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The Case for Micromobility in Petersburg, Virginia

Background

Micromobility can be defined as “any small, low-speed, human or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles (e-bikes), electric scooters (e-scooters), and other small, lightweight, wheeled conveyances” (Federal, 2023). Micromobility has been slowly introduced across many cities in the United States successfully as a means to advance equitable access to transit and to enhance mobility for residents. Its easily accessible nature and its privately owned nature have made the transportation option attractive to cities.

One such city that is in the process of considering whether micromobility will be beneficial to its community is Petersburg, VA. The micromobility vendor Bird met with the city to evaluate whether or not the City of Petersburg was a good fit for a partnership in October of 2023. Ultimately, Petersburg decided that they were not ready to agree to bring micromobility services to their city at that time.

Though the City decided they were not ready to introduce micromobility, the Director of Planning and Community Development of Petersburg, Naomi Siodmok, asked us to analyze whether introducing micromobility to Petersburg would be feasible to bridge first mile/last mile transportation gaps in Petersburg considering the existing transportation infrastructure.

Purpose

We are taking an exploratory approach to this project by building a broad database for the City of Petersburg. We are doing this by collecting, analyzing, and visualizing a variety of geospatial data and developing a series of maps to help give recommendations for the City of Petersburg when they decide whether or not to introduce micromobility devices to the city.

We defined the study area as the entire City of Petersburg because micromobility devices would be taken across the city. However, we also included Virginia State University (VSU) as a major stakeholder in potential micromobility usage, because university attendees are more likely to use micromobility devices than other demographic groups (Sanders et. al., 2020). We were also told by Naomi Siodmok that VSU students traveled between their campus and downtown Petersburg frequently, and introducing micromobility devices would make access between both sites easier for students and anyone else.

Hypotheses

Following a direct site visit to Petersburg in September of 2023, we hypothesized that the city has the potential to have the makings for micromobility vendors to successfully operate within it. Most of the city streets have speed limits at a micromobility-friendly speed of under 35 miles per hour maximum but the majority of street speed limits are around 25 mph. We agreed at the outset of this project that micromobilty has the potential to service transit-underserved populations due to its nature. However, there were some concerns over the existing infrastructure and safety. We found very few bike lanes in the city, and e-scooters are not legal to ride on sidewalks in most places, including Petersburg. There were various hazards on roads, including potholes and cracks. These conditions suggested that Petersburg might need to make major infrastructural improvements before safely being able to introduce micromobility.

Process and Data

The final results of our analysis can be viewed in our final dashboard here.
All data layers created are available for download here.
The Source Code is available here.

Our final product is an ArcGIS dashboard that includes three separate ArcGIS web maps for bus stops, schools, and activity centers with micromobility coverage analysis and demographic analysis for equity zones.

We categorized the likely destinations into three broad categories: bus stops, activity centers, and schools. For each of these categories, we made a separate isochrone layer to analyze the potential micromobility coverage. We broke down our process into four broad steps: determine likely destinations, define polygons (isochrones), analysis of isochrone coverage, and consider demographics.

Determine Likely Destinations:

We received the bus stop location data from Naomi Siodmok. For the schools and activity center layers, we pulled our data from Open Street Map and Overpass Turbo to obtain the GeoJSON files needed to be uploaded in R. For the Activity Centers, we combined the various keys we took from Open Street Map which includes: amenity, building, craft, healthcare, historic, leisure, office, shop, tourism. We chose to include these keys based on the Planning Advisory Service (PAS) Memo *Identifying Activity Centers: A How-To Guide* published by the American Planning Association. An example of our code and data extraction for schools from Overpass Turbo is seen in *Figure 1*.

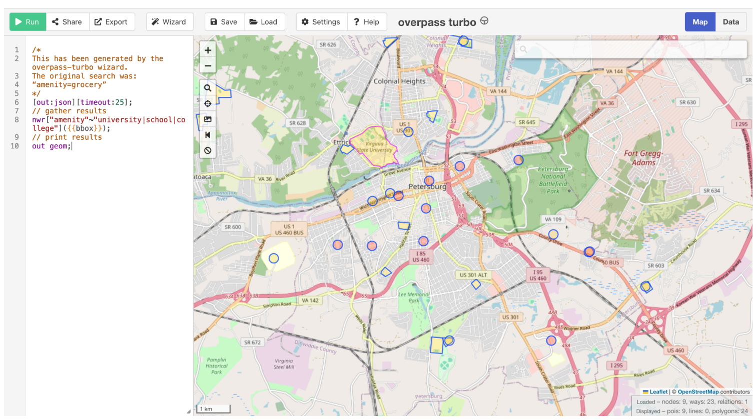

Figure 1: Overpass Turbo

We sent our school and activity center heat map to Naomi Siodmok and the Petersburg Planning Department for cross-checking and ensuring a level of accuracy in our data. Lastly, the boundary of Petersburg was provided by Professor Bev Wilson.

After importing all the GeoJSON files into R we proceeded to do some data cleaning to ensure accurate and reliable likely destination points. For the activity centers, we used the kernel density function provided by Professor Wilson to highlight areas that have a higher density of likely destinations by micromobility. By varying the degree of density, we were able to create multiple layers with different areas to represent the activity centers which we will combine to create a heat map in our ArcGIS web map.

Define Polygons (isochrones):

We defined polygons around each likely destination point showing the areas where people can start their micromobility journey and reach the identified destination, known as an isochrone. According to the National Association of City Transportation Officials (NACTO), 11 minutes was the average micromobility trip duration in 2019. Using the MapBox data, we created isochrones around each bus stop, school, and centroid of activity centers based on the distance a bicycle (similar to the traveling speed of a micromobility device) could travel in 11 minutes.

Demographics:

The demographics data for the ratio of low-income households in Petersburg and the ratio of households with no vehicles was pulled from the 2021 American Community Survey (ACS). Low-income is defined by the United States Department of Housing and Urban Development (HUD) as at or below 80% of the Area Median Income (AMI) of Petersburg. We needed to sign up for a Census API Key and include our own API code to obtain the demographic data. We then created a Transit Dependent Inference (TDI) which was the average between the ratio of households with no vehicles and the ratio of low-income households for each block group. We identified equity zones as areas that had a TDI greater than 30%, which was about ½ of a standard deviation from the mean of TDI values in Petersburg.

Results

Coverage:

Based on our analysis of potential micromobility coverage, the introduction of micromobility to Petersburg would likely make transit geographically accessible nearly everywhere in the city. There are notable gaps in coverage, however, in the Southwestern corner of the city, where a majority of the uncovered land is more rural than the rest of Petersburg. The current transit coverage in Petersburg is mainly concentrated in the Northern part of the city and along South Crater Road, which runs North-South through the center of the city. The spotty transit coverage in the area combined with a less dense road network likely contributed to the lack of micromobility coverage in the Southwestern corner of Petersburg.

Coverage of areas that could reach likely destinations was also fairly widespread. The activity center isochrones clustered mainly along the central I-95 corridor, excluding the eastern and western portions of Petersburg. School isochrones also covered a majority of the city, with uncovered spaces including the Southwestern and Southeastern corners of the city and Petersburg National Battlefield. The VSU isochrone also covers the activity center corresponding to downtown Petersburg, allowing VSU students easy access to that area. This coverage indicates that a majority of the area of Petersburg could use micromobility to reach at least one likely destination, whether it is an activity center or school.

Equity:

Our equity analysis highlighted 11 of the 31 census block groups in Petersburg as having a high proportion of likely transit-dependent residents based on factors of household vehicle ownership and income. All but one block group, which was a suggested equity zone, has at least one bus stop inside its borders. The average number of bus stops in a block group was about 10 with a range of 0 to 32, whereas the average for equity zones was 14 with the same range. *Figure 2* shows the relationship between TDI and the Number of Bus Stops per census block group is generally positive, but with an R^2 value of 0.1, only 10% of the variation in TDI can be explained by the number of bus stops. Additionally, the correlation between the two was found to be about 0.32, also showing a slight positive association. In summary, equity zones have above-average transit coverage in Petersburg, and generally, as the number of bus stops increases so does the TDI. This indicates that,

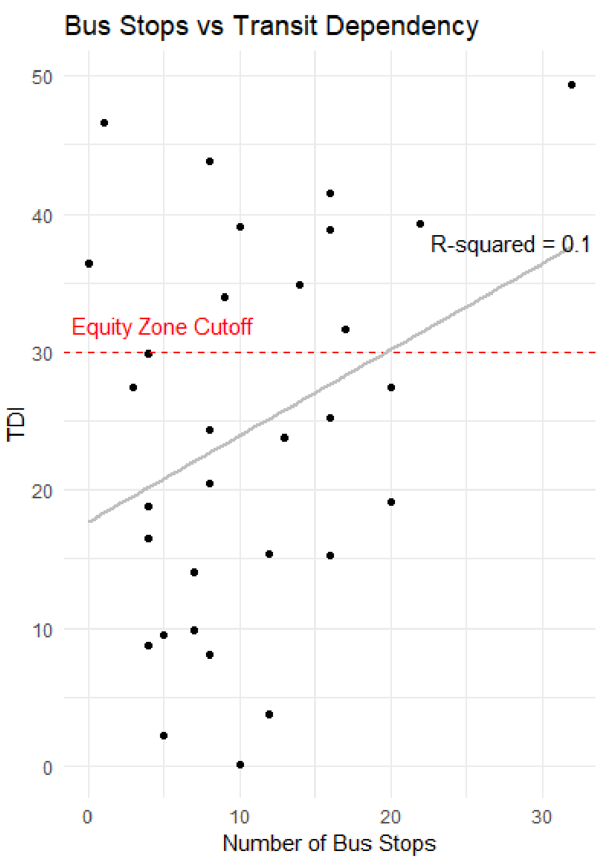

Figure 2: Bus Stops vs. Transit Dependency

overall, the populations who likely need transit access in Petersburg have it, at least at the granularity of census block groups. However, it is also worth noting that the block groups with the two lowest number of bus stops, 0 and 1, were both equity zones.

In terms of micromobility coverage, each equity zone is nearly entirely covered by the bus stop isochrones, showing that micromobility would increase access to those who likely need it most, including those equity zones with no or few bus stops within their borders. Additionally, the isochrones around activity centers, which indicate where micromobility devices are most likely to cluster naturally, cover nearly every equity zone. This shows that without vendors rebalancing the micromobility fleet, devices are likely to end up in equity zones anyway. However, there are some equity zones with little or no coverage by activity center isochrones, making rebalancing important for those block groups.

Recommendations

Infrastructural Analysis:

Based on the factors of micromobility coverage and equitable access, Petersburg residents would likely benefit from the introduction of micromobility to their city. However, without an infrastructural analysis, it is difficult to determine whether Petersburg is ready for micromobility. Micromobility riding requires “safe and connected bicycle and pedestrian facilities,” according to the Federal Highway Administration in 2023. As such, the next step for the City of Petersburg is to determine if there is sufficient pedestrian and bicycle infrastructure to support micromobility. One common metric for assessing cycling infrastructure is the Level of Traffic Stress (LTS), which considers the number of lanes, vehicular traffic speed, existing cycling facilities, cycling facility width, and more (Weikl and Meyer, 2023). An analysis of the main roads using this metric would allow for a better understanding of the state of cycling infrastructure in Petersburg and if it is sufficient for micromobility. Additionally, if the city decides to allow sidewalk riding, an analysis of the Pedestrian Level of Service (PLOS) for the main roads of Petersburg would also be a useful piece of an infrastructural analysis.

Lastly, micromobility devices will need spaces to park out of the way of pedestrian and motorized traffic. On average, E-scooters are about 3 feet wide, which would take up over half of the 5-foot minimum sidewalk width declared by the Virginia Department of Transportation (VDOT) (Sandt, 2019; VDOT, 2018). To support micromobility without it becoming an obstacle to pedestrians and drivers, Petersburg should assess if there are ample spaces around the city for these devices to park. If not, the city may need to invest in creating and designating spaces for micromobility devices to park.

Limitations

Methodology Changes:

Our methodology did change a fair amount from where we started as we found issues with some of the tools we used. Firstly, we had originally planned to pull likely destinations from the Google Places API, but we learned that the API would only pull 25 points at a time, which didn't suit our purposes. After that, we switched to MapBox Overpass Turbo, which required our methodology to change to match the new querying process. Mapbox Overpass Turbo had a much more strict querying process than Google Places API: the latter allowed us to just enter a search string, like “Restaurants in Petersburg.” The former required us to specify a key, such as ‘amenity’ or ‘building’, both of which had ‘restaurant’ as potential values.

Because of the possibilities for overlap and the difficulties in differentiating between our original categories, we abandoned the methodology outlined in the PAS memo. The PAS memo outlined 5 activity types: community, tourism, consumption, institutional, and economic. Originally, we had planned to develop 5 activity center types based on each of these categories. However, after changing to Mapbox Overpass Turbo, we found that it became too difficult to confidently make distinctions between each of the activity types. Therefore, we decided to only create one activity center type, including likely destinations from each activity category.

Lastly, we had originally used Open Street Map to generate our isochrones around schools and activity centers, but we later found that this method resulted in significant errors when calculating bus stop isochrones. In the Eastern part of Petersburg, the isochrones generated would not even touch the bus stop destination point. Because of this, we switched to a Mapbox isochrone function. This worked well, and we re-generated all of our isochrones using this function for consistency.

Improvements:

In addition to the aforementioned infrastructure analysis, one potential improvement could be including more demographic considerations. The TDI created to outline equity zones only includes 2 factors: household vehicle ownership and income. To improve this demographic analysis, factors such as race could also be included. For example, the National Capital Region Transportation Planning Board describes one method in its 2017 Methodology for Equity Emphasis Areas where census tracts with higher proportions of low-income, African American, Asian, Hispanic, or Latino populations than the regional average are designated "Equity Emphasis Areas."

Caveats:

We have since addressed the outdated bus data used in the first iteration of our project, but likely destinations still remain an area of lower accuracy. The data pulled from Mapbox Overpass Turbo is not entirely consistent with the data present on Google Maps. It originally included some historic schools that we were able to remove from our data, but the inaccuracies with the other likely destinations were too significant to clean. Though our final activity center polygons appeared accurate after speaking with Naomi Siodmok and her colleagues, the individual points from which the activity centers were derived were incorrect.

Generalizability:

The analysis we performed was localized directly to the city of Petersburg and the surrounding areas, but the methodology used could certainly be applied to other jurisdictions looking to determine the utility of bringing micromobility to their area. For municipalities with greater or lesser population density, the kernel density numbers used would likely need to be adjusted so that activity center areas are not too large or small. Additionally, the equity zone cut-off of 30% was about ½ of a standard deviation away from the mean TDI, but it was chosen based on the visualization of Petersburg's data. Other jurisdictions may have more or less dispersed TDI distributions, and therefore the equity zone cut-off should likely differ across localities. Other than those changes, our methodology is easily replicable in other places and useful with these small changes, provided there is bus stop data available.

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