STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

Technology Transfer Final Report

STRIDE Project ID: F3

Project Title: Evaluation of Transportation Network Infrastructure, Safety, and Travel Route Characteristics of Bike Share, Electric-Powered Pedal-Assist Bike Share, and Electric Scooter System Operation

Project Grant Period: 02/01/20 to 06/30/22

Submitted by: Dimitra Michalaka

Date Prepared: September 12, 2023,

1. Project Overview

Please provide a description of the project in easily accessible language to the public using the past tense. Approximately 10-15 sentences and explain what challenge the project addressed and how it accomplished this.

This project, now completed, delved into the dynamic landscape of individual ridesharing Mobility as a Service (MaaS) options in various U.S. cities. These options, ranging from bike share to electric-powered pedal-assist bikes (e-bikes) and electric scooters (e-scooters), emerged as potential solutions to address short-distance (3 miles or less) urban travel demands more efficiently than private vehicles. The project aimed to explore the benefits associated with these MaaS ridesharing systems, such as alleviation of traffic congestion, increased physical activity, and improved public health outcomes.

Utilizing GPS tracking and data aggregation, the research provided valuable insights into these MaaS modes. It examined differences between bike share systems, e-pedal-assist bike share, and e-scooters by analyzing trip characteristics, user demographics, transportation network conditions, and traffic operations. More specifically, GPS data of e-bike and e-scooter trips in Birmingham and Mobile, Alabama retrieved from Gotcha Powered by Bolt was used. The data was generated by e-bike and e-scooter users in both locations, where every ride is recorded with a corresponding user ID, start and end times, and trip lengths that can be inferred from latitudes and longitudes.

Roadway network characteristics, bicycle and sidewalk infrastructure, traffic operations, safety, land use, and demographics data were also collected in Mobile and Birmingham, serving as a basemap for analysis. ArcGIS Pro and ModelBuilder were employed to examine generated routes for each mode under current road infrastructures. Metrics like posted speed limits, bike lanes, and traffic counts facilitated a Level of Traffic Stress (LTS) analysis, illustrating the comfort levels users experienced on different road types.

In addition, this study quantified differences in energy expenditure, perceptions of difficulty, and acceleration between regular bikes and e-bikes in a bike share system. Initially, participants (n=15) underwent a bicycle maximal fitness test, and body composition was assessed. Two-hour steady-state bicycle rides were conducted at a local park, once on a regular bike and once on an e-bike. Continuous measurements of heart rate and speed were recorded with a heart rate monitor during each ride. Participants reported perceived exertion at four intervals within each ride, along with perceived enjoyment, difficulty, and tiredness at the ride's conclusion. Paired t-tests revealed that participants exerted more energy at a greater percentage of their maximum heart rate on the regular bike (mean=69.6%) compared to the e-bike (mean=61.5%, p=0.006). Enjoyment was higher on the e-bike (mean=4.6) than the regular bike (mean=3.8; p=0.009; 5-point Likert scale). Furthermore, perceived exertion and difficulty were lower on the e-bike compared to the regular bike ride. In conclusion, e-bike share rides resulted in lower energy expenditure than regular bike share rides, both falling into the moderate-intensity physical activity category, contributing to meeting national physical activity guidelines. E-bikes in bike share systems may be appealing for integrating physical activity into daily routines due to reported lower difficulty and increased enjoyment.

By examining the aforementioned aspects, the project contributed to a comprehensive understanding of the micro-mobility systems and provided valuable information to enhance transportation network infrastructure for accommodating these evolving MaaS travel options.

2. Research Goals

Please provide a description of the research goals easily accessible language to the public. Maximum 5 sentences.

The goals of this research project were to:

1. Examine the differences between traditional bike share, e-bike, and e-scooter micro-mobility systems in terms of trip patterns, operations, and user characteristics. Using GPS tracks and GIS analysis, the aim was to assess their potential to meet the demand for short-distance urban trips (3 miles or less).
2. Evaluate how traditional bike share, e-bike share, and e-scooter systems contribute to physical activity and public health outcomes, understanding the varying impacts of each.
3. Catalog essential elements for implementing these individual ridesharing Mobility as a Service (MaaS) modes, including traditional bike share, e-bike share, and e-scooter systems. This involves identifying steps local jurisdictions can take to address planning, operation, safety, infrastructure, capacity, and coordination challenges.
4. Investigate how roadway infrastructure influences the choice between e-bikes and e-scooters as modes of transportation, route selection, and the distances traveled by users of these micro-mobility systems.

3. Findings

Please provide a brief summary of the findings in easily accessible language to the public. Maximum 5 sentences.

This study compared e-bikes and e-scooters within urban environments using GPS data in Birmingham and Mobile, Alabama from Gotcha Powered by Bolt. The research highlighted that users tend to prefer local roads with safe bicycle infrastructure for their trips. However, some users still opt for major roadways, prompting questions about the factors influencing this choice, whether by preference or necessity. The findings emphasized the need for improved infrastructure to alleviate stress levels for users navigating e-bikes and e-scooters, even as cities adopt regulations to support micro-mobility. As e-bikes and e-scooters transition from recreational vehicles to practical first and last-mile options, it becomes crucial for cities to regulate and design infrastructure to accommodate these evolving modes of transportation. The study proposed using the Level of Traffic Stress (LTS) as a measure for identifying areas where infrastructure enhancements can promote the thriving of micro-mobility. However, the study acknowledged limitations, including the absence of complete data on other modes of transportation, origin-destination information, and user attitudes toward shared micro-mobility. Addressing these gaps could offer a clearer understanding of user preferences and inform infrastructure improvements to promote e-bikes and e-scooters as viable alternatives to traditional modes of travel. Additionally, when examining the differences in energy expenditure, perceptions of difficulty, and acceleration between regular bikes and e-bikes in a bike share system, e-bike share rides resulted in lower energy expenditure than regular bike share rides, both falling into the moderate-intensity physical activity category, contributing to meeting national physical activity guidelines. E-bikes in bike share systems may be appealing for integrating physical activity into daily routines due to reported lower difficulty and increased enjoyment

4. Performance Metrics

Please enter #s in the "Completed" column. Refer to the technology transfer plan that you created to ensure you reached your targets.

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	
Technical Report: Number of client-based technical reports published	1 – STRIDE Final Report
OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	1 – STRIDE Webinar
Professionals Trained: Number of professionals participating in trainings *(Students NOT included)*	48
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	

5. Product(s) – New/improved tool, technology, product, method, practice, or process

a) **Non-Technical Description for Each Product**

Describe all products that were created or improved during your project in 3-5 sentences in easily accessible language for the public that includes

- what problem it solves,
- how it solves the problem,
- how it can improve congestion, and
- who can use it.

The following publication was produced:

Hughey, S.M., Sella, J., Adams, J.D., Porto, S.C., Bornstein, D., Brown, K., Amahrir, S., Michalaka, D., Watkins, K., Davis, J. (in press) It's Electric! Measuring Energy Expenditure and Perceptual Differences Between Bicycles and Electric-assist Bicycles. Journal of Transport & Health.

Accessible at: https://www.sciencedirect.com/science/article/abs/pii/S2214140522001955?via%3Dihub

Abstract:
Background: One way to promote regular activity in communities is through bike share systems, which are increasingly integrating electric-assist pedal bikes (e-bikes). This study quantified the differences in energy expenditure, perceptions of difficulty, and acceleration between regular bikes and e-bikes in a bike share system. Methods: First, participants (n=15) completed a bicycle maximal fitness test and had body composition assessed. Then, two hour-long steady-state bicycle rides were completed at a local park, once on a regular bike and once on an e-bike. During each ride, heart rate and speed were continuously measured with a heart rate monitor. Participants reported perceived exertion at four intervals within each ride as well as perceived enjoyment, difficulty, and tiredness at the end of each ride. Paired t-tests were used to assess differences between the e-bike and regular bike share rides. Results: Participants exerted more energy at a greater percentage of maximum heart rate on the regular bike (mean=69.6%) compared to the e-bike (mean=61.5%, p=0.006). Enjoyment was higher on the e-bike (mean=4.6) than the regular bike (mean=3.8; p=0.009; 5-point Likert scale). Perceived exertion and difficulty were lower on the e-bike compared to the regular bike ride. Conclusions: E-bike share rides resulted in lower energy expenditure than regular bike share rides. Both bike rides resulted in moderate intensity physical activity category, which can contribute to meeting national physical activity guidelines. In bike share systems, e-bikes may be attractive for integrating activity in daily routines since participants reported less difficulty and more enjoyment.

b) Technical Description (Optional)

For technical audiences/stakeholders, please provide a more detailed description of all products.

6. Who benefits/will benefit from your product(s)?

The following groups can benefit for the findings of this research:

- Traffic and Transportation Engineers
- Transportation Planners
- Urban, Regional, and City Planners
- Architects and Landscape Architects
- Public Administrators
- Environmental Sciences
- Public Health Professionals
- Recreation and Physical Activity Professions
- Non-Profit Organizations and Advocacy Groups
- Social Science and Social Services Professions

7. Image of Product (if applicable)

If there is an image or a web link to the product please include. This will only apply to some products.

8. Body of Knowledge & Professionals Trained

A webinar with title “Transportation Infrastructure, Safety, and Travel Route Characteristics of Bike Share, e-Pedal-Assist Bike Share, and e-Scooter System Operation” was offered on September 21, 2022 by William J. Davis and Kweku Brown from The Citadel. Forty-eight professionals attended the webinar live. The webinar is now available at YouTube at: https://www.youtube.com/watch?v=0bu53qJ8QuQ The YouTube video had 65 views as of Sept. 12, 2023.

The following presentation of the completed research was made:

Michalaka, D. (Presenter), Davis, W. J. (Author), Brown, K. (Author), Watkins, K. (Author), Hughey, M. (Author), 9th Annual International Conference on Transportation, "Evaluation of Transportation Network Infrastructure, Safety, and Travel Route Characteristics of Bike Share, Electric-Powered Pedal-Assist Bike Share, and Electric Scooter System Operation," ATINER, 9 Chalkokondili Street, 10677 Athens, Greece, Athens, Greece. (May 29, 2023).

The following publication was produced:

Hughey, S.M., Sella, J., Adams, J.D., Porto, S.C., Bornstein, D., Brown, K., Amahrir, S., Michalaka, D., Watkins, K., Davis, J. (in press) It's Electric! Measuring Energy Expenditure and Perceptual Differences Between Bicycles and Electric-assist Bicycles. Journal of Transport & Health.

Accessible at: https://www.sciencedirect.com/science/article/abs/pii/S2214140522001955?via%3Dihub

9. Stakeholder Engagement

Please copy any meetings included in your quarterly reports and expand the table as needed to include all stakeholder meetings.

<table>
<tr><td>STRIDE person at meeting</td><td>William Davis, Dimitra Michalaka, Morgan Hughey, Kweku Brown</td><td rowspan="5">Narrative Description
Meeting discussions were on:
I. Sample Findings from previous Gotcha Mobility collaborations that lead into new project
II. Research Data Needs for e-bikes, e-scooters project, including locations and availability
III. Next Steps for coordination, data, analysis, deliverables and dissemination</td></tr>
<tr><td>Date of Activity</td><td>Jan. 31, 2020</td></tr>
<tr><td>Type of Activity</td><td>in-person meeting</td></tr>
<tr><td>Location</td><td>Charleston, SC</td></tr>
<tr><td>Stakeholder(s) – Name, title, affiliation</td><td>Gotcha Mobility – Jim Hemphill (Site Planning Director)</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>STRIDE person at meeting</td><td>William Davis, Dimitra Michalaka, Morgan Hughey, Kweku Brown</td><td rowspan="5">Narrative Description
Meeting agenda was on:
I. UTC and Project overview
II. Presentation of similar research done with Charleston bike share data and possible benefits of our collaboration to Gotcha Mobility
III. Data requests and dashboard access.</td></tr>
<tr><td>Date of Activity</td><td>July 27th, 2020</td></tr>
<tr><td>Type of Activity</td><td>other - please describe</td></tr>
<tr><td>Location</td><td>Charleston SC on a Zoom Conference Call</td></tr>
<tr><td>Stakeholder(s) – Name, title, affiliation</td><td>Jake Soule, Director of Operational Strategy, Gotcha Mobility</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>STRIDE person at meeting</td><td>William Davis, Morgan Hughey, Kweku Brown</td><td rowspan="4">Narrative Description
Meeting agenda was on:
I. UTC and Project overview
II. Presentation of similar research done with Charleston bike share data and possible benefits of our collaboration to the City of Columbia</td></tr>
<tr><td>Date of Activity</td><td>July 28th, 2020</td></tr>
<tr><td>Type of Activity</td><td>other - please describe</td></tr>
<tr><td>Location</td><td>Charleston/Columbia SC on a Zoom Conference Call</td></tr>
</table>

Stakeholder(s) – Name, title, affiliation	*John Fellows, City Planning Administrator, City of Columbia, SC; Shane Shaughnessy, Assist. City Planner, City of Columbia, SC*	*III. Data requests and dashboard access*
STRIDE person at meeting	*Morgan Hughey*	***Narrative Description*** *Meeting agenda was on:* *I. Reestablishing collaboration for project with new management of Gotcha - Powered by Bolt* *II. Overview of the partnership with Gotcha since 2018, including Active Living Research Conference, C2M2 Grant for case study work in Charleston + local presentations, STRIDE grant overview.* *III. Inquiry into e-bike lab testing*
Date of Activity	*January 28th, 2021*	
Type of Activity	*phone meeting*	
Location	*Charleston SC*	
Stakeholder(s) – Name, title, affiliation	*Gotcha - Powered by Bolt* *Kathryn Sims, Account Manager* *Jonathan White, Bicycle Technician*	
STRIDE person at meeting	*Morgan Hughey*	***Narrative Description*** *Meeting agenda was on:* *I. Data sharing and account dashboard access*
Date of Activity	*March 2nd, 2021*	
Type of Activity	*phone meeting*	
Location	*Charleston SC*	
Stakeholder(s) – Name, title, affiliation	*Gotcha - Powered by Bolt* *Kathryn Sims, Account Manager* *Jessica Bent, Data Manager and Analyst* *Michelle Glowacki, Account Manager* *Jonathan White, Bicycle Technician*	
STRIDE person at meeting	*Morgan Hughey, Kweku Brown*	***Narrative Description*** *Meeting agenda was on:* *I. Reestablishing collaboration for project with new planning director of City of Columbia, SC* *II. Update and review of data sharing agreement*
Date of Activity	*July 14th, 2021*	
Type of Activity	*phone meeting*	
Location	*Charleston/Columbia SC on a Zoom Conference Call*	
Stakeholder(s) – Name, title, affiliation	*Lucinda Statler, City Planning Administrator, City of Columbia, SC;*	

<table>
<tr><td>STRIDE person at meeting</td><td>Morgan Hughey, Kweku Brown</td><td rowspan="5">Narrative Description
Meeting agenda was on:
I. Establishing relationship and collaboration with Yanik Hardy, Customer Service Manager, Bewegen Bikes, Canada (Venders for Blue Bikes, Columbia, SC)
II. Providing data (dashboard) access to Blue Bikes (Columbia, SC) data. Access to detailed trip GPS tracking data and aggregated trip characteristics</td></tr>
<tr><td>Date of Activity</td><td>January 14th, 2022</td></tr>
<tr><td>Type of Activity</td><td>phone meeting</td></tr>
<tr><td>Location</td><td>Charleston/Columbia SC/Canada on a Microsoft 'Teams' Conference Call</td></tr>
<tr><td>Stakeholder(s) – Name, title, affiliation</td><td>Lucinda Statler, City Planning Administrator, City of Columbia, SC; Yanik Hardy, Customer Service Manager, Bewegen Bikes, Canada; Shane Shaughnessy, Assist. City Planner, City of Columbia, SC</td></tr>
</table>

10. Adoption/Implementation

For each product, please answer the following in 3-6 sentences.

- *Describe the adoption/implementation of your product(s) and any changes this product has or will make to the transportation system, or its regulatory, legislative, or policy framework.*
- *Who adopted/implemented the product and how will it be used (if not covered above)?*
- *Describe additional efforts that were taken (or will be taken) to encourage adoption/implementation of the product(s) (ex. demonstration/pilot projects, adoption of guidelines, change in process, commercialization).*

Adoption and Implementation:

MaaS options has been adopted by both public and private entities, including city authorities, bike share operators, and users of e-bikes and e-scooters. The data for analysis was collected from bike share systems and individual ridesharing services like e-bike and e-scooter trips in Birmingham and Mobile, Alabama. The research aimed to understand how these modes were being utilized and how they could integrate into existing transportation systems. Efforts to encourage adoption included the use of GPS data from real-world scenarios, enabling a detailed analysis of the interaction between micro-mobility options and urban infrastructure.

Impact on Transportation Systems:

The project assessed the impact of micro-mobility systems on transportation infrastructure, examining roadway network characteristics, bicycle and sidewalk infrastructure, traffic operations, and safety. Tools like ArcGIS Pro and ModelBuilder were employed to visualize and analyze the data, providing insights into route choices, road types, and the overall user experience so planners, policy makers, and engineers can understand users choices and improve transportation corridors.

Enhancing Infrastructure:
The data collected served as a baseline for understanding the dynamics between micro-mobility systems and urban infrastructure. The project suggests the use of Level of Traffic Stress (LTS) analysis as a valuable tool for policymakers and decision-makers to identify locations requiring infrastructure fortification, promoting the thriving of micro-mobility.

Promoting Physical Activity Integration:
The study not only focused on the technical aspects but also delved into the user experience, examining perceptions of difficulty, enjoyment, and tiredness while s/he was riding a conventional bike vs. an e-bike. The findings suggested that e-bikes in bike share systems could be attractive for integrating physical activity into daily routines, offering a mode of transportation that users found less difficult and more enjoyable. These insights aimed to encourage the adoption of e-bikes as a viable alternative, aligning with national physical activity guidelines.

In conclusion, the project's comprehensive approach, combining technical analysis with user experience insights, provided a valuable foundation for enhancing micro-mobility systems and fostering their integration into urban transportation frameworks.

11. Broader Impacts

Please answer the following in 3-6 sentences.

- *How has each product positively impacted the transportation system in terms of safety, reliability, durability, costs etc.?*
- *What will be the short and long-term impact of this product when adopted/implemented? Describe how the impact can be measured.*
- *Has the product resulted in new practices, behaviors, start-ups, commercialization, or transfer of results to government and/or industry?*

Short-Term Impacts:

Increased Awareness: In the short term, the project likely raised awareness about the potential of individual ridesharing Mobility as a Service (MaaS) options, especially the benefits of bike shares, e-bikes, and e-scooters for short-distance urban travel. Local communities and policymakers may have gained insights into the advantages of these modes.

Policy Considerations: The data collected and analyzed could have immediate implications for local transportation policies. Project results were presented to city authorities, that may consider implementing changes in infrastructure or regulations to better accommodate micro-mobility systems and enhance the overall transportation network.

Long-Term Impacts:

Infrastructure Improvements/Development: The project's findings likely influenced long-term infrastructure planning. Governments and city planners may have incorporated the insights from the study to develop or enhance bicycle lanes, sidewalk infrastructure, and overall traffic operations, creating a more supportive environment for micro-mobility.

Policy Revisions: Over the long term, the project's data could contribute to revisions in transportation policies. Regulatory frameworks may evolve to better integrate MaaS options into urban planning, considering factors such as safety, traffic stress, and user preferences.

Public Health Benefits: If the recommendations from the study were implemented, there could be long-term public health benefits. The integration of MaaS options into daily routines, as suggested by the project, might contribute to sustained physical activity levels, leading to improved overall public health outcomes.

Societal Shifts: If the adoption of e-bikes and other MaaS options proves successful and sustainable, there could be a broader societal shift towards embracing more eco-friendly and efficient modes of transportation. This could have implications for urban culture, lifestyle, and environmental consciousness.