, communities with the least bike share experience are greatly affected (Kenney 2012). In winter cities the system is operated until November and then redeployed in March or April (Alta 2013, DeMaio and Sebastian 2009).

2.2.12.2 Topography

An area with no more than 4% grade along bicycle routes is ideal for implementation of bike-share systems. Users dislike grades more than 4%, and completely evade routes with a grade greater than 8%. Therefore, topography is a critical parameter that needs to be considered during the planning stage. In cities where the grade is greater than 8% empty stations have been found on top of the hills and overflowed stations at the bottom of the hills. Users are willing to ride down the hill, but refuse to bike up. A commonly used solution is to place a large number of bikes at the top of the hill and implement a redistribution system to bring bikes up the slope. Another more costly solution is to use electric bicycles (DeMaio and Sebastian 2009). Such systems have been introduced on a trial basis in European countries such as Italy, Croatia, Sweden, Spain, and Denmark (Intelligent Energy Europe Programme of the European Union 2015); and in the U.S. (the city of San Francisco, the University of Tennessee, Knoxville, and the University of California, Berkeley). However, the cost is not favorable for developing large programs (Midgley 2011).

2.2.12.3 Potential for Transit Intermodality

Bike-share systems are designed for short trips. Metropolitan transit systems are designed for longer trips and are limited to specific routes. By combining these two systems, it is possible to provide seamless travel between destinations. Also, this helps attract more users to a bike-share system. Further, by offering financial incentives for those who uses both transit and bike-share as a combined service, more users can be attracted to such programs. There are several examples of public systems that have implemented transit intermodality. In German cities such as Berlin, Frankfurt, Munich and Hamburg, the national rail company that operates most of urban commuter rail services has a program called *Call-a-Bike.* Bicycles are located at rail stations and the rail users are offered discounted prices for using bicycles. In the Netherlands, a service is explicitly designed for train commuters to use bicycle with a flat rate per 20-hour block (DeMaio and Sebastian 2009).

2.2.12.4 Accessibility by Minority and Low Income Communities

A bike-share system provides the choice of low cost transportation to communities. Low income and minority communities have the lowest automobile ownership rates and highest dependency on public transit (FHWA 2012). Requirements for bike-share system participation can be a barrier in some low income and minority communities. Certain measures taken to overcome these barrier are as follows (Alta 2013):

- Locate stations where the revenue projections may not be as profitable as others.
- Facilitate the use of phones for obtaining memberships to encourage individuals who do not have access to computers.
- Provide information and services in multiple languages.

- Accept debit cards. Develop partnerships with local financial institutions and banks to assist new users in opening checking accounts and obtaining debit cards.
- Subsidize memberships by securing sponsorships from various institutions and businesses. As an example, coupons with sponsors' advertisements can be printed and distributed to low income residents. Another option is to partner with employers of low-income individuals to encourage participation through a corporate membership.
- Offer introductory rates.
- Provide learn-to-ride classes.

2.2.12.5 Timing

When scheduling a program launching date, adequate consideration needs to be given for the type of equipment and stations selected to avoid delays. Time to procure and install stations, and procure bicycles depends on the type and number of bicycles and stations. For example, the construction related to fixed-permanent stations can take several months. In contrast, locating portable stations may take only a few days (DeMaio and Sebastian 2009).

2.3 MAINTENANCE

2.3.1 Bicycle Redistribution

Bicycle redistribution plays a major role in making a successful bike-share program. Users expect to have open racks to return the bikes and have access to bikes when needed. Full stations with no available docks to return bikes are commonly found in the areas with the highest concentration of jobs, housing, and activity centers. When the topography varies and the grade is greater than 4%, bike rides are primarily generated in the downhill direction. Hence, the frequency of bicycle redistribution need to be determined based on users' travel patterns within a jurisdiction. Once a bike share-system is implemented, additional studies need to be conducted to evaluate the program performance and fine-tune the operational parameters (FHWA 2012).

Redistribution requirements are included in the program's contract to mitigate inconvenience to the users. For example, the contract executed with Capital Bikeshare systems in Washington D.C. requires that stations cannot have all empty docks or all full docks for more than three hours between 6 a.m. and 12 a.m.; and for more than 6 hours between 12:01 a.m. and 5:59 a.m. during any day (Section 3-E 2012). Redistribution methods include trucks/vans carrying bicycles from one station to another, bike-powered trailers, and recompensing bike sharing system users who manually help to redistribute bicycles (Figure 2-4). The trucks/vans method is used in large bike-share programs, and it is the most expensive mode of redistribution. Irrespective of the method of redistribution, traffic jams during peak hours can affect redistribution (FHWA 2012).

(a) Redistributing van (b) Bike-powered trailer

Figure 2-4. Methods of bikes redistribution (FHWA 2012)

When planning a bike-share program, it is difficult to accurately estimate the cost of bike redistribution. In order to estimate the cost, an understanding of station density (or proximity to each other) and travel patterns are needed (FHWA 2012).

2.3.2 Operational Service Levels and Maintenance

Bike maintenance, removing graffiti on stations, and bike redistribution are part of the services required to develop a successful bike-share program. Level of service provided by a specific program depends on the availability of funding as operational costs. For example, the cost of checking bikes every day to provide a high level of service is more expensive than checking the bikes in every month. If operational costs are covered by using program profits, the level of service is affected by the amount of profit generated. When the profit is less than anticipated, certain services can be postponed to offset the expenses; yet, it will impact the quality of service provided by the program. If operational costs are funded by other means, quality of service is not affected by the profit generated by the program (Alta 2013).

The costs of preventive maintenance can be reduced by allowing users to report bicycles needing repairs at the kiosk with a user interface. It is paramount to maintain an inventory with a detailed and updated repair history for each bicycle. A bike maintenance checklist needs to be developed and used during regular inspections. In order to minimize the cost of maintenance by eliminating potential duplications, it is important to double check the maintenance checklist at the time of distributing bicycles to different stations.

2.3.3 Prevention of Theft and Vandalism

Reported cases of theft and vandalism are not very common in the United States. Most of the existing bike-share systems have taken measures to prevent theft. These measures include the use of high tech locking mechanisms, integrated GPS transmitters, and the use of specialized shape, size and branding bicycles with unique parts. Besides, some bike-share equipment suppliers provided built-in cable locks on bikes to allow the users to lock the bike when needed during their trip without getting into a docking station (FHWA 2012).

2.4 PROGRAM EVALUATION

Evaluation of program needs, effectiveness, and the impacts on the users is a critical step in developing a sustainable program. During the program planning stage, potential for developing a sustainable program needs to be evaluated. After a program is launched, user's feedback, data collected at Kiosks, data from bike mounted technology such as Global Positioning Systems (GPS) units, or a combination thereof can be used for performance evaluation. Community-based surveys are very useful in evaluating user perspective.

2.4.1 Program Sustainability

The success of a bike-share program depends on its ability to economically self-maintain operational and administrative costs. Due to limited resources and funding available for public transportation, developing self-sustaining programs are not supported (FHWA 2012). The potential revenue sources are user fees, membership fees, grant funding, private foundation contributions and donations, and advertising and/or sponsorships (Alta 2013). It must be kept in mind that bike-share programs typically take a number of years to "mature" and self-sustain. The time it takes to be self-sufficient varies from program to program (Alta 2013).

2.4.2 Program Follow-up

Once a program is launched, user's satisfaction is evaluated aside from monitoring bicycle usage. The first evaluation needs to be performed a year after launching a program. Primarily, surveys are used for obtaining user feedback. Users can be asked to rate the overall satisfaction based on the accessibility to the community destinations, quality of bicycles, bike-route safety, mobility with bike-route slope, and the suitability of the bike-station location. In addition, the ease of use, available payment methods, cost, availability of bicycles and empty spots at stations, and maintenance could be evaluated based on the user's satisfaction level. The survey responses are instrumental in identifying areas needing improvements and possible expansion of the system. As an example, a year after launching Velib bike-share system in Paris, a survey was conducted with the following questions (DeMaio and Sebastian 2009):

- Did the program allow to make trips that were previously impossible?
- Did the program complement the current transportation options?
- Was the program useful at the beginning or end of an intermodal trip?
- Did the program allow using cars less frequently than normal?

Instead of using questions that require descriptive feedback from the users, a list of questions can be developed to get user feedback as a rating. A sample questionnaire is shown in Table 2-4.

Table 2-4. A Sample Follow-up Survey Questionnaire Form

	Unsatisfied	Moderately unsatisfied	Satisfied	Moderately satisfied	Highly satisfied
Access to community destinations by bikes					
Quality of bicycle					
Bike-route safety					
Mobility with bike-route slope					
Bike-station location					
Available payment methods					
Bicycle fare/User fees					
Maintenance of bike-station					
Availability of bicycles at the station for check out					
Availability of empty slots for bicycle return					

2.4.3 Data for Program Performance Evaluation

Kiosks at bike share stations enable convenient bicycle check-in or check-out. GPS units are mounted on bicycles to collect location and route data. Data collected from kiosks and GPS systems can be used to determine travel patterns and system utilization in order to develop plans for program improvement based on user's perspective. This data can also help track the environmental and health impact to the community by determining the amount of burned calories and carbon offset from the miles ridden by users. Different socio-economic data about the bicycle users could be assessed based on community surveys. The collected data can also be used to secure additional funding to expand the program. The following is a list of data items that can be used to justify an expansion request (FHWA 2012) based on the user's perspective:

Kiosk-based Data:

- Average Travel Time (hour)
- Average Trip Length (mile)
- Average Delay (hour)
- Type of Membership (monthly/annual/life-time)
- Usage (in peak/off-peak hours)
- Number of trips per day
- Total burned calories/trip
- Carbon offset/trip
- Battery run-out time (of solar powered stations)
- Run-out duration of all the bicycles at a station

GPS-based Data:

- Number of destinations per trip
- Frequently visited routes

Community-based Survey Data:

- Purpose of typical trips
- User's annual income
- User's occupation

Certain programs have made the data available to public. The general public can track the progress, evaluate transparency of a program, and perform necessary analysis to evaluate the overall impact and performance of the program (FHWA 2012).

Jurisdictions need to have access to data in order to evaluate performance and to develop plans for program expansion. User feedback can also be used to measure the effectiveness of marketing initiatives by the decision maker's perspective (FHWA 2012). Bike-share performance can be evaluated in different scales e.g. local jurisdictions, regional planning agency and state wide agency from the view of decision maker's perspective. Planning scenario evaluation, long-term benchmark, alternatives comparison, and project need with near-term standard are evaluated in terms of different scales for bike-share programs. For example, the local jurisdictions could improve the integrated network planning by maintaining long-term or near-term standard for current bike-share program by reviewing the user's feedback. The local decision makers also could take an initiative whether any alternate scenario is needed for current bike-share program in respect to network planning, project planning, development review or street design; whereas the entire decision would be based on user's feedback. Table 2-5 provides a check list for performance evaluation by local jurisdictions.

Regional planning agency scope includes policy development and funding allocation in addition to network planning. For example, funding allocation by regional planning agencies could be varied (whether it would be long-term, near-term, or alternatives) based on the user's feedback. The regional agency could make decisions for allocating necessary funds based on current project need or planning scenario evaluation; while the correct decision of fund allocation would be solely based on the user's need for the current bike-share program. Table 2-6 provides a check list for performance evaluation by regional planning agencies.

State agency work includes code compliance checking while considering all other indicators as mentioned above in regional agency for evaluating performance of a bike-share program (FHWA 2016). Table 2-7 provides a check list for performance evaluation by state agencies. Different evaluation criterion also could be established based on different land use e.g. urban, suburban, rural, transitional etc., for a bike-share program.

Table 2-5. A Check List for Performance Evaluation by Local Jurisdictions

	Planning Scenario Evaluation	Long-term Benchmark	Alternatives Comparison	Project Need	Near-term Standard
Network planning					
Project planning					
Development Review					
Street design					

Table 2-6. A Check List for Performance Evaluation by Regional Planning Agencies

	Planning Scenario Evaluation	Long-term Benchmark	Alternatives Comparison	Project Need	Near-term standard
Network planning					
Regional policy development					
Funding allocation					

Table 2-7. A Check List for Performance Evaluation by State Agencies

	Planning Scenario Evaluation	Long-term Benchmark	Alternatives Comparison	Project Need	Near-term standard
Statewide network planning					
Statewide policy development					
Funding allocation					
Code compliance					

2.5 PLANNING TOOLS - LOCATION-ALLOCATION MODELS

Location-allocation models are used to identify the optimal location for new facilities such as fire stations, schools, hospitals, and bus stations. In other words, the location-allocation models tend to choose optimal locations from a group of candidates and designate demand to the location based on the demand distribution. The demand locations represent the dispersion of people, employment, and locations of interest. Location-allocation models, depending on the objective of an application, require defining delimited constraints. Commonly used constraints include limited number of facilities (when budget is limited), predefined methods of travel to the closest facility, and predefined impedance cutoff – travel distance or time from demand to a facility or vice versa (Zhang et al. 2013). Location-allocation models designate demand to only one facility; thus, the demand at a certain point is not split or shared by different facilities. Also, any demand that is located outside of the predefined impedance cutoff will not be allocated by the models (Algharib 2011).

2.5.1 Optimization Models

Location-allocation models can be programed into a Geographic Information System (GIS) to develop a decision-support tool for locating critical facilities (ArcGIS 2016; Yeh and Chow 1997; Valeo et al. 1998). ArcGIS software provides a geographic information system tool that is used for network-based spatial analysis to solve complex routing problems. ArcGIS-Network Analyst extension tool contains six location-allocation models that can be used to solve various problems by (1) minimizing impedance, (2) maximizing coverage, (3) minimizing facilities, (4) maximizing attendance, (5) maximizing market share, and (6) targeting market share (ArcGIS 2016).

The minimize impedance model is used to identify an optimum location of a facility, such as a public-sector facility (a library, a health clinic, etc.), to minimize travel time or travel distance.

The location-allocation model that maximizes coverage provided by a facility has been implemented to determine the location of ambulances (Eaton and Daskin 1980), fire stations (Schilling 1976), and rain gauges (Courtney 1978). The other model needed for locating facilities is the one that minimizes the number of facilities to serve a large population with the least number of facilities. The maximize attendance, maximize market share, and target market share models are used for solving competitive facility location problems. Public-sector facilities do not compete with each other, rather they complement each other. Hence, minimize impedance, maximize coverage, and minimize facilities are the three location-allocation models applicable for locating public facilities.

The objective of the study presented in this chapter is to provide a process for developing, implementing, and maintaining a bike-share program. One key aspect of a program is identifying the locations of bike-share stations. This requires defining demand locations, candidate facilities; and a distance and/or travel time matrix. The demand locations considered in this study represent the population density, employment, and locations of interest. The candidate facilities are the predefined locations that are determined based on a set of criteria such as the area of influence, available non-motorized facilities, possibility of intermodality, topography, and the desired walking distance. The distance and/or travel time matrix contains the distances or travel times between demand locations and candidates facilities (Keane and Ward 2002).

Bike-share stations are located to complement each other. Hence, maximize coverage and minimize facilities models are selected as the optimization models. Desired walking distance from a demand location to a bike-share station is defined as the impedance cutoff. Integration of minimize impedance and maximize coverage models helps identifying optimum bike-share station locations to serve a large population while maintaining the desired walking distance.

2.5.1.1 Maximize Coverage Model

This model maximizes the number of demand locations served by a facility. This means that the facility located nearest the high demand density has the preference to be chosen (Algharib 2011). First, the model allows the user to pre-define a number of facilities within a selected area after considering the budgetary constraints. Then, the optimization is performed to cover the greatest demand (Bryant 2013). The maximize coverage model presented by Church and ReVelle (1974) is described below:

$$Maximize \sum_{i \in I} a_i y_i \qquad (1)$$

subject to (s.t.)

$$\sum_{j \in N_i} x_j \geq y_i \qquad (2) \quad for\ all\ i \in I$$

$$\sum_{j \in J} x_j = P \qquad (3)$$

where,

I = set of demand locations,

J = set of candidate stations,

P = number of stations to be allocated,

x_j = 1 if station is allocated at j, 0 otherwise,

y_i = 1 if demand is covered at i, 0 otherwise,

S = standard distance (impedance cutoff),

d_{ij} = distance from demand node to candidate facility,

N_i = $\{j \in J | d_{ij} \leq S\}$ set of candidates which can cover demand i,

a_i = demand at node i

Equation (1) maximizes the number of demands covered by a facility. Equation (2) assures that a demand location is covered by at least one facility as long as the demand location is situated within the impedance cutoff (S). Equation (3) calculates the total number of facilities that can be located within a pre-defined service area (Algharib 2011).

Maximize coverage model can be used to locate public-sector facilities such as emergency service facilities. The primary purpose of efficiently locating an emergency facility is to enable the public in the area to have the quickest access to the facility in case of an emergency. The same approach can be used when locating bike-share stations and entry/exit points for underground pedestrian facilities. The main limitation of this maximize coverage model is that it does not consider demand locations situated outside the impedance cutoff.

2.5.1.2 Minimize Facilities Model

Minimize facilities model is used to determine the minimum number of facilities needed to serve a targeted demand based on pre-defined facility locations and impedance cutoff (Bryant

2013; Current et al. 1985). In other words, minimize facilities model aims to minimize the number of facilities needed to serve the demand located within a defined service distance (Church 1984). The difference between maximize coverage and minimize facilities is that minimize facilities model does not allow users to specify the number of facilities to be allocated, rather it is determined through the mathematical process based on the demand and impedance cutoff.

Below is the mathematical formulation of the minimize facilities model as presented by Toregas et al. (1971):

$$Minimize \sum_{j \in J} x_j \qquad (4)$$

s.t.

$$\sum_{j \in N_i} x_j \geq 1 \quad i \in I \qquad (5)$$

$$x_j = \begin{cases} 1 \; if \; node \; j \; is \; a \; facility \; site \\ 0 \; otherwise \end{cases} \qquad j \in J$$

Where,

$N_i = \{j | d_{ij} \leq S\}$ demand covered

S = standard distance (impedance cutoff),

d_{ij} = distance from demand node to candidate facility

i = set of demand

j = set of candidate facilities

Equation (4) minimizes the number of facilities required to serve an area. As per Equation (5) the number of candidates has to be greater than or equal to 1 (Algharib 2011). One of the limitations in the model is that it does not include budget (or the maximum number of facilities) as a constraint. Hence, the number of facilities determined by the model for total coverage may be unrealistic when budget is limited (Chung 1986).

2.5.2 Example: Bike-share Stations for Downtown Kalamazoo

Downtown Kalamazoo is surrounded by a significant population of students, visitors, commuters, and residents making it a suitable place for initiating a bike-share program. Population, employment, and locations of interest were considered as the demands (see Appendix

B Section B.2 for more details). A program size and number of bike-share stations are determined based on the availability of funds and the goals of the program. However, having 10 stations is considered as the minimum to provide an effective mix of origin and destination trips to make a program sustainable (Alta 2012).

ArcGIS is used as the analysis tool and all the required data was uploaded as layers. For this example, the funds and goals of the program were not defined. In order to initiate the analysis, thirty (30) stations were selected as the candidates after evaluating the distribution of non-motorized facilities, bus stations/shelters, topography, and the locations of interest. Figure 2-5 shows the locations of the candidate stations. Additional details on selecting candidate station locations are presented in Appendix B Section B.3.

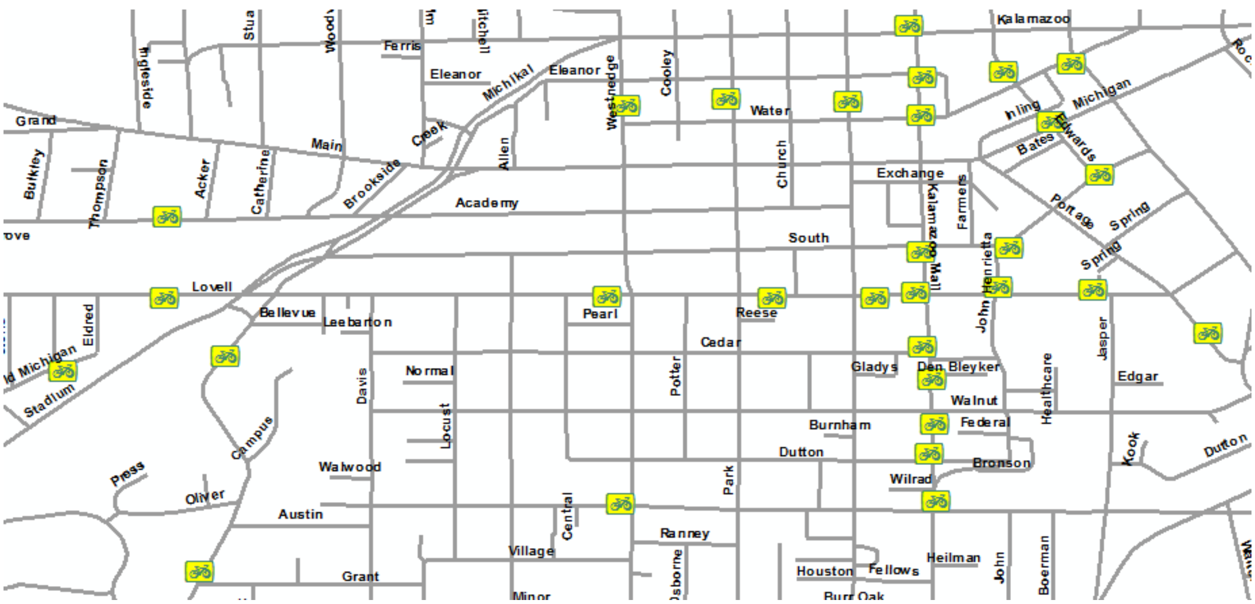

Figure 2-5. Candidate bike stations assigned for preliminary analysis

Maximize coverage and minimize facilities models were selected as the optimization models. Desired walking distance from a demand location to a bike-share station is defined as the impedance cutoff. The maximize coverage model provided the upper bound and minimize facilities provided the lower bound of the bike-share stations for each demand type. Analysis results are presented in Appendix B Table B-1. In order to select a set of optimal candidates that serves each demand type, the station that satisfied two (2) or more demand types was selected as optimal for this analysis. Twelve (12) stations were selected through the above procedure (see Appendix B Section B.4.3 for more details). The main constraint use in the analysis was the desired walking distance. The final set of optimal bike-share stations for downtown Kalamazoo is presented in Figure 2-6.

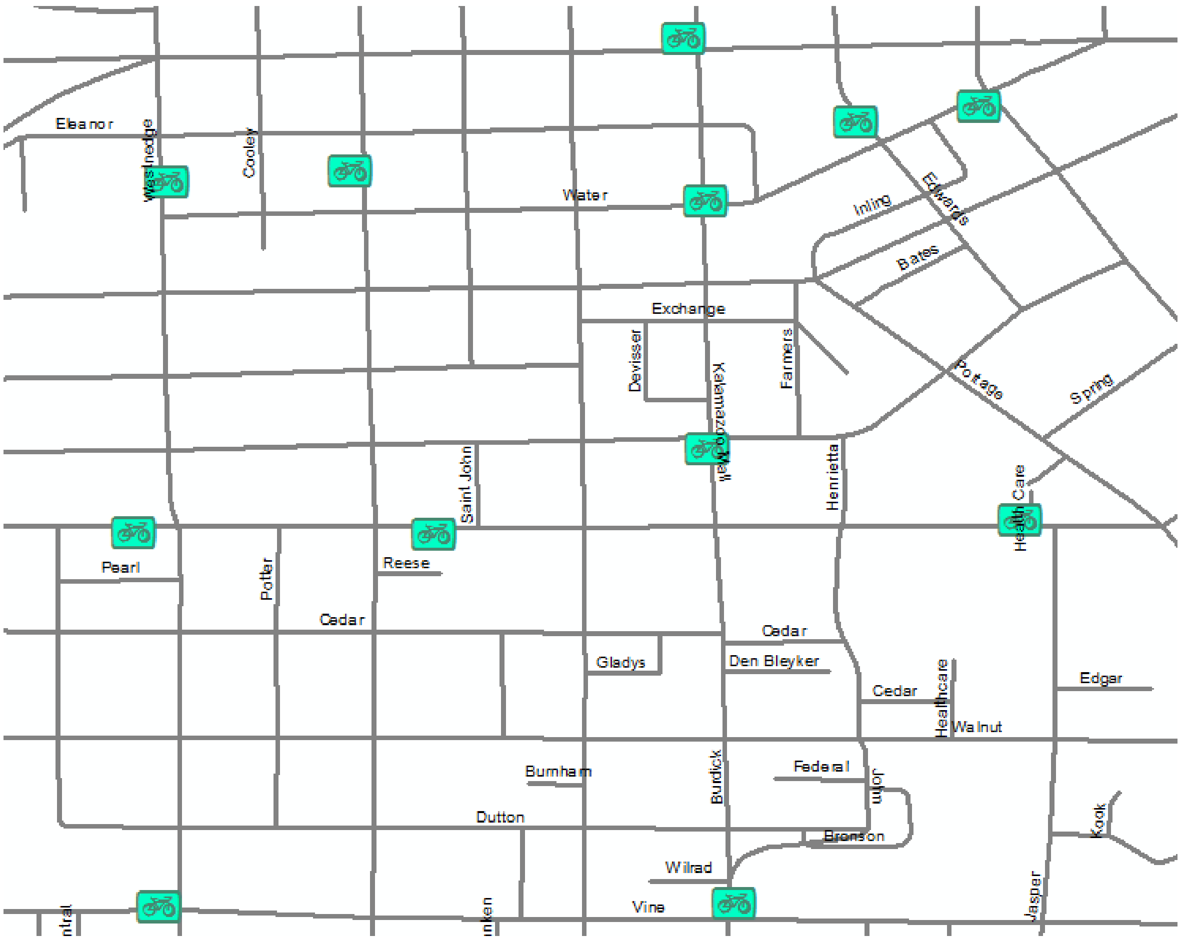

Figure 2-6. The most suitable locations for bike-share stations in downtown Kalamazoo

2.6 TECHNOLOGY AND INFRASTRUCTURE

Developing a bike sharing program seems like an emerging trend; however, it dates back to 1965 and has already gone through four generations over the course of the past 50 years (DeMario 2009). The first generation required no credit card or identification resulting in higher risk of theft and vandalism. The second generation required a check-out deposit; however, the minimal deposit was not enough to significantly reduce theft. The third generation introduced the use of credit card transaction and radio-frequency identification (RFID) chips to unlock the bikes. The user identification and security deposit advanced the program providing accountability against theft and vandalism. Finally, the fourth generation introduced solar powered stations with wireless communication. The following sections present a brief overview of kiosks and RFID and GPS technology; power supply; and electrical bicycles used in bike-share programs.

2.6.1 Kiosks, RFID, and GPS Technology

The recovery of bike sharing was related to the initiation of technological advancements such as credit card transactions and RFID chips (radio-frequency identification). These advancements allow operators to introduce accountability and reduce theft and vandalism. The credit card transaction are performed by using a kiosk. The kiosks have a software back-end that keeps track of transaction and ridership information. Thus, credit card transaction at the kiosks allows collection of user's identification and deposit.

The RFID chip tags are a remote/self-powered asset tracking technology. Another emerging feature is the use of integrated GPS transmitters that allow for the tracking bicycles throughout the service area. In addition to helping in the rare case that a bike is stolen, this information can be useful both for planning bike-share system expansion as well as overall bicycle network infrastructure improvements (FHWA 2012).

2.6.2 Solar Powered Stations

Typically, grid power is used for the stations and requires hardwiring. Use of grid power requires additional infrastructure and deployment time. Further, it limits the ability flexibility in relocating the stations (FHWA 2012; DeMaio 2009). The most recent development is in a form of a modular system with solar power and wireless communication. The advantage of this modular system is that the stations can be moved, relocated, expanded, or reduced to cope with the demand. The integrated power management programs turn the system into sleep mode after a pre-defined inactive time period until the next user touches the screen to activate the station. This feature helps in saving power for operating the system for an extended period of time (Sherman 2011). When solar energy is inadequate during certain periods, additional rechargeable batteries can be integrated (DeMaio 2009). In winter cities, the solar powered stations can be removed and stored during winter months (Austen 2009).

2.6.3 Other Technologies

Other improvements include incorporating integrated transportation cards, electric bikes, and high-tech bicycle components. The integrated transportation allows the use of one card to ride both bikes and public transportation (Colin 2013). Electric bikes have been introduced in cities such as Knoxville, Tennessee, and San Francisco, California (Colin 2013). Electric bikes have an electric motor that offers several speed setting to assist users to travel in different terrain types. Compared to traditional bicycles electric bikes enable the user to travel longer distances and over hills with less fatigue and sweat. Because an electric bike typically costs twice the price of a similarly equipped bicycle, the electric bike market has not grown as rapidly in the U.S. when compared to other countries (Pro-E-Bike 2015; Dill and Rose 2012; Rose 2012). Figure 2-7 shows components of a typical bicycle.

Figure 2-7. Fourth generation bicycle components (Source: Inhabitat 2013)

2.7 A REVIEW OF TWO RECENT IMPLEMENTATIONS

This section presents an overview of two bike-share programs implemented in two cities in Michigan, USA. The following sections detail funding sources, implementation requirements, power sources for bike-share stations, and program evaluation.

2.7.1 Bike-Share System in the City of Ann Arbor

The president of University of Michigan (UofM) was inspired to initiate a bike-share program after observing the program in the University of Colorado Boulder. At the same time, there was an interest from the city of Ann Arbor to add a program in the community. Clean Energy Coalition (CEC), a nonprofit organization dedicated to promote clean energy technologies as a way to create a healthier environment, was able to bring UofM and city of Ann Arbor together in a partnership to start a program called *ArborBike* (CEC 2016). CEC is the owner-operator of the system. B-Cycle is the equipment vendor. The system includes 14 stations. The majority of the stations are located in downtown Ann Arbor where there are areas with high population and employment densities, including large concentrations of UofM students. The program usually operates annually from April 1st to November 15th (Stanton 2014).

The initial capital cost for launching the program was $750,000. These initial funds were secured from two sources - federal and local. Federal funds amounting to $600,000 were secured from the Congestion Mitigation and Air Quality Improvement (CMAQ) program that is jointly administered by FHWA and the Federal Transit Administration (FTA). A local match worth $150,000 over the first two years was provided by the city. The University is the title sponsor and committed $200k a year for the first three years with a total of $600,000 to help cover operational cost for the first three years. The program is currently in the third year of that agreement. Additional operating costs are covered using ridership and sponsorship revenue. The current sponsors include the title sponsor (UofM) and the community sponsors (Underground Printing - UGP, University Musical Society - UMS, KerryTown Market & Shops, Om of Medicine, and the Uptown of Downtown). The program partners are the city of Ann Arbor, The Ride, the University of Michigan, and Clean Energy Coalition.

Based on personal communication with the program supervisor, it was determined that the city of Ann Arbor did not have to have a specific mileage on non-motorized facilities in the city to get the program started. Increasing bike infrastructure has always been a constant goal of the city. Although mileage was often increasing, it was not a requirement for the system. During the first year, the number of memberships, rides, and sponsorships, along with just feedback on how well people liked the program were considered as the measure of success. Currently, the city of Ann Arbor is evaluating success based on ridership/membership targets. For example, the current goal is an increase of 15% in membership by the end of 2016.

All the stations are solar powered. When solar power is insufficient, the batteries in the system are replaced with charged batteries. "During the summer, the sunlight is sufficient and hardly ever there is the need to exchange batteries. However, in the early spring and fall, the stations that are not optimally located had been requiring batteries exchange", expressed the system manager, Heather Croteau, through personal communication. Figure 2-8 presents one of the Ann Arbor bike sharing system stations.

Figure 2-8. A bike-share station in Ann Arbor, MI (Source: Rupersburg 2014)

2.7.2 Bike-Share System in the City of Battle Creek

In 2013, the bike-share program in Battle Creek, MI, started with a single station and has added a new station every year since then. To date, there are 3 operating stations and another will be added during 2016. The initiative started from the Battle Creek Community Foundation, a nonprofit organization, with the purpose of improving personal health and wellness of the community. The system is currently owned and managed by the Battle Creek Community Foundation. The first station was sponsored by the Battle Creek Community Foundation. The 2nd and 3rd stations were sponsored by local institutions such as Calhoun County Visitors Bureau, Bronson Battle Creek hospital, and Kellogg Community College. A few business organizations around the town (Arcadia Brewing Co. and Heritage Chevrolet) also contributed. During the implementation process, the sponsor was involved in selecting a location for the bike-share station and helping with the permitting process.

TeamActive, a local bike shop, maintains the bicycles. *TeamActive* performs weekly routine checks to ensure the bikes are in good condition. *TeamActive* also stores the bicycles during winter and installs a protective cover over the stations (Lewis 2013).

There was no mileage requirement from the city of Battle Creek for implementing a bike-share program. Since there was no defined grant process, the city of Battle Creek did not have any restrictions (Angela Myers, the system manager, though personal communication). The first station was solar powered. Because of the cost of solar powered stations, grid power was used for the rest of the stations to make the cost of installation more affordable to future sponsors. As per the system manager, the kiosks consume very little power and there was no significant cost saving by running the system on solar. A new station can cost about $20,000 including the entire solar system for the infrastructure (Bowman 2014).

The Battle Creek system vendor, *Bcycle*, provides the city of Battle Creek a back-end website to track the usage. So far, the city has not formally evaluated the performance or success of the system. However, the usage increases with the installation of every new station. The goal of the program is to make it self-sustaining. Figure 2-9 shows one of the stations in Battle Creek, MI.

Figure 2-9. A bike-share station in Battle Creek (Source: Kellogg Community College 2015)

2.8 LESSONS LEARNED FROM IMPLEMENTATIONS

Documenting experience in bike-share planning, implementation, operation, and evaluation is vital to enhance performance of the existing systems as well as to make the future implementations more effective. Six lessons learned topics are addressed: (a) theft and vandalism; (b) bicycle redistribution; (c) information systems; (d) prelaunch considerations; (e) station; and (f) system in general. Under each topic, a problem and potential solutions are presented. Table 2-8 provides a summary of lessons learned from the implementations in cities. Table 2-9 presents a summary of pros, challenges, and recommendation from implementations in colleges and/or universities.

Table 2-8. Lessons Learned - City Implementations

Topic	Problem	Solution
Theft and vandalism (Shaheen et al. 2010)	(a) Anonymity when checking out bicycles created a system susceptible to theft.	(a) Third generation bike-share systems introduced smartcard to checkout bikes. The cards recorded user identification and usage. Allocate 8% to 9% of the budget to address theft.
Bicycle redistribution (Shaheen et al. 2010)	(a) Bicycle redistribution is a challenge in high demand areas.	(a) Use of natural gas powered vehicles and trucks for bicycle redistribution. Implement real-time information on bicycle stations (shortage and overcrowding) to increase efficiency and effectiveness in bike redistribution.
Information systems (Shaheen et al. 2010)	(a) Access to real-time information about empty docks and bicycle availability is needed.	(a) Real-time information can be provided through internet, text messages, or calling hotlines.
Prelaunch considerations (Shaheen el al. 2010)	(a) System needs to be flexible enough to adopt to the change in demand.	(a) Implement mobile stations to help relocate based on usage patterns.
Station (DeMaio and Sebastian 2009)	(a) Station is often empty. (b) Station is often full. (c) Station is underused.	(a) Increase redistribution capacity. (b) Increase station capacity, add more stations nearby. (c) Relocate station to a more visible or busier location.
System in general (DeMaio and Sebastian 2009)	(a) System is underused. (b) System is not used in combination with other transit modes.	(a) Reduce membership fees, improve bicycle infrastructure, provide temporary financial incentives, and increase marketing. (b) Advertise on the transit system, provide free or discounted memberships to transit holders.

Table 2-9. Lessons Learned - Implementations in Colleges and Universities (Kenney 2012)

University and Bike share system Name	Pros	Challenges	Recommendations
University of Illinois at Chicago *B-Cycles*	• Program offered flexibility to pick up and return bikes at multiple locations. • Kiosks were used to make the service available during 24 hours/day and 7 days/week.	• High cost incurred for infrastructure and purchase of bicycles. Need for recuperating cost by overcharging to users. • Program was not successful due to issues with paperwork and proper authority. Consequently, program was launched at the end of semester and did not have much acceptance. Also, weather was severe immediately after installation and contributed to low usage.	• Invest adequate time in planning, preparation and marketing.
University of Chicago *Recycles*	• Uses properly labeled impounded bikes from campus to minimize costs • Free for students, faculty and staff when campus ID is used. • Must sign a waiver prior to admission • Multiple locations on campus	• Offers only round trips. Bicycles must check-out and return at same location during working hours. • Hours vary at different times of the year • Program is unable to charge late fee to student accounts. Only when a student owes $200 or more, a hold is put on the account. • $34,000 is required annually to hire a coordinator in its Office of Sustainability to run the program • There was not enough budget to add more bikes. • Hours limited by staffing at each station.	• Students need to be educated about locking the bicycles during member sign up process to prevent theft. • Parking fees can be used as sources of funding. • Program needs to be linked to and payable through a card system.
Loyola University *ChainLinks*	• Students manages the program. • Flexible terms for duration of rental - daily, weekly, monthly, semester basis, and academic year basis.	• Started as student-run organization of volunteers and then changed to paid student laborers. This resulted in higher operational costs • Training students to manage the system and transferring authority between students were challenging. • Additional operational cost was needed to store bicycles during winter.	• Staff support/oversight is recommended to help with the transition between students
University of Kentucky *Wildcat Wheels*	• Two programs: student (students operated) and faculty/staff (department operated) • Used federal grant (CMAQ)	• Residential hall only have two bicycles available for rentals • There is no daily rentals. • More difficult and costlier to maintain.	• TIAA-CREF is a potential funding source to explore for large-scale bike sharing systems.

	• Bicycles can be rented for various durations: weekly, semester-long, and residential hall fleets. • No membership or usage feeds, but requires to sign a waiver. • Uses refurbished bikes	• Bike shop is mainly operated by students making it challenging to train and transition authority between students.	
University of Illinois at Chicago *Illinois Cross-Campus Bicycles*	• Free of charge • Does not require a waiver • Department funded and operated	• Only available for faculty, staff, and paid graduate students of a particular department. • Store during winter season • Not inspected after each use. Difficult to notice problems and fix them, especially overnight.	• Partnering with local bike shops is recommended for maintenance. • Small-scale programs are proven to be successful.