IMPROVING SHARED MICROMOBILITY
TO SOLVE THE LAST MILE PROBLEM

by

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1. Introduction

Within major cities, public transportation infrastructure is crucial to the daily function of almost all residents. Historically, buses and trains have been the most popular forms of transportation. Shared micromobility, defined as rentable lightweight devices such as bikes and scooters, is a new form of transportation that has been growing in popularity. In 2022, 130 million micromobility trips were made in North America. The number of micromobility trips made per year has increased by a factor of 35 since 2010, with an increase of 40% since 2018 (Ink, 2023). This is a lot of rides, however just the NYC subway alone had over one billion rides in 2022, showing how much room there is for the expansion of shared micromobility systems (MTA, 2024).

The last mile problem, defined as the distance between the last form of public transportation and a commuters final destination, is not currently solved by any form of public transportation. Despite being called the last mile problem, this issue is also applicable to the first stretch of any commute. The goal of this project is to adapt current shared micromobility systems to solve the last mile problem within large cities. Solving this issue will result in more efficient and faster transportation. Increasing use of shared micromobility also promotes sustainable transportation.

This thesis introduces the idea of a flexible docked and dockless micromobility solution that is targeted towards solving the last mile problem. This system will promote usage by increasing the distribution of docking stations and decreasing the size and sidewalk space needed for each station. Beyond the range of pre-existing public transportation, bikes and scooters will work as a dockless system to increase range and number of users.

This document is written to fully capture the proposed design as well as the design process. Following this introduction the literature review highlights previous research into this field while pinpointing inconsistencies and framing why a project in this space is necessary. A design narrative explains the proposed solution in depth, drawing on the literature review as validation. The design process section discusses the development of this project and how it has been changed since the concept was first proposed two months ago as of writing this document. Finally, future work and conclusion serve to summarize the project and offer methods of improvement.

2. Literature Review

This section will introduce previous research regarding shared micromobility and promoting usage of these systems, while tying this project into an overarching theme of social responsibility. These sources provide valuable insight into the field of walking type pedestrian conveyances, and the final product of this project is based on these findings. The majority of the referenced sources are statistical analyses on the demographic and system data available publicly. All cited sources are peer-reviewed journal articles. Many of these sources also conducted surveys to obtain additional data to support the claims made. That being said, while surveys can be inherently limiting due to the format constricting the amount of information that can be provided by the respondents, all surveys obtained enough responses to generate statistically significant data. Surveys were conducted in both the United States and around Europe. All sources are from 2019 and later, but because micromobility is such a new and emerging field there is no analysis of the effects of COVID-19 on the results. This literature review will discuss the main users of micromobility systems as well the main use cases and reasons for use. Additionally, the last mile problem will be explored within the context of miromobility.

2.1 Who uses micromobility?

To explore the field of shared rolling-type pedestrian conveyance, it is first important to analyze the user demographics. There are many factors that correlate towards usage of micromobility systems, most notably gender and age (Wang and Akar, 2019; Nasri et al., 2020; Meng and Brown, 2021; Arias-Molinares et al., 2021; Oeschger et al., 2023). Micromobility is a field dominated by male use. Oeschger et al. 2023 found that 5.22% of female respondents had tried e-bike sharing compared to 13.18% of male respondents, which is nearly triple the rate. Similarly, Arias-Molinares et al., 2021 concluded that 35.7% and 64.3% of female and male respondents, respectively, had tried micromobility in Madrid. The general lack of female users is potentially due to feelings of safety and conflict. Many women are more concerned with safety whereas men are concerned with other factors, such as cost and speed (Oeschger et al., 2023; Esztergár-Kiss and Lizarraga, 2021). Designated bike paths and number of bike racks all positively correlate to female bike usage while traffic conditions and increased pedestrian density seem to decrease female bike usage at a higher rate than male bike usage (Wang and Akar, 2019;). Age is also an important factor in bike usage, with young adults using these systems far more than other age groups (Esztergár-Kiss and Lizarraga, 2021; Arias-Molinares et al., 2021; Oeschger et al., 2023; Meng and Brown, 2021). Biking and scootering in cities is inherently dangerous and therefore the primary audience is young adults. The main usage of micromobility systems is commuting to and from school or work, and this also explains the average age demographic (Arias-Molinares et al., 2021; Yunhe et al., 2022; Esztergár-Kiss and Lizarraga, 2021).

It is unclear whether income plays a factor in scooter or bike share usage because various studies provide conflicting results (Gong et al., 2024; Esztergár-Kiss and Lizarraga, 2021). Gong et al., 2024 provided the result that the majority of bikeshare users were middle class, but this is not a normalized result that accounts for the fact that the middle class is the largest class by population. Esztergár-Kiss and Lizarraga, 2021 and Gong et al., 2024 follows with the same conclusion. A conflict between articles arises with Arias-Molinares et al., 2021 citing a lower income for the average user. The most common reason for using micromobility as opposed to other modes of transport is because it is cheap, and this promotes a trend of lower income users (Oeschger et al., 2023). Dockless systems especially have lower income users as compared to docked systems because dockless systems tend to equitably spread among the outskirts of cities that tend to have lower average incomes. Docked systems, however, have very conflicting results, most likely correlating to the area that the study took place in (Meng and Brown, 2021).

2.2 Factors of use

After understanding who uses docked and dockless micromobility systems and why they are used, the next step is understanding what factors increase and decrease usage. One of the most influential factors that increases use is the proximity to various other public transportation hubs (Nasri et al., 2020; Weschke, 2023; Wang and Akar, 2019). In major cities, it is inevitable that most transit stops are near bike stations, but due to the mass amount of micromobility docking stations, not all of these are near transit stops. There is a significant increase in usage of micromobility stations that are within a half mile of public transit stops (Nasri et al., 2020). Weschke, 2023 analyzed scooter trips in Germany, claiming that scooters complement public transport. In this case, users transfer between public transportation and micromobility while commuting. During rush-hours on weekdays the stations that are within the closest proximity to bus and train stops are used the most (Wang and Akar, 2019).

There are a variety of factors that are cited to increase or decrease micromobility usage. General bike friendliness, defined as pedestrian oriented roads and an availability of bike racks and docking stations, has a large positive correlation with bike usage (Nasri et al., 2020; Wang and Akar, 2019). Gong et al., 2024 compared natural environment factors, such as weather and its relation to visibility, with visible quality factors, such as vibrant streets with minimal tree canopy. The conclusion drawn is that while all these provided factors promote usage, the natural environment factors are far more statistically significant. Interestingly, it is demonstrated that lower visibility due to fog promotes micromobility use, and it is theorized that this is because there are fewer cars on the roads. The majority of trends that promote the use of micromobility systems all stem from increasing the users perception of safety (Nasri et al., 2020; Wang and Akar, 2019; Gong et al., 2024; Arias-Molinares et al., 2021; Oeschger et al., 2023; Esztergár-Kiss and Lizarraga, 2021; Meng and Brown, 2021). Without supporting evidence, a conclusion is made in multiple articles, stating that increased regulations around micromobility will increase usage. These forms of legislation should regulate parking and general usage (Arias-Molinares et al., 2021; Oeschger et al., 2023; Esztergár-Kiss and Lizarraga, 2021; Meng and Brown, 2021, Fong et al., 2023, Boamah et al., 2024). Additionally, docked and dockless systems complement one another, with docked systems implemented in city centers and dockless systems implemented around the margins of the city (Arias-Molinares et al., 2021; Meng and Brown, 2021). Boamah et al., 2024 speculated that while the legislation is necessary, it is important to use it to address the inequalities that have arisen from docked systems.

2.3 The last mile problem

The last mile problem, sometimes called the first mile problem, poses many challenges for micromobility, and various sources have starkly opposing conclusions as to whether micromobility solves this stretch of commuting or not. The most common conclusion in large cities is that micromobility does not solve the last mile problem (Cui et al., 2022; Arias-Molinares et al., 2021; Oeschger et al., 2023). However, micromobility is often implemented specifically to solve the last mile problem, and in some cases it works as intended (Nasri et al., 2020; Weschke, 2023; Esztergár-Kiss and Lizarraga, 2021). In these cases, however, the claims of specifically and completely solving this problem are weak and often only hinted towards. Conflicting with the positive correlation between public transportation hubs and micromobility usage, Cui et al., 2022 found that micromobility in New York City largely competes with public transportation. In this case, competition is described in terms of users opting for one system over another, instead of using both. In this aspect, Yunhe et al., 2022 claims that micromobility does not solve the last mile problem. The presence of ambiguity in answering whether micromobility systems function as intended to solve this problem point to the conclusion these systems are imperfect and therefore do not solve the problem well enough, if at all.

Creating a system to solve the last mile problem will increase usage in micromobility systems, promote eco-friendly transportation, and increase commuter efficiency within city limits. This project can be used as a stepping stone towards reorganizing and reshaping existing systems, such as Citi bikes and Lime scooters. All referenced literature is used as a foundation on which this project is built. Any areas of conflicting data are assumed as whatever is the worst case.

3. Design Narrative

Using the analysis within the literature review, the following system was created and iterated upon. The proposed system was specifically designed for Manhattan and the preexisting Citi Bike system in place, however this system can be implemented in many large cities with small tweaks.

3.1 Existing Solutions

Currently, there are two models of shared micromobility: docked and dockless. Each of these systems has pros and cons, and various companies have adopted different models. Citi Bikes, found in Manhattan follow a docked system whereas Lime scooters, located all around the United States and Europe, are completely dockless.

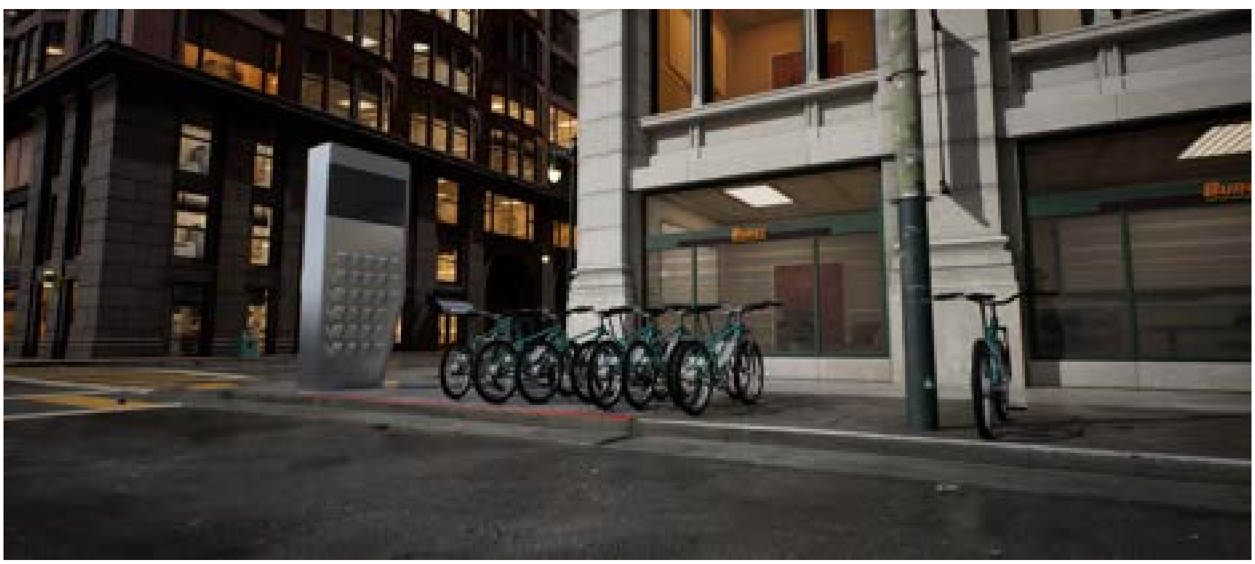
Docked systems, such as Citi Bike, require a user to start and end their trip at designated docking stations. These stations function to provide charging to the units while also structuring the usage and management of the units. With docking stations, users know exactly where to go to get a bike or scooter, and that location never changes unless the station is completely empty. This brings to light a negative aspect of docking systems: full and empty stations. When a station is completely empty, a user is unable to begin their trip at that location and must transport themselves to the next nearest unit. On a similar note, when a station is completely full a user is unable to end their trip at that station. According to Meng and Brown, 2021, this issue is less of an issue for frequently used stations in citi hubs. This issue is most prevalent for stations that are in less densely traveled areas of cities.

Dockless systems, such as Lime, allow users to leave the units along sidewalks, offering a tailored experience that allows users to end destinations anywhere they desire. The benefit of a dockless system is that a user's trip ends exactly at their final destination. However, this benefit also proves to be a negative aspect of the system. To begin a trip, a user must use the Lime app to locate the nearest scooter to them. After locating the scooter, the user must travel to it and then their trip may begin. Without docking stations, there is also a question about charging these devices so that they are ready for each day's user. To tackle this, Lime hires "juicers" who are paid to collect and charge the bikes and scooters overnight and then return them to designated locations in the morning.

It is obvious that both docked and dockless systems have positive and negative aspects to them, and therefore the proposed solution to the last mile problem utilizes both docked and dockless methods to obtain the benefits of each system.

3.2 Final Design

The final design proposed to tackle the last mile problem is a revamping of the existing Citi Bike system that allows for smaller docking stations to therefore increase the number of stations located around Manhattan. This system also utilizes a dockless method outside of the bounds of the Metropolitan Transportation Authority's (MTA) subway and bus region to equitably distribute bikes and scooters.



Figures 1 - 4: Proposed design for a condensed docking station.

As mentioned in the literature review, one of the most important aspects to increasing the usage of shared micromobility is to increase the availability of these systems. Additionally, docking stations inherently do not solve the last mile problem, and thus it can only be solved if these stations are located all over Manhattan, within a block or two of any destination. To accomplish this, docking stations must be made smaller to reduce the amount of sidewalk space that is taken up. To shrink traditional docking stations, the proposed solution involves a battery rental system. Citi bike stations consume a large amount of space because each bike needs a spot where it can lock into a battery charger. By creating a central charging station, the bikes and scooters can be greatly condensed. Utilizing the dockless method of leaving scooters and bikes on the sidewalk, this solution involves areas next to the battery kiosks where the bikes and scooters can be leaned against one another and closely contained. Kiosks such as this will be located on almost every city block of Manhattan, effectively eliminating the last mile problem because of the proximity to all destinations. Figures 1-4 showcase the proposed docking stations on a standard Manhattan city block.

Another key piece of information from the literature review is that shared micromobility is greatly promoted when docking stations are near public transportation stops such as bus or train stations. This solution will be closely integrated with the existing MTA infrastructure around Manhattan. With the intent to solve the last mile problem, it is expected that the docking stations adjacent to train and bus stops will get the most use, and therefore these locations will require larger areas with multiple charging kiosks or one larger kiosk. While not shown in the figures above, this is a consideration that is accounted for. Solving the last mile problem within Manhattan is inherently a very large and complicated task, and thus each docking station attached to a public transportation stop would require a large amount of data analysis to properly determine the proper size. The current solution is to include multiple charging kiosks, adding more to each station if necessary once the system gains popularity.

According to Meng and Brown, 2021, docked models thrive within busy cities, while dockless models are beneficial around the outskirts of cities where it is not feasible to have a large quantity of docking stations. This solution accounts for this, with the ability for a user to use their device docklessly if their required final destination is outside the bounds of Manhattan and significantly distant from any train or bus stop.

Additionally, a major theme for supporting the use of shared micromobility was improving the previewed safety around these systems. To that end, if this system is adopted by Citi Bike there will also be increased legislation and a marketing campaign accompanying it. This legislation will need to be looked into more in depth, however by adding simple rules such as including forward and rear facing lights on all models and then communicating that with the public people will be more interested in using the bikes. In an ideal world, this legislation would expand as far as completely remaking Manhattan streets to include safe bike lanes, however that is a concern for the future.

Finally, this improved Citi Bike system will be accessible through a smartphone application, where users can put a short hold on batteries to ensure that they can seamlessly transfer from trains and buses to bikes and scooters. To rent a battery, a user will go through the process of paying and reserving the battery within the smartphone application. Once rented, a barcode will show on the phone screen. A quick scan at the kiosk will unlock a battery, and a ring of light around the battery will be lit to identify which battery is removable. Once removed, the user will transfer the battery to their transportation mode of choice, and it will seamlessly lock into place. After traveling to the final destination the user will end their trip. If ending at a docking station, all the user will have to do is remove the battery and slot it into the kiosk. If the user is leaving the device dockless, they will have to end the trip within the app.

3.3 Social Responsibility

The theme for this project was ‘social responsibility,’ and this project engages with it in a number of ways. Firstly, biking and scootering is an environmentally friendly method of transportation and this entire project is centered around increasing the usage of these systems. By promoting active forms of transportation, there is potential to see a meaningful decrease in dependance on fossil fuels for short range transportation. This project also promotes accessibility, as it is specifically designed to not only function within the bounds of Manhattan but to provide cheap transportation with neighboring communities, promoting connection between them. Finally, this project also focuses on safety, as this is a key element in if the solution will work or not. Remodeling the Citi Bike system specifically to promote safety is an excellent first step in more meaningful legislation around safety and eco-friendly travel.

4. Design Process

This project was completed over the spring semester of my senior year at Rensselaer Polytechnic Institute. Beginning in February 2024, this project went through the stages of ideation, pinup, and then three prototypes, with the third being the final renders shown above in figure 1-4.

4.1 Ideation

When starting this project, I originally knew that I was interested in an issue surrounding transportation in Manhattan because that is where I grew up and I am very familiar with the current state of available public transportation. After some preliminary research I created a project proposal narrowing down the topic to focusing on micromobility. After annotating nine peer reviewed sources and completing two synthetic annotated bibliographies in my design journal I was able to narrow down the problem to the following question:

Why does micromobility fail to solve the last mile problem and how can it be adapted to better solve this issue within large cities?

With this question in mind, I was able to begin to think about a potential solution to this question. To help visualize the question and a potential solution, I created two moodboards, one for the problem and one for the solution.

Figure 5: Problem space moodboard.

Figure 5 shows the first moodboard created which serves to show existing micromobility systems in both a functional and nonfunctional state. On the left Lime scooters are shown and on the right are Citi Bikes. There is also a trend of functional devices towards the top of the moodboard and broken devices towards the bottom. During the creation of this moodboard I was already formulating the idea of a rentable battery system, and being able to look at both Lime and Citi Bike devices next to one another was useful in showing what is attractive in a system and what is not. The middle photo on the left side of the moodboard showing Lime scooters on a sidewalk was especially useful because it mimicked the row of Citi Bikes but it contained the ability to be greatly condensed due to the lack of docking station. With this in mind, I created a second moodboard.

Figure 6: Design solution moodboard.

Figure 6 shows a moodboard of pictures that inspired my initial design. Regarding the battery kiosk, my initial idea was for this to have the same functionality as a vending machine. Vending machines are not especially good looking, however, and that is why I included the bottom right photo of existing wifi kiosks that are located around Manhattan. While creating this moodboard, I wanted to focus on inspiration for the user interaction with a battery, and therefore both an electric skateboard and a hand drill with removable batteries are shown. Finally, as mentioned above, a big takeaway from the first moodboard was the ability to closely line multiple scooters on a street, and I furthered this by including a photo of both bikes and scooters aligned together and a photo of dockless scooters in a designated area. This designated area was another photo that was especially useful to my project because it shows a dockless model that still retains the structure and order of a docked model, and this is exactly how I wanted my final product to act. After both moodboards and over the course of a few weeks, I performed ethnography while traveling to record further inspiration. The results of this ethnography can be found in Appendix A.

4.2 Pinup

After creating two moodboards and understanding what aspects of each were most meaningful to my project, I used this knowledge to sketch my imagined final product. This sketch was closely based on existing Lime scooters and Citi Bikes to accurately show the final product.

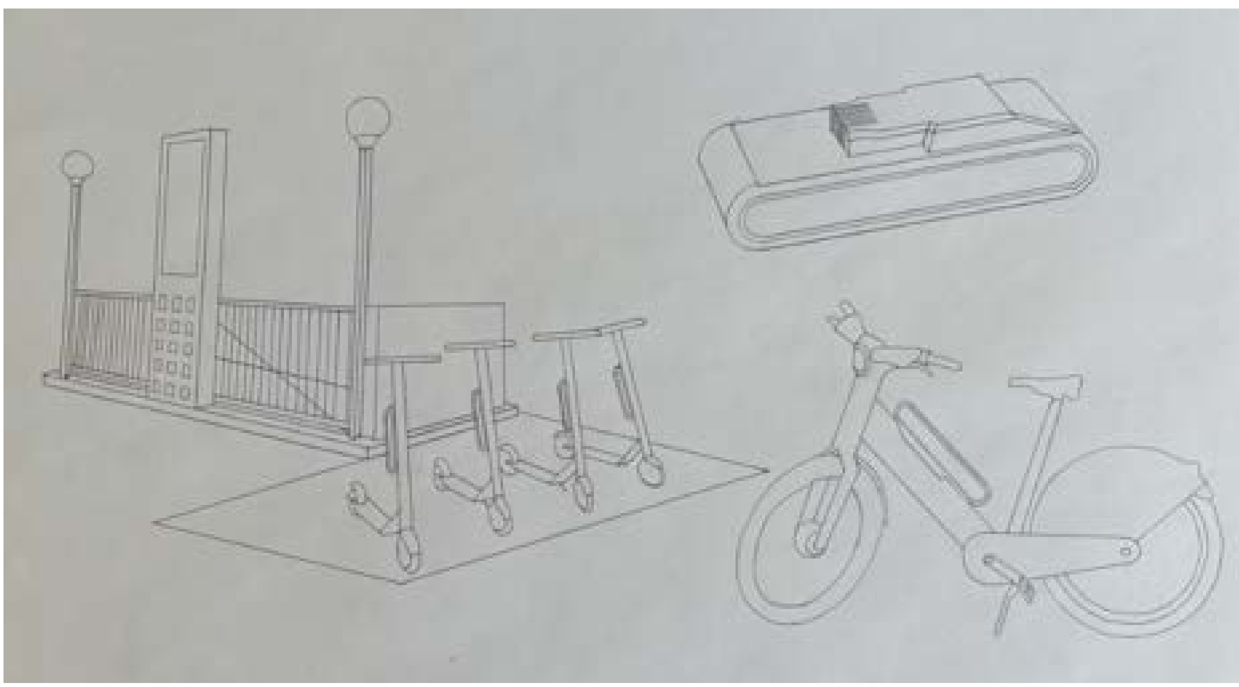
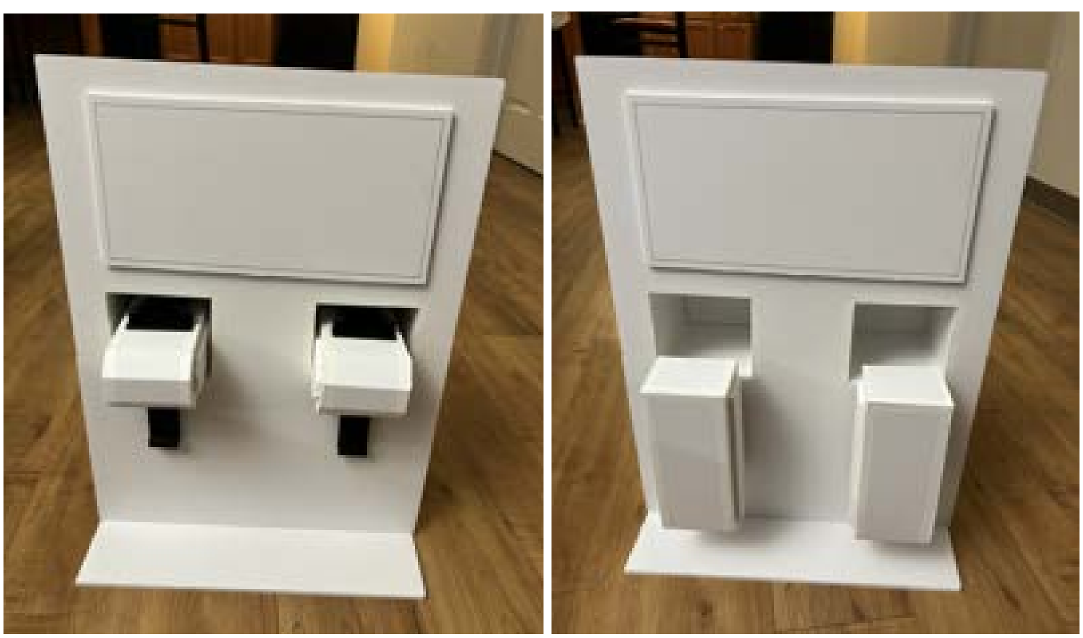


Figure 7: Pinup of battery rental kiosk.

Within this pinup, the left side showcases a battery rental system mounted to a Manhattan subway station. On the ground there is a defined line where scooters and bikes can be parked. On the bike and each scooter a battery is mounted in a position that I felt was most optimal for the ease of attachment after rental. The top right also showcases a potential design for the battery that is based off of a clip-in battery for a hand power tool, as seen in Figure 6. It was during this time that I understood the importance of a smooth user experience. A battery that smoothly slides and then clicks into place is an important part of a user's interaction with this system, and this is an idea that I carried with me into my first prototype.

4.3 Prototypes and Feedback

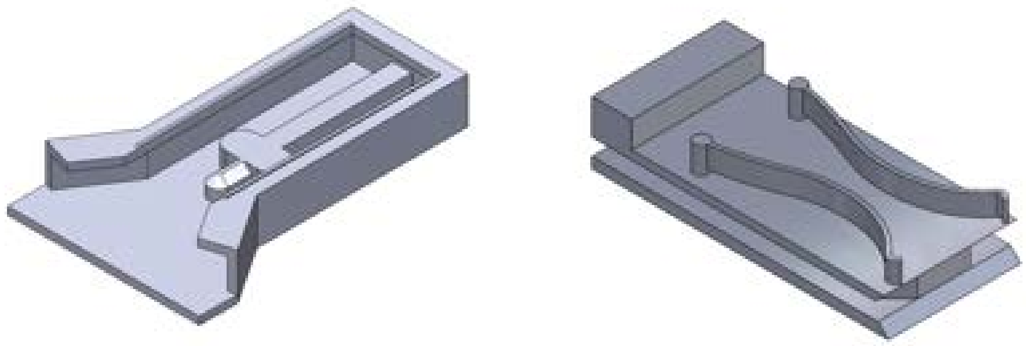
With a vision of a final product in mind, I began prototyping as well as reaching out to users of existing micromobility systems to achieve outside perspectives on what can be improved with existing systems as well as with the design I showed to them.



Figures 8 - 9: Usability prototype of a battery kiosk.

Figure 10: Usability prototype of a battery.

The first prototype was designed specifically with the goal of obtaining valuable user feedback regarding interaction with the battery kiosk. This prototype was designed as a usability model, where a user is able to mimic renting a battery and attaching it to a bike. This prototype was made out of foam core, and white painters tape was used to cover all seams to create a polished look. When creating this prototype, my main goal was to not only make a prototype that looked simple and well put together, but I really aimed to focus on the feel of the device. The black part located on the top of each battery and their paired units on the foam core kiosk are a custom designed and 3d printed compliant mechanism that allows the batteries to lock into place with a satisfying click.



Figures 11 - 12: Spring clip mechanism.

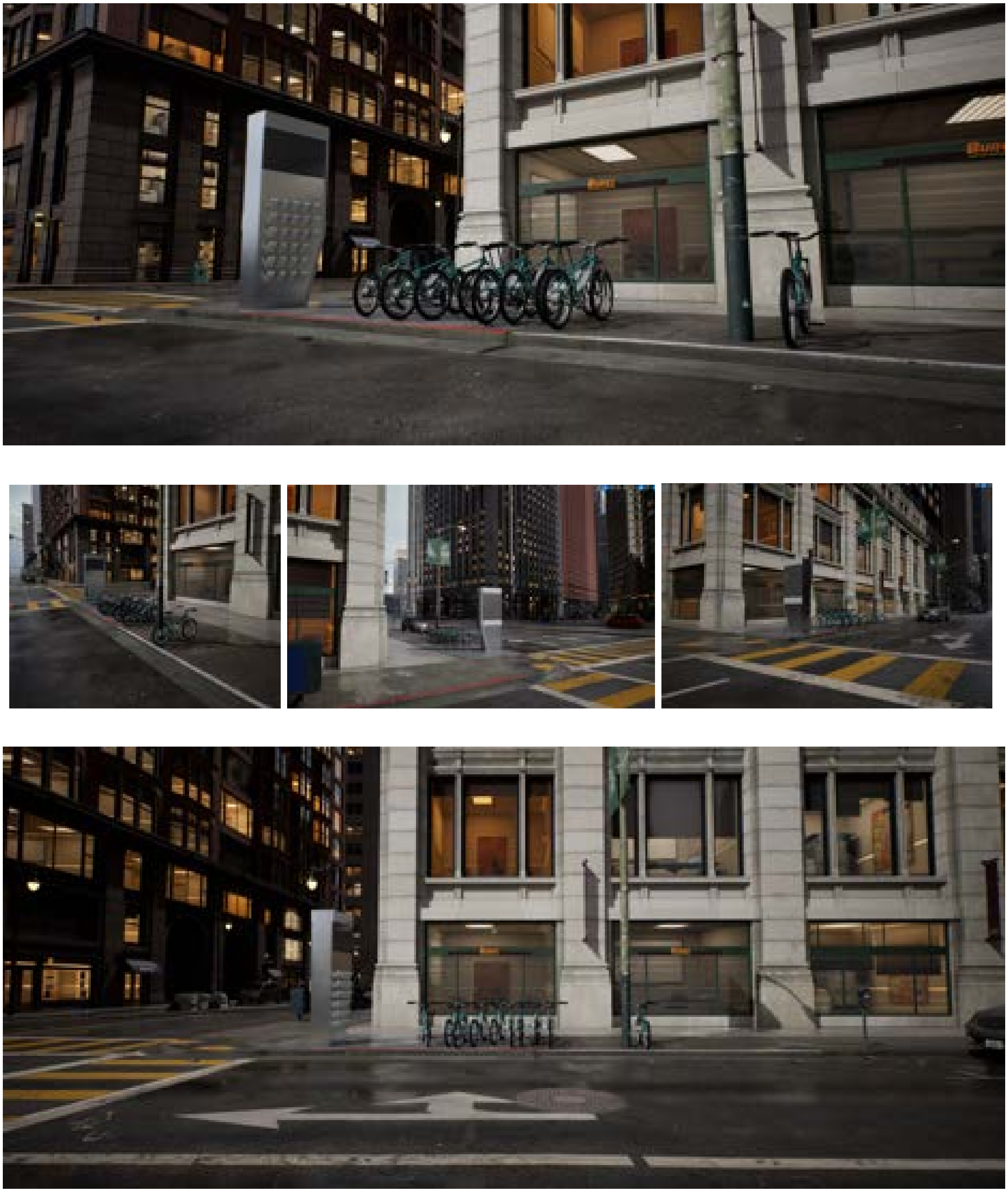
Figures 11 and 12 show the fourth iteration of the spring clip mechanism. This mechanism required multiple iterations to perfect tolerancing and provide the most satisfying click to lock the battery into place. The device in figure 12 is the part that is attached to the kiosk below each battery in figure 8, allowing for the batteries to be mounted as they are in figure 9. This is not to test different mounting configurations for the kiosk, but rather it is a simulation of attaching the battery to a bike or scooter, so that a user can fully walk through the process of beginning and ending a trip using this system.

With the creation of this prototype, I was able to reach out to users of existing micromobility systems to pitch my design. The first person I interviewed was a friend of mine named Charlotte. Being from Manhattan, Charlotte has plenty of experience using Citi Bikes. After being asked about what prompts her use, she explained that it was always for leisure and never for transportation. Because of this she would oftentimes end a trip at the same docking station that she began at. After being asked about what caused her not to use Citi Bikes for transportation, she mentioned that she travels to Europe quite often and has used Lime scooters around Germany because of the dockless aspect and the ease of use. At this point in the discussion I transitioned to pitching my prototype. This interview was conducted over the phone, but I was able to send a video of the prototype through text and then discuss the process while Charlotte watched. After understanding the idea, Charlotte's first concern was regarding theft of the bikes lined up next to the battery kiosk. After some discussion, however, we arrived at the conclusion that this was not a pressing issue because the bikes will be able to lock without a battery much like any shared dockless micromobility device. After more general discussion about the project, Charlotte's conclusion was that it seems to be an interesting redesign, but while she thought it would be popular there would be no way to really tell for sure without fully implementing it.

Seeking more feedback, I reached out to Craig, another friend from Manhattan who has experience with Citi Bikes. This interview happened over FaceTime and Craig had similar positive feedback to Charlotte, however the discussion with him became more focused on the specific user interaction with the kiosk. After an explanation of the last mile problem and then showcasing my prototype, Craig asked a very important question of "I know these are supposed to be located everywhere, but for this demo specifically where is this one?" This was an important question that I had failed to address with Charlotte. Current Citi Bikes are located on the sidewalk already, so I decided that for this demonstration it should be a model that is built into a subway station. To explain this, I showed Craig the pinup in figure 7. When walking through the use, Craig and I began by talking about getting off of a train and going up the stairs to the sidewalk. It was at this part of the conversation that I had the realization that different sized kiosks would be needed for different locations. Additionally, Craig and I discussed how users of this kiosk would arrive in large waves because they would all be getting off of a train at once. In figures 8 and 9, there is a piece of foam core with a rectangle drawn on it to mimic a user interface. At this point in the project, I had imagined that this is a touch screen, however during the discussion with Craig we decided that a phone app paired with a simple barcode reader would be much more efficient and able to account for a large number of users at once.

Figure 13: Model of a kiosk and subway combination.

Figure 13 draws on the feedback from interviews, showcasing a physical model based off of the original pinup sketch shown in figure 7. This new model of a kiosk is much larger than previous models because of its attachment to the subway. It also has two screens to accommodate multiple users at once. In this model, the kiosk is strategically placed behind the staircase down into the station because this is the position that obstructs pedestrian traffic the least. Growing up in Manhattan, I have always known that the area right behind subway stations gets little traffic because people need to move over to pass the station. Capitalizing on this I believe that this prototype highlights the optimal position for the kiosk. While this prototype offered a good visual model, I came to the conclusion that the size of the docking station will have to vary among different subway stops and determining this size will require a much more in-depth analysis of each station. This analysis is too much for myself to handle within one semester.



Figures 14-18: Final renders of a docking station on a city block.

The goal of this final prototype was to create a polished visual of my solution. These images were made in Unreal Engine, using the free City Sample level as a background. This prototype shows a docking station on a city block, not connected to a bus or train station. This was an intentional choice because the previous prototype had covered what a station connected to a subway stop might look like. Stations such as the one depicted in this render will be the most common if implemented because these are the stations that will be on almost every city block that does not have other forms of public transportation.

5. Future Work

There is quite a lot of future work that is necessary before this project can be feasibly implemented within Manhattan. The first step would be a more detailed focus on the design, specifically as it differs among locations. Following this, there is a lot of work needed to be done to implement this design.

5.1 Design Updates

Regarding the design of this system, the most important next step is understanding how the battery kiosks will differ between bus and train stations, and also how it will differ between various subway stations. Subway stations that are stops on the express trains have to deal with these as well as the local trains, making them naturally larger stations to accommodate for more people. A stop like this will need a different kiosk design to a stop that is in place for a single train line. If connecting with Citi Bike, little work will need to be done around the battery besides finalizing a locking mechanism to keep it in place while a bike or scooter is in motion. Because they already run electric bikes, they will already have an existing battery that can be adapted to a removable format. All of this work is too difficult for a single person to handle, and therefore it will need to be done by Citi Bike if they were to accept this redesign. It may also be interesting to figure out an interlocking mechanism, much like shopping carts have, to minimize the space that bikes and scooters are taking up on the sidewalk.

5.2 Implementation

If Citi Bike accepts this redesign, they will need to completely change their existing system. First of all, specific locations on sidewalks will need to be chosen and mapped out to ensure that the last mile problem is minimized for every location within Manhattan. Additionally, Citi Bike will need to work with the New York state government regarding legislation that is needed to improve safety and promote usage of these systems. Once the system is finalized enough where it can be feasibly implemented, it should be implemented in a small area at first to serve as a case study and ensure that it is both an effective system and profitable if implemented completely.

6. Conclusion

The last mile problem is an issue within all major cities. This thesis has proposed a solution in which the Citi Bike system can be updated to solve this issue within Manhattan. This solution is a flexible docked and dockless micromobility system that promotes usage by increasing the distribution of docking stations around the city while decreasing the size and sidewalk space needed for each station. Beyond the range of pre-existing public transportation, bikes and scooters will work as a dockless system to increase range and number of users.

Overall this project has resulted in one large change to Citi Bikes, the conversion to a battery rental system, that will need to be supplemented with a series of smaller changes, such as improved legislation, to be effectively used to solve the last mile problem. The magnitude of the identified problem requires additional work on the proposed solution before it is able to be added to the streets of Manhattan. This project was completed over the course of the 2024 spring semester at Rensselaer Polytechnic Institute as part of the senior project for a Design, Innovation, and Society major.

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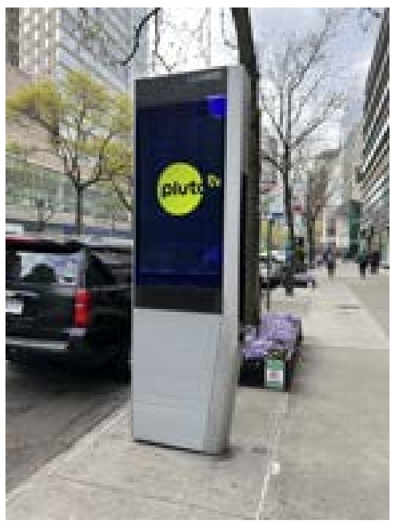
Appendix A: Ethnography

The following images were taken in Troy, New York surrounding the Rensselaer Polytechnic Institute campus:




The following images were taken in Manhattan:







Appendix B: Poster Presentation