# Micromobility in North Carolina

## 2024

## Appendix A & B

# Contents

# Appendix A: Literature Review

Micromobility is a continuously evolving and emerging form of transportation that spans different devices and types of service. A comprehensive literature review was necessary to better define the North Carolina Department of Transportation (NCDOT)'s Integrated Mobility Division (IMD)'s role to support the implementation of micromobility service in communities across the state. This review attempts to define the state of micromobility nationally and internationally and its emergence in North Carolina. Over 40 resources on micromobility topics provided a starting point for this structured review of available, relevant literature.

The literature review is organized into the four key themes below, followed by a statement of future research needs.

- Existing conditions and background, policy, coordination, and regulations
- Planning and implementation
- Infrastructure
- Innovations and data

# Summary of Findings

## Existing Conditions and Background, Policy, Coordination, and Regulations

This section provides a general overview of micromobility, including:

- Definitions and categories of micromobility devices
- Inventory of existing micromobility
- Funding support programs and options, including federal eligibility
- State, regional, and local coordination
- Regulatory issues and local ordinances
- State Department of Transportation (DOT)'s role in setting policy, developing guidelines, and advancing innovations and emerging mobility concepts

Micromobility is a relatively new concept in transportation, resulting in largely ad hoc community responses and approaches that make it difficult to compare common experiences at the local level. Therefore, it is critical to establish a shared understanding of micromobility and how state DOTs and communities are addressing it.

### Definitions and categories of micromobility devices

Micromobility devices can be categorized into two broad groups: human-powered devices and motorized devices. Human-powered micromobility devices are moved by pedaling or kicking and primarily include bicycles, skateboards, and standing push scooters. Motorized micromobility devices are low-speed, personal mobility devices that are either fully or partially motorized, such as electric pedal assist bikes (e-bikes), electric (sitting or standing) scooters (e-scooters), electric skateboards (e-skateboards), and other self-balancing devices (National Academies of Sciences, Engineering, and Medicine, 2022a). Powered, or motorized, micromobility devices are defined in Figure 1.

**Figure 1: Types of Powered Micromobility Devices**

| | Powered Bicycle | Powered Standing Scooter | Powered Seated Scooter | Powered Self-Balancing Board | Powered Non-Self-Balancing Board | Powered Skates |
|---|---|---|---|---|---|---|
| Center column | Y | Y | Y | Possible | N | N |
| Seat | Y | N | Y | N | N | N |
| Operable pedals | Y | N | N | N | N | N |
| Floorboard / foot pegs | Possible | Y | Y | Y | Y | Y |
| Self-balancing[2] | N | N | N | Y | N | Possible |

[1]All vehicles typically designed for one person, except for those specifically designed to accommodate additional passenger(s)
[2]Self-balancing refers to dynamic stabilization achieved via a combination of sensors and gyroscopes contained in/on the vehicle

*Source: Society of Automotive Engineers*

*Source: Fischer, 2020*

The U.S. Department of Transportation (USDOT) defines micromobility as: a category of modes of transportation that includes very light, low-occupancy vehicles such as e-scooters, e-skateboards, shared bicycles, and e-bikes (USDOT Bureau of Transportation Statistics, 2022).

As of 2022, 26 states (not including North Carolina) classify e-bikes into a three-tier classification system. Class 1 e-bikes, often called "pedal-assist e-bikes" require the rider to pedal to initiate electric motor assistance, with some offering start-up aid after the rider stops. The maximum speed for Class 1 e-bikes in the United States (U.S.) is 20 miles per hour (mph), meaning the motor no longer assists above that speed. Class 2 e-bikes, or "throttle assisted e-bikes" do not require the rider to pedal to engage the motor but still have a maximum of 20 mph. Class 3 e-bikes, or "pedal-assisted high-speed e-bikes," are similar to Class 1 e-bikes but have a higher maximum speed of 28 mph. While Class 3 e-bikes are considered bicycles in the U.S., some European countries consider them motor vehicles and require a driver's license and vehicle registration (NASEM, 2022a). These three e-bike classifications, as well as e-scooters and other micromobility devices, are shown graphically and described in Figure 2.

Figure 2: Graphic Depictions and Definitions of Micromobility Devices

| Device | Electric standing or sitting scooters (e scooters) | Electric bicycles (e-bikes) | | | Other[1] |
|---|---|---|---|---|---|
| |  |  | | |  |
| | | Class 1<br>Pedal assist (pedalec) | Class 2<br>Throttle assist | Class 3<br>Pedal assist (pedalec) at higher speed | |
| Example brands | **Shared:** Bird, Lime, and many others<br><br>**Owned:** Inboard Glider, Segway 9Bot | **Shared:** Lime, Mobike, Ofo, Pace, Spin, and many others<br><br>**Owned:** Most major bike brands; multiple passenger versions include Organic Transit (ELF) and Yuba | **Owned:** Several bike brands (less common than Class 1 and 3) | **Owned:** Several major brands; multiple passenger versions include Better Bike (PEBL), and Podride | **Owned:** Boosted, Inboard, Mellow Boards, Metroboard |
| Weight | Typically < 50 lbs | Typically < 100 lbs; multiple passenger versions near 200 lbs | Typically < 100 lbs | Typically < 100 lbs; multiple passenger versions near 200 lbs | < 50 lbs |
| Occupants | Single rider | Usually a single rider; some cargo e-bikes or bike cars designed for multiple riders | Typically designed for single riders | Usually a single rider; some designed for multiple riders | Single rider |
| Power supply | Electric motor typically < 750 watts | Electric motor typically < 750 watts | Electric motor typically < 750 watts | Electric motor typically < 750 watts | Electric motor typically < 750 watts |
| Product speed[2] | 20 MPH or less; some cities apply additional speed restrictions | 20 MPH or less | 20 MPH or less | 28 MPH or less | Most are 20 MPH or less though some can go up to 30 MPH |
| Operating space | Varies by place;[3] some cities restrict in crowded places | Varies by place;[3] usually allowed on bike transportation facilities and paths | Varies by place;[3] usually allowed on bike transportation facilities and paths | Varies by place;[3] some States restrict access on bike paths | Varies by place[3] |
| Regulated by | Consumer Product Safety Commission (CPSC), for personally owned devices[4] | CPSC (only for personally owned devices) | CPSC (only for personally owned devices) | CPSC (only for personally owned devices) | CPSC (only for personally owned devices) |

[1] *This category includes e-skateboards; e-skates; e-boards or other self-balancing devices (sometimes called hoverboards or balance wheels).*

[2] *Speed intended for usage by manufacturer; this may be regulated by State or local ordinances and may differ from actual operating speeds or modifications made by the device user.*

[3] *In some circumstances, paths may have restrictions based on the Federal or State regulations, or the source of funding. These restrictions are often marked at the entrance to the facility, but not always.*

[4] *CPSC is a regulatory body that identifies if a product is safe to sell in the U.S. under the Consumer Product Safety Act. It does not regulate who can purchase a device or where or when devices can be legally ridden.*

*Source: Sandt, 2019*

Other definitions break micromobility down into classifications defined by weight and speed as shown in Table 1. The International Transportation Forum (ITF) generally defines micromobility as the use of devices with a mass of less than 350 kg (771.6 lbs) and a design speed of 45 km/h (28 mph) or less.

**Table 1: Types of Micromobility Devices**

| Type | Weight | Speed | Device Examples |
|---|---|---|---|
| Type A | 0 – 77.2 lbs | Power supply (if any) limits vehicle speed to less than 15.5 mph | Most bicycles, e-bikes, e-scooters, and self-balancing devices (i.e., Onewheels, hoverboards, Segways) |
| Type B | 77.3 – 771.6 lbs | | Cargo e-bikes and larger electric mobility devices |
| Type C | 0 – 77.2 lbs | Powered with top speed between 15.5 – 28 mph | Some e-bikes, motor-powered bicycles, and electric unicycles |
| Type D | 77.3 – 771.6 lbs | | Some motor scooters |

*Adapted from Safe Micromobility, International Transportation Forum (2020)*

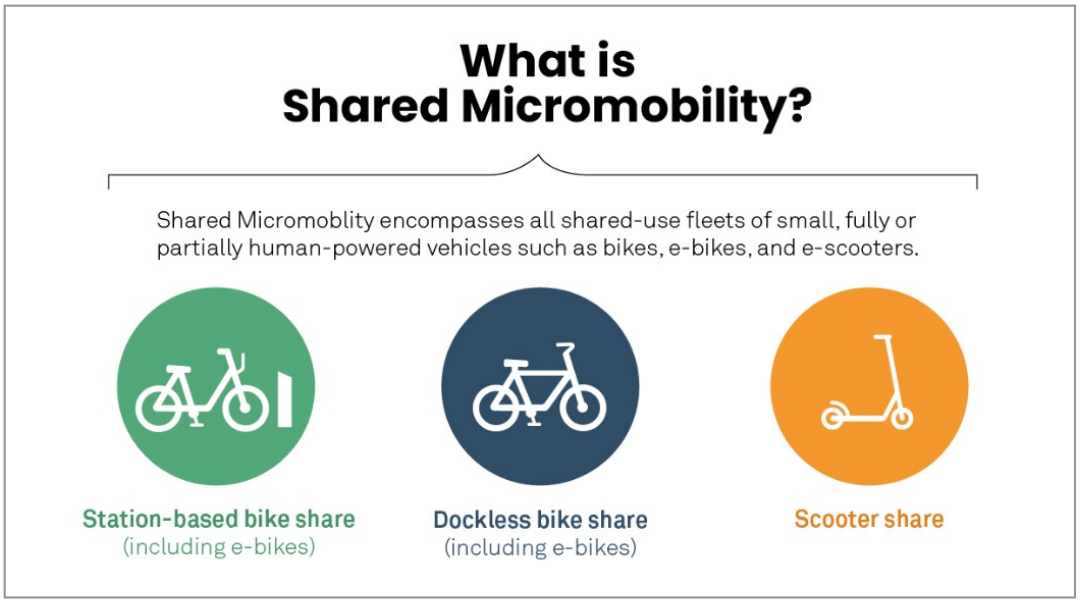
North Carolina legislation defines an "electric assisted bicycle" as "a bicycle with two or three wheels that is equipped with a seat or saddle for use by the rider, fully operable pedals for human propulsion, and an electric motor of no more than 750 watts, whose maximum speed on a level surface when powered solely by such a motor is no greater than 20 miles per hour." Electric assisted bicycles must adhere to the same road rules as bicycles but have a minimum use age of 16 years old. This is distinguished from "electric personal assistive mobility devices," which must be self-balancing nontandem two-wheeled device with a maximum speed of 15 mph (North Carolina General Statues, 2020).

How micromobility device classes are defined at the state level varies widely but has far reaching and important implications. For example, some states may classify an e-bike as a traditional bicycle while others classify it as a moped. This can translate to differing regulations around helmet requirements, license requirements, and where the vehicle can be driven. Inconsistencies in definition can lead to unreliable or incomparable data collection, challenges in developing programs or funding opportunities, and unclear policies.

**Inventory of existing micromobility**

Although micromobility devices may be individually owned, the recent surge in micromobility is due to shared use device fleets by private companies, also called shared micromobility systems (Price, 2021). These shared systems, typically comprised of bikes, e-bikes, and/or e-scooters, are either docked (also called "station-based"), with permanent stations where devices must be picked up or dropped off, or dockless systems, which allows users to park anywhere within a geographic region, sometimes with additional regulations (Davies, Blazejewski & Sherriff, 2020). The definition of shared micromobility is further depicted in Figure 3.

**Figure 3: Graphic Depiction of Shared Micromobility**




*Source: National Association of City Transportation Officials, 2018*

There are two databases that inventory micromobility programs across the country:

- University of Oregon's Operationalizing Equity: US Micromobility Equity Requirements Database (2022)
- USDOT's Interactive Bikeshare and e-Scooter Map (last accessed 2023)

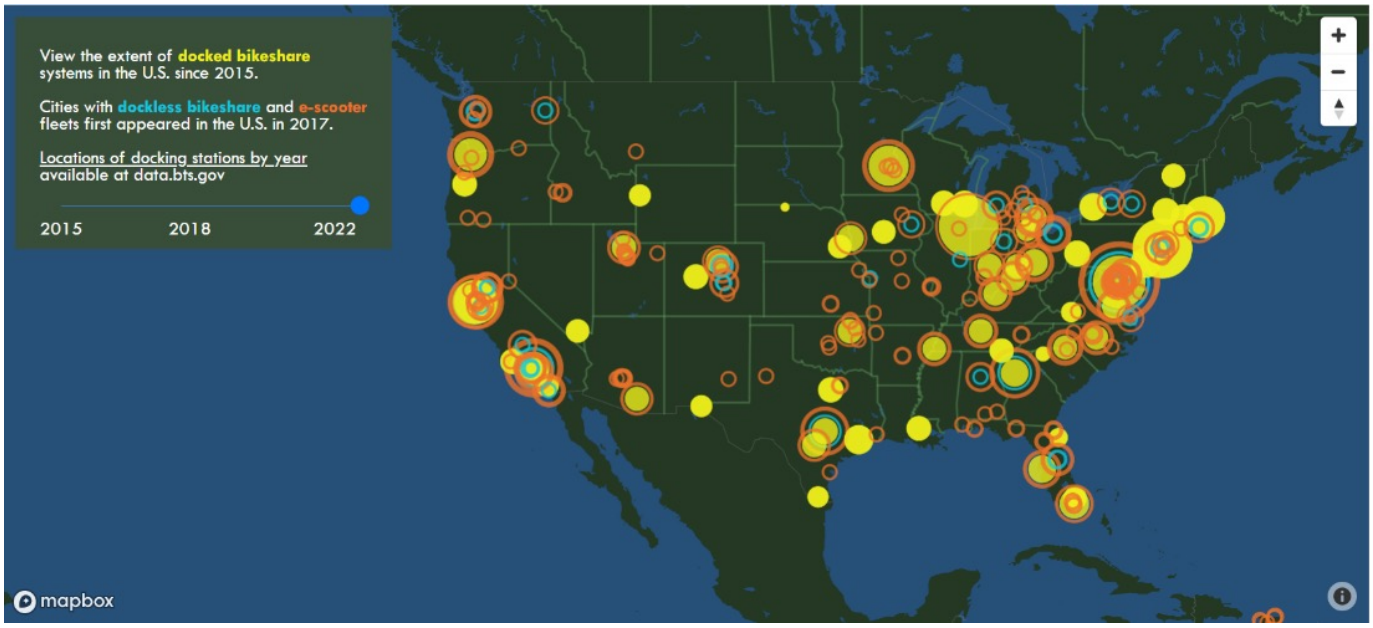
Because neither of these maps appear to provide a comprehensive listing of micromobility systems in North Carolina, a separate survey, as detailed in Appendix B, was sent out to select municipalities, metropolitan and rural planning organizations (MPOs and RPOs), and universities and community colleges across North Carolina to inventory current and planned micromobility systems across the state.

Across the U.S. since 2019, the total number of docked bikeshare systems have declined, while total docked bikeshare stations increased. Both dockless bikeshare and e-scooter systems have increased since 2020 (USDOT, 2022). The COVID-19 pandemic introduced new factors which contributed to the decrease of docked bikeshare systems and the increase of dockless systems. During the first few weeks of the pandemic several large U.S. cities, such as New York and Chicago experienced an increase in micromobility ridership. However, ridership started to decline across the country once lockdowns and shelter-in-place orders took effect forcing some micromobility programs to close due to dwindling revenue or by government order. Over the course of the pandemic, ridership started to increase because micromobility became a safer alternative compared to public transportation. Lower traffic volumes caused by remote work and shuttering of non-essential business allowed for greater movement of micromobility devices on street networks.  Micromobility was particularly helpful for essential workers, many of whom were given free or discounted rates. Some cities, such as Detroit, Kansas City, Missouri, Memphis, Tennessee and the Big Island of Hawaii, offered unlimited free rides. The permanency of some

of these programs combined with increased active transportation infrastructure investment is expected to benefit the longevity of micromobility programs (Fischer, 2020). As of July 2022, dockless bikeshare systems serve 35 cities and e-scooters serve 158 U.S. cities (USDOT, 2022).

Figure 4 illustrates the geographic spread of micromobility systems across the country. E-scooter systems have grown since the COVID-19 pandemic and are more evenly spread across the country. Bikeshare programs tend to be in larger cities (USDOT, 2022). This is consistent with larger cities using micromobility programs as a tourism strategy, which is further explored in the Planning and Implementation section.

**Figure 4: 2022 Bikeshare & E-Scooter System Map**




*Source: USDOT: Bureau of Transportation Statistics: https://data.bts.gov/stories/s/fwcs-jprj*

**Funding support programs and options, including federal eligibility**

Based on the inclusion of micromobility in new federal bills and the 2021 round of the USDOT Rebuilding American Infrastructure with Sustainability and Equity (RAISE) grant awards, there are several new opportunities for micromobility. The Congestion Mitigation and Air Quality (CMAQ) and Surface Transportation Block Grant Programs (STBG) funding sources explicitly include micromobility. There is more funding for pedestrian and bike safety, safe street infrastructure through Complete Streets policy requirements and Transportation Alternatives Program (TAP), as well as a new Carbon Reduction Program that will promote non-single occupancy vehicle trips and reduce transportation emissions. These funding sources are outlined in Table 2 (NABSA, 2022).

While funding for a standalone micromobility project is limited, there are many opportunities for micromobility to be included as a component of a larger transportation project. Another approach is to integrate micromobility into mobility hubs other transportation projects, such as Transit-Oriented Developments (TOD) and consider public-private partnerships with micromobility companies

(Metropolitan Transportation Commission, 2021). Advancing micromobility solutions may require a combination of different types of funding from federal, state, and/or county/local sources. The newly established Center of Excellence on New Mobility and Automated Vehicles is expected to expand research on micromobility.

**Table 2: Micromobility Federal Funding Opportunities**

| Funding Source | Eligible Recipients | Eligible Projects | Funding Type |
|---|---|---|---|
| Accelerating Innovative Mobility | • Primary recipients are transit agencies and local, state, or tribal governments<br>• Primary recipients can identify strategic partners that include micromobility providers | • All activities leading to the development and testing of innovative mobility, such as planning and developing business models, obtaining equipment and services, acquiring or developing software and hardware interfaces to implement the project, operating or implementing the new service model, and evaluating project results | • Discretionary |
| Advanced Transportation Technologies & Innovative Mobility | • State or local government, a transit agency, MPOs (MPOs of 50K - 200K population now eligible), a multi-jurisdictional group or a consortia of research institutions | • Projects that improve safety, mobility, efficiency, system performance, intermodal connectivity, and infrastructure return on investment<br>• Focus on projects to deploy advanced transportation and congestion management technologies | • Discretionary<br>• Cooperative agreements |
| Carbon Reduction | • State DOTs receive funding; 65 percent suballocated to MPOs; and MPOs have the authority to allocate funding within the region | • Funding available for facility planning and design, network integration, technology, street and curb design, and possible vehicle acquisition | • Formula |
| Center of Excellence on New Mobility and Autonomous Vehicles | • Institutions of higher education, public or private research institution, non-profit | • Studies, research and development, best practices, and modeling<br>• Direct acquisition or operations not eligible | • Cooperative agreement |

| Funding Source | Eligible Recipients | Eligible Projects | Funding Type |
|---|---|---|---|
| Congestion Mitigation & Air Quality Improvement Program (CMAQ) | • State DOTs receive and distribute federal funding<br>• Opportunity for local governments to engage with state officials in securing funding for newly eligible projects<br>• States provide separate guidance regarding their own process | • Explicit eligibility for micromobility projects (bike and scooter share systems)<br>• Details pending release of new guidance but typically for capital projects, vehicle acquisition, planning<br>• Operational support unlikely | • Formula |
| Rebuilding American Infrastructure with Sustainability and Equity (RAISE) | • States, U.S. territories, or local government<br>• Public agency or publicly chartered authority established by one or more states<br>• Special purpose district or public authority with a transportation function, including a port authority<br>• Tribal government or a consortium of Tribal governments<br>• A partnership between Amtrak and one or more eligible entities<br>• A group of eligible entities | • Opportunity to incorporate micromobility into funding applications, particularly to bolster scoring on criteria for climate, equity, access, and/or land use where micromobility can add a benefit or be incorporated into a broader project or plan | • Discretionary |
| Surface Transportation Block Grant Program (STBG) | • State DOTs, MPOs, direct suballocation for regions 200K+ in population, and expanded authority for regions 50K - 200K | • Projects can be included in Transportation Improvement Programs (TIP)<br>• Shared micromobility is not explicitly referenced but could be an element within several eligible project categories | • Formula funding to states with direct allocations for programs (such as TAP) and suballocations to larger MPOs |
| Transportation Alternatives Program (TAP) | • MPOs provide competitive grant funding to local governments, government agencies, or non-profit entities | • Primary funding source of bike and pedestrian infrastructure<br>• Possible opportunity to broaden eligibility to shared micromobility in grant guidance document | • Formula funding to states<br>• Competitive funding from MPOs to projects |

*Note: Requirements for matching funds are not shown in Table 4. Individual grant opportunities should be reviewed in greater detail for any matching funds required.*

*Source: Adapted from NABSA, 2022*

### State, regional, and local coordination

Most management and regulation of micromobility in the U.S. takes place at the local/municipal level. Laws and ordinances around micromobility vary greatly between different states, cities, and jurisdictions. The speed at which micromobility has been deployed has led to some of this variability. A 2019 nationwide study of regulations relating to e-scooters found that cities had to respond quickly to an "explosion" of e-scooters and other devices at the end of the 2010s, and swiftly created regulations, established permitting requirements for vendors, brokered public-private partnerships, or issued cease and desist orders to vendors (Anderson-Hall, 2019).

Following the initial rush to manage the influx of micromobility options, it became evident that variability in local regulations and requirements had created challenges. The Governor's Highway Safety Association recommends that regulations be established by state legislatures while still allowing local governments the ability to manage devices based on local conditions (Fischer, 2020). Coordination at the state, regional, and local levels of government can support the establishment of consistent standards, which the Governor's Highway Safety Association recommends as a strategy for managing micromobility challenges. MITRE (2022), a non-profit information technology and engineering firm that works exclusively with government agencies, also recommends harmonizing regulations across regions to avoid users inadvertently breaking laws due to differences such as sidewalk riding being permitted in one jurisdiction and prohibited in a neighboring jurisdiction.

### Regulatory issues and local ordinances

Regulations and ordinances may apply to micromobility users, vendors, and service providers or those involved in collecting, reporting, and sharing data. Table 3 provides examples of the types of micromobility issues addressed in regulations or local ordinances for various audiences.

**Table 3: Micromobility Regulations and Ordinance Types**

| Users | Vendors | Data and Reporting |
|---|---|---|
| • Locations where vehicles are permitted or prohibited<br>• Speed limits<br>• License requirements<br>• Helmet requirements<br>• Parking requirements | • Permit requirements and fees<br>• Fleet size or range restrictions<br>• Selection criteria<br>• Maximum speeds<br>• Helmet availability requirements<br>• Insurance requirements<br>• Equity requirements, such as income-based pricing or discounts<br>• Infrastructure or facility requirements | • Data sharing requirements<br>• Privacy laws<br>• Guidelines for data management<br>• Crash reporting guidelines |

The National Association of City Transportation Officials (NACTO) provides best practice recommendations for regulations related to shared micromobility. These recommendations are focused on vendor and service provider requirements, such as permitting, fleet restrictions, parking management plans, data sharing and auditing, outreach and engagement, and equity requirements (NACTO, 2019). Additionally, the American Association of State Highway and Transportation Officials (AASHTO) (n.d.), provides examples of actions for state DOTs to take to help municipalities and institutions develop policies and regulations for shared micromobility.

**State DOT's role in setting policy, developing guidelines, and advancing innovations and emerging mobility concepts**

The primary roles state DOTs currently serve regarding micromobility include developing guidance, performing research, collecting data and promoting the implementation of micromobility. State DOTs are rarely involved in directly regulating or enforcing regulations on micromobility (NASEM, 2022a). However, state DOTs may interface with state health and human service agencies engaged with mobility dependent communities, cities, counties, MPOs and RPOs, transit agencies, and non-profits on the topic of micromobility. State DOTs can also be subject to helping local agencies and operators respond to state legislative requirement which may impose micromobility regulations associated with state-maintained facilities. Two state DOTs, Minnesota (MnDOT) and Maryland (MDOT), are presented here to illustrate their role and involvement in micromobility:

- **MnDOT's** approach to state regulation is to defer to local regulations unless there is a significant reason to step in, such as safety. Definitions of micromobility devices are still being clarified at the state level. MnDOT is not involved in operational requirements, such as number of vendors allowed in a certain area or where vehicles can ride, or regulation enforcement – this is left to local jurisdictions. MnDOT is building a Federal Transit Administration (FTA) funded multimodal, regional trip-planning application, which will collect information on how users plan and book trips for all types of mobility options, including micromobility (NASEM, 2022a).
- **MDOT** also leaves micromobility regulations up to local jurisdictions, but state law defines micromobility devices similar to bicycles outlining safety and operational requirements. These umbrella state regulations can be altered by local regulations. MDOT is coordinating with the state legislature to design state-level regulations to address how micromobility devices are used, including for individuals with disabilities. MDOT also ensures MPOs are exchanging information across local jurisdictions. While safety data is collected by local jurisdictions, the State Highway Administration and the Highway Safety Office help these jurisdictions identify and analyze relevant roadway data. Additionally, MDOT provides technical guidance and resources to support safety-related activities to assist local jurisdictions in their enforcement of micromobility regulations. The Maryland Transit Administration (MTA) is involved with regulation of micromobility devices on or in proximity of their facilities (NASEM, 2022a).

Some state DOTs have worked to develop pilot projects, but DOTs could play a greater role in creating and supporting pilot projects in general (AASHTO, n.d.). A study by the University of California – Davis suggests that structured pilot programs were preferred for introducing micromobility to a municipality over open

competition. Pilot programs provide a proven method to gauge public response, fine tune policies and regulations, integrate with existing transit systems, and inform the management of limited licenses (Fuller, 2021). As evidenced by feedback solicited through a survey of North Carolina communities detailed in Appendix B, there is expressed interest for NCDOT to support pilot micromobility projects. In light of practice in other states and new federal emphases, NCDOT can help to ensure pilot projects consider equity, sustainability, data collection and management, and community and stakeholder engagement.

## Planning and Implementation

Micromobility represents a variety of mobility options that can meet diverse transportation needs as a component of a broader, multimodal transportation system. Thoughtful planning for micromobility can support effective system integration. This section summarizes available literature on planning topics, including:

- Micromobility network planning
- Feasibility analysis, including methods and other considerations
- Equity considerations
- Role of micromobility in tourist communities

**Micromobility network planning**

Planning for micromobility starts with understanding how micromobility fits into the broader transportation network. A National League of Cities study compares early integration of micromobility to the early integration of cars on city streets and calls on cities to consider similar approaches (Korb, 2022).

In the last few years, several North Carolina municipalities have taken on the role of micromobility network planning. This included requiring vendors to follow ordinances, operate with permits, and follow safety regulations. This was the case in Raleigh, North Carolina where the city's Request for Proposal (RFP) received seven proposals from private operators, three of which were offered Master Encroachment Agreements with the city and launched May 18, 2021 (City of Raleigh, 2023). Charlotte, North Carolina, took on micromobility network planning by implementing a dynamic pricing model for e-scooter vendors (Kanowitz, 2020). Instead of each vendor paying a flat parking fee to the city, vendors paid based on which zone of the city the e-scooters were placed (Kanowitz, 2020). This incentivized the vendors to distribute e-scooters in a more balanced way across the city, avoiding clustering of e-scooters in Uptown, the most congested area (Kanowitz, 2020). By tracking e-scooter usage and parking, the city also knew where to place scooter corrals for parking (Kanowitz, 2020).

The availability of user-generated data offers opportunities for micromobility planning, but additional data such as multimodal patterns, vehicle traffic, door-to-door transit routes, logistics insights, and demand rankings can also inform effective planning (Cohen-Abravil, 2021). A study in southern Italy used a two-level methodology to design a sustainable urban mobility plan, starting with floating car data and systemic trips and distances, then analyzing origin-destination data to determine hot spots. The study found that 22.2 percent of the car trips examined were round trips that were less than 5 km (3.1 miles) and under 20

minutes making them suitable for micromobility (Comia et al., 2021). Both MnDOT and MDOT are making efforts to promote integration of micromobility and understand how best micromobility fits into the existing transportation network. MnDOT, as mentioned in the previous section, is building an FTA grant-funded multi-modal planning application that will be able to track how people plan and book trips for different types of mobility, providing vital information for network planning (NASEM, 2022a).

Ignaccolo et al. (2022) proposed a set of micromobility network planning principles, criteria, and design recommendations adapted from the European Union's basic principles for cycling. These are summarized in Table 4. Ignaccolo et al. (2022) then utilized these criteria to evaluate the e-scooter network in Palermo, Italy. The design recommendations provide potential solutions to the principles and criteria that are underperforming in the current transportation network.

**Table 4: Principles, Criteria, and Design Recommendations for Micromobility Networks**

| Principles | Criteria | Design Recommendations |
|---|---|---|
| Coherence and Accessibility | • Continuity of the route<br>• Freedom of choice of routes<br>• Route connectivity<br>• Appropriate parking spaces | • Limit interruptions and minimize changes in the road section<br>• Signaling and clear indications along the route<br>• Consider the opportunity of at least two path alternatives<br>• Ensure the presence of parking spaces and regulated by signage<br>• Route design to ensure accessibility to the main points of interest |
| Linearity | • Adequate operating speeds<br>• Ratio between direct distance and distance actually traveled (Detour factor) | • Geometric design to allow a constant operating speed consistent with the road level considered<br>• Minimize overall travel time by considering detours, number of stops at intersections, traffic lights and slopes<br>• Prioritize non-motorized traffic over motorized one |
| Safety and Security | • Reduce the risk of accidents<br>• Reduce the risk of conflicts<br>• Reduce the risk of theft | • Identify any links between accidents and road design<br>• Segregate e-scooter traffic from high-speed vehicular one<br>• Reduce speeds and volumes of vehicular traffic in mixed use areas<br>• Ensure good visibility, especially at intersections<br>• Include the new mode in road safety education paths<br>• Presence of secure parking facilities close to the main points of interest |

| Principles | Criteria | Design Recommendations |
|---|---|---|
| Attractivity and Intermodality | • Attractiveness of the context<br>• Connection options with different transport modes | • Ensure good lighting and visibility<br>• Create connection paths with the park-n-ride facilities<br>• Provide at public transport nodes a safe parking area<br>• Define suitable spaces for resting vehicles in public transport (if allowed to bring vehicles on board) |
| Comfort | • Reduced slopes<br>• Reduced number of stops<br>• Protection from adverse weather conditions<br>• Low vibrations | • Reduce the elements of discontinuity (e.g., steps)<br>• Reduce illegal parking of other vehicles on the route<br>• Ensure the presence of trees to create areas of shade and shelter<br>• Ensure constant maintenance of the pavement |

*Source: Ignaccolo et al., 2022*

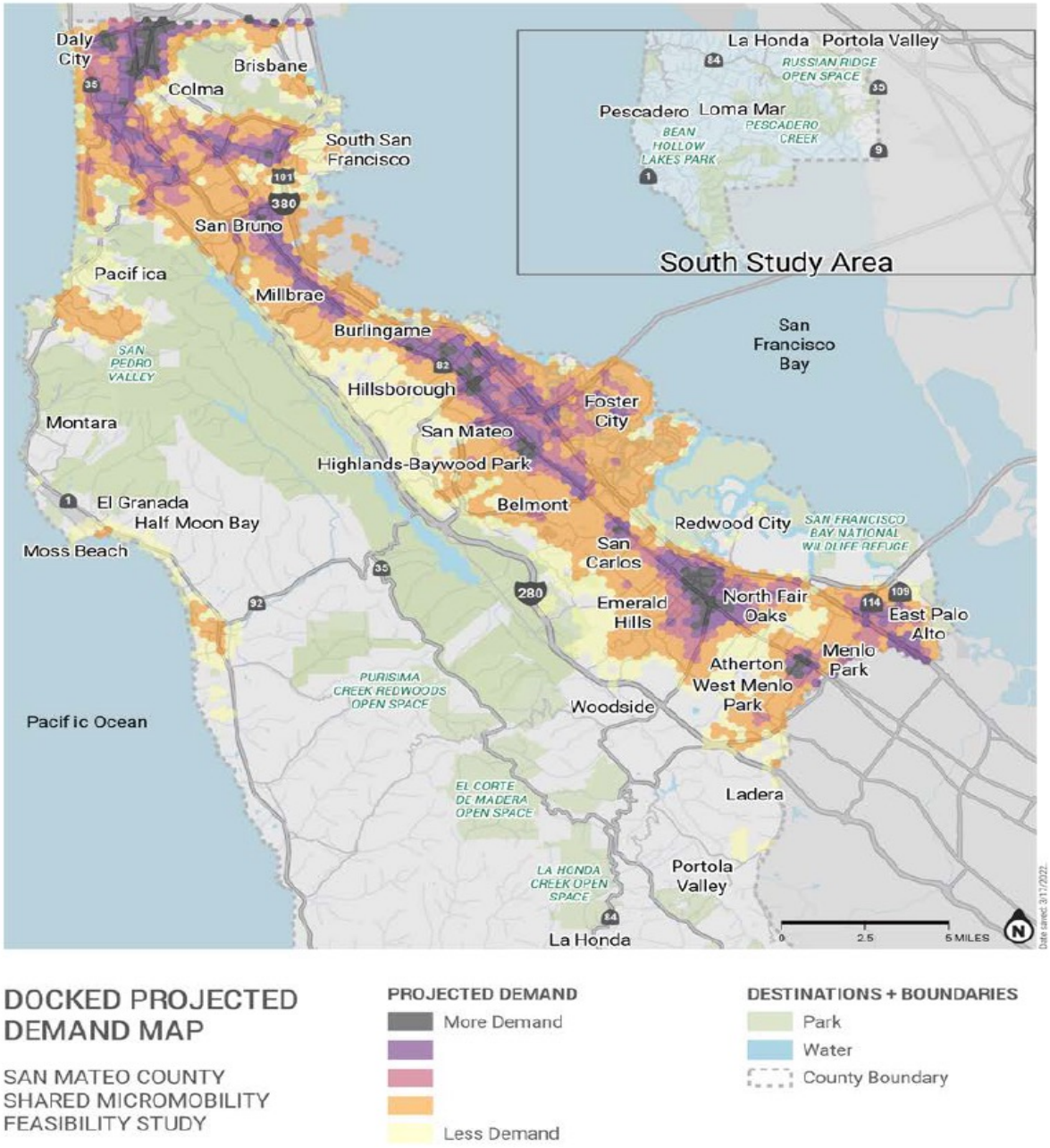
**Feasibility analysis, including methods and other considerations**

Before implementing a micromobility program, many municipalities conduct a feasibility analysis. Research found that while there is not an agreed upon standard for micromobility, there are many case studies that are available for review. Some feasibility analyses were conducted to support decision-making without programmatic recommendations for moving forward, while others made program recommendations (City/County Association of Governments of San Mateo County Bicycle and Pedestrian Advisory Committee, 2022). Other municipalities included a feasibility analysis within a larger micromobility study that included implementation options and recommendations, such as size of system, considering dockless versus docked systems, or expanding existing nearby systems versus bringing in new micromobility companies (Foursquare ITP, 2021). Drafting goals to evaluate the feasibility of a micromobility system was a common approach among feasibility studies reviewed. The following were other common components in feasibility studies to consider:

- Demand or market analysis can include factors that are considered to make micromobility programs successful, such as population, employment, retail, and student density, transit availability, and tourist destinations (C/CAG of San Mateo County, 2022). Another resource utilized resident age (20-44 years old was desired), bike infrastructure, and park density (Sheng, 2020). A heat map, as seen in Figure 5, is a useful way to visualize this demand analysis and initially show where the most successful areas may be for a micromobility program.
- Barrier analysis is a geographic-based component which shows areas where a micromobility program may not be successful. Such barriers can include level of traffic stress, clusters of auto-focused businesses, rail lines, highways, and slopes greater than 10 percent.

- Program opportunity and resource analysis considers factors such as management capability, vendor availability, and funding capacity (C/CAG of San Mateo County, 2022).
- Equity analysis is a key portion of the feasibility study. Most examples reviewed utilized their own locally established equity focused areas. One equity focused area included poverty and minority density (Sheng, 2020), while another also included collision history (C/CAG of San Mateo County, 2022).

**Figure 5: San Mateo County Micromobility Demand Analysis Heat Map**




*Source: C/CAG of San Mateo County, 2022*

**Equity considerations**

Micromobility has the potential to increase access and equity for all. Micromobility can augment first-and-last mile access to and from transit, serving as a short distance service extension for transit dependent communities. The emergence of more accessible micromobility devices increases the potential for micromobility to serve a wider spectrum of persons with disabilities.

Diversifying micromobility device types and free or discounted programs are creating more opportunity for low-income workers and both older and younger populations to access micromobility for getting to jobs and destinations in their communities. However national trends continue to show most micromobility users are disproportionately white, male, and young with higher income levels (Aman et al, 2021; Dill & McNeil, 2020; Washburn, 2020). Some of the overrepresentation of white and higher income riders is due to the fact providers deploy more vehicles in high density areas of cities represented by predominantly white and high-income populations (Aman et al., 2021). Conversely, transit dependent areas, low-income communities, and minority communities are frequently found to have little to no access to micromobility (Dill & McNeil, 2020; Johnston et al., 2021).

Many providers plan deployment of vehicles based on use. An inequitable feedback loop is created in places where early adopters are predominantly males, young, and white and more devices are added to these areas based on demand (Washburn, 2020). To combat this, many municipalities target equity zones and require providers to deploy a minimum percentage of their fleet to each zone to ensure equitable access (Johnston et al., 2020). As mentioned in the network planning section, Charlotte, North Carolina implemented a dynamic pricing model for e-scooter vendors to encourage a more geographically balanced distribution of e-scooters (Kanowitz, 2020). This is another approach that could be used by municipalities to incentive vendors to distribute devices more equitably.

Research on racial and ethnic equity around micromobility focuses on Black, Indigenous, and people of color (BIPOC), most commonly Black/African American and Hispanic communities. Research suggests that, despite lower levels of micromobility usage, there is greater interest among BIPOC to utilize micromobility. Specific barriers cited by BIPOC include harassment from police, the need for a credit card, and a negative stigma around cycling. Another barrier is the ability to locate and rent vehicles without a smartphone, which some programs address by providing these services via text message. To address the barrier of needing a credit card some systems provide cash payment options. An example of this is Indego bikeshare in Philadelphia, where members could sign up online and pay cash at a PayNearMe location in nearby stores. Dockless systems also tend to increase use by BIPOC compared to docked systems (Aman et al., 2021; Dill et al 2022; Dill & McNeil, 2022).

Gender-based research on micromobility is more limited compared to other populations, especially in the U.S. Available research around micromobility and gender indicates that the gender gap in micromobility usage is driven by the same factors as the gender gap in cycling: women are more concerned about safety; use vehicles more often when there is safe infrastructure; use vehicles for recreation; and have a higher preference for traveling in groups. The gender gap is smaller when comparing e-bikes to traditional bicycles, presenting an opportunity to increase bicycling usage for women (Bruntlet, 2022; Dill & McNeil, 2022).

While e-bikes are more accessible to certain physically challenged groups compared to purely human-powered bikes, micromobility is often seen as inaccessible to older populations and persons with disabilities due to the level of physical ability required to operate stand-up scooters and traditional shared bikes and e-bikes. Micromobility devices can be designed with persons with disabilities in mind. Sit-down scooters and modified e-bike designs, such as recumbent bicycles and tricycles, are expanding options to accommodate a wider range of users with different levels of physical abilities. Some municipalities are requiring micromobility companies to provide these vehicle options. For example, Oakland, California requires scooter providers to offer an accessible vehicle with a seat and wider wheelbase (Wright, 2020). In 2022, Helbiz, an e-scooter company, introduced wheelchair attachment and sit-down scooter options in Charlotte, North Carolina (WSCOTV.com News Staff, 2022).

While there is work to be done from an equity perspective for most micromobility programs, some vendors and municipalities provide case studies and best practices. For example, Lime has a service called Lime Able, providing accessible vehicles, and Spin rents scooters at half the price to job seekers (Marlen LNU, SkedGo Pty Ltd., 2022). In 2022, Providence, Rhode Island expanded access to e-bikes and scooters with a focus on accessibility for low-income riders. This equitable expansion included alternative payment methods for users without smartphones or credit cards and discounted rates for low-income riders, veterans, senior citizens, people receiving state or federal assistance, and select non-profit and community organizations (City of Providence, 2022).

Denver implemented another type of program to help tackle equitable accessibility. The city provides a $1,200 rebate for low- to moderate-income residents who purchase their own electric micromobility devices. This program is funded by a voter-approved sales tax dedicated to climate and resiliency projects (Brasch, 2022). More than half of the shared micromobility programs in the U.S. are privately owned and run. This leaves programs that people depend on for accessible transportation vulnerable to market whims and profit-based decisions (Aoun Angueira, 2023). Such was the case when Uber removed their popular New Orleans bikeshare program during the COVID-19 pandemic in May 2020 (Aoun Angueira, 2023). Subsequently, a non-profit was established to secure financial sponsors and operate the bikeshare system in New Orleans, fulfilling the program's original goal of providing "affordable, equitable transportation" (Aoun Angueira, 2023).

Rural communities have not seen the surge in micromobility programs that urban centers have. While rural residents typically have longer trips than those in urban areas, the availability of electric micromobility devices, over the human-powered counter parts, makes micromobility more via in rural communities (National Center for Micromobility Staff, 2020). According to the National Center for Micromobility (NCMM) (2020), two main steps to increase the success of micromobility in rural areas are to:

- Start with infrastructure, particularly what are called cycle superhighways, which can be separated paths on the side of state highways, and
- Create a policy framework that supports viable long term business operations, which for smaller communities, is typically partnering with a potential provider (NCMM Staff, 2020).

### Role of micromobility in tourist communities

Mobility directly impacts the tourist experience and can positively or negatively contribute to a destination's marketability. Many tourists travel without a personal vehicle or bicycle. Even tourists with a personal vehicle may find that parking is limited in areas with high tourism such as downtowns and small coastal communities. For local trips in tourist communities, tourists relying on ride hailing services could use micromobility devices instead. Tourist destinations that are walkable and bikeable are more favorable to tourists and in turn generate more use of micromobility devices. (Davies, Blazejewski & Sherriff, 2020).

Bikeshare and e-scooters are a popular way for tourists to explore a new city as they allow users more interaction with their local environment than a car trip and are faster than walking (Burke, Yang, Kaufman & Leung, 2021). Since tourists can make quicker trips using bikes, e-scooters, or e-bikes, they are able to visit more destinations, which translates to more money being spent within the local economy (Burke, Yang, Kaufman & Leung, 2021). After a one-year e-scooter trial in London, the most popular parking areas were at the city's most famous tourist destinations (Intelligent Transport, 2020). Additionally, micromobility tourism platform, GoGiro, partnered with a multinational hotel chain to create successful tourism tours on e-scooters (Hubbard, 2022). One noted challenge for tourists using micromobility is that almost every micromobility vendor requires a different phone app and sign-up process, which can be time consuming for tourists looking to only use the system for a short period of time (Davies, Blazejewski & Sherriff, 2020).

## Infrastructure

Implementing a micromobility program is more than acquiring micromobility devices. Careful review and planning of how these devices will interact with the community and surrounding infrastructure is also important. This has implications on the safety of both users and non-users, considerations for the parking of the devices, what facilities micromobility users will use, and more. This section summarizes available literature on infrastructure topics, including:

- Safety considerations
- Parking considerations
- Other infrastructure considerations

### Safety considerations

Micromobility systems are safest when paired with a robust network of interconnected bike lanes (NACTO, 2019). According to several studies, bike lanes are also the strong preference for e-scooter users. For e-scooter users, the largest safety concern is auto traffic, but differences exist in perception of safety between different user groups. Generally, women feel less safe on e-scooters than men, which follows the trend of more men utilizing micromobility programs than women. A Portland, Oregon-based study found that focus groups of black communities in East Portland were most concerned about racial profiling and harassment over having a helmet, lacking safe spaces to learn how to ride, and lacking safe

bicycle infrastructure. Additionally, in a survey conducted in Chicago, almost half of respondents with vision, ambulatory, or hearing disabilities reported that e-scooters on the sidewalk were a safety issue for them (NASEM, 2022b). Dockless systems often result in vehicles being left on the sidewalk, creating a potentially unsafe barrier for persons with disabilities.

More research is needed to get a full understanding of micromobility safety. Based on the data available for e-scooters, single device crashes comprise the majority of crashes, not collisions. The most common reasons for these crashes were roadway surfaces or features, loss of balance, stationary objects, and vehicle issues. Inexperience also plays a role. More data is needed to understand impairment's role in crashes. Another noted safety challenge is the consistently low helmet usage for e-scooters (NASEM, 2022b). While safety is rightfully a key topic for micromobility, most forms of micromobility devices using lower-speed are the safest transportation mode, aside from walking (International Transport Forum, 2020).

One way many local jurisdictions regulate micromobility safety is through technological solutions, particularly geofencing. Geofencing creates a virtual geographic boundary that enables software to trigger an action (typically stopping) in the micromobility device. This is commonly used to control where micromobility devices can be operated and at what speed, both of which are crucial to safety (NASEM, 2022b).

In a survey of micromobility programs, the most common e-scooter safety management practice was "geofencing where e-scooter riding is prohibited" and "setting maximum speeds," while the least common safety practice was "limiting motor vehicle speeds in e-scooter areas" (NASEM, 2022b). The most recommended safety mitigations for micromobility include:

- Allocating protected space and keeping pedestrians safe,
- Reducing drunk driving in all vehicles (including micromobility)
- Eliminating incentives for micromobility riders to speed (e.g., by-the-minute rentals)
- Supporting better collection of safety data (ITF, 2020).

**Parking considerations**

Parking is one of the biggest challenges for micromobility programs. Most complaints about micromobility programs are related to improperly parked devices that block sidewalks and create safety hazards and accessibility issues (NACTO, 2019c; Transportation for America, 2022b). Approaches to micromobility parking generally fall into one or more of these categories:

- **Designated Areas Where Parking Is Permitted:** Specific areas where users must park their micromobility devices. These areas can be established through demarcating areas in the furniture zone or right-of-way, converted parking spaces, or through geofencing.
- **Designated Areas Where Parking Is Prohibited:** Does not set out or require areas for parking, but clearly spells out all of the areas where micromobility devices should not be parked.

- **Lock To Physical Infrastructure:** Requires all micromobility devices have the equipment necessary to be locked to physical infrastructure when parked (i.e. docking station).
- **Unrestricted Parking:** Users can park vehicles anywhere as long as they don't restrict the movement of the sidewalk or right-of-way. (T4A, 2022b).

These regulations can also be reinforced through geofencing technology (T4A, 2022b). There is not a clear best practice for micromobility parking. Some sources argue that requiring e-scooters be locked to bike racks ensures more parking compliance compared to sidewalk decals and in-app reminders (Klein, Brown, & Thigpen, 2022).

San Francisco requires micromobility devices be locked to street furniture, while others expanded micromobility parking corrals (NACTO, 2019c). Paris retrofitted 2,500 single parking spaces closest to crosswalks to micromobility parking corrals just by painting them and found that incorrect parking behavior dropped from 65 percent in Spring 2019 to 29 percent in Fall 2019 and then to three percent in Fall 2020 (NACTO, 2019c; Ellis, 2020; Gauquelin, 2020). Paris learned that the parking bays need to be densely placed to be effective: 90 percent of the users agree to walk for up to two minutes to their micromobility device, while only 50 percent are prepared to walk up to five minutes (Gauquelin, 2020).

An example of an on-street micromobility parking corral, likely converted from parking spots, from Arlington, Virginia is shown in Figure 6. Figure 7 is an example of dockless bikeshare vehicles parked in specified micromobility sidewalk parking "drop zones." To enforce this, the bikeshare program's devices may utilize geofencing technology to ensure bikes are dropped off within a certain radius of these "drop zones."

**Other infrastructure considerations**

As previously mentioned, the surrounding infrastructure is a major consideration for a micromobility program. Where micromobility devices will actually ride – whether that is on the sidewalk, with vehicular traffic, or within bike infrastructure – is one major decision. Additionally, when creating a program, particularly for bikeshare, docked and dockless are two options. Docked services, which include older bikeshare programs such as Capital Bikeshare in Washington, D.C., use fixed stations where users can pick up and return devices. Dockless systems allow riders to start and end a trip without using a station and instead leave the device anywhere that is permitted. This could be in certain geofenced zones built into the device or the device having a locking mechanism to lock to municipal infrastructure, such as bike racks or street furniture (Foursquare ITP, 2021).

**Figure 6: On-street micromobility parking bay**

*Source: pedbikeimages/Laura Sandt*

**Figure 7: Delineated sidewalk dockless bikeshare parking area**


*Source: pedbikeimages/Laura Sandt*

## Innovations and Data

Micromobility provides exciting new opportunities to the transportation sector. As a new form of mobility, there is a need for more cohesion in the types of micromobility data collected and how that data is stored and shared. This section summarizes available literature on innovations and data, including:

- Data collection and sharing
- Micromobility as an element of Mobility-as-a-Service (MaaS)
- Compliance issues

**Data collection and sharing**

Data collection and sharing varies widely across vendors and their public or institutional partners, making it a challenge for some municipalities and the research community to fully evaluate some micromobility programs (T4A, 2022a). This micromobility data sharing is important for municipalities to effectively integrate micromobility into their transportation network, create supportive policies, evaluate safety, and collaborate with state agencies and other municipalities. Micromobility data sharing is also crucial to MaaS, which is described in the next section. Best practices include adopting clear data sharing agreements, data use standards, publishing clear policies, practicing data minimization, limiting data access, using third party data aggregators, and deleting raw data as soon as possible (Ride Report, 2020).

The two primary standardized systems for data sharing are General Bikeshare Feed Specification (GBFS) and Mobility Data Specifications (MDS) (Li & Wang, 2022). The GBFS is open source and provides information on a system at a current point in time, not device-level information, such as traveler information or records of trips taken. GBFS is intended for public use and provides municipalities with a standardized way to understand, analyze, and compare data from micromobility service providers. GBFS defines a common format to share the real-time status of a shared mobility system. As of 2019, 56 percent of cities in North America required shared micromobility operators to release an open, public GBFS feed (NABSA, 2021).

MDS is detailed, device-level data. This data is considered non-public and intended for regulatory use only allowing municipalities to have more control over monitoring and regulation of device operations within the public right-of-way (Ride Report, 2020). MDS allows cities to make decisions about safety, pricing, equity, and infrastructure improvements. If vendors collect and provide data in a standard format, stakeholders across all levels and sectors can more easily analyze and interpret results (Li & Wang, 2022).

Under the new federal Bipartisan Infrastructure Law, crash data must differentiate between e-scooter and bicycles, which will improve industry understanding of safety (Destinie, 2022). However, most police-reported crash data currently require involvement of a motor vehicle and property damage, so police-reported crashes fail to capture most e-scooter injuries—most of which involve falling from the e-scooter or colliding with a person or object other than a motor vehicle (NASEM, 2022b). Crash

reporting involving micromobility devices could follow a universal model to ensure data collected is reliable and accurate, including training police officers and hospital staff to use consistent standards for micromobility crash reporting (Fischer, 2020).

Data privacy is another key aspect of micromobility data. Micromobility service providers and data aggregators can have protocols for collection, protection, and sharing of information, including user data (MITRE, 2022). Municipalities can stipulate that micromobility service providers share their trip level data with third parties for security audits (T4A, 2022a). Other local, state and federal laws, such as the California Consumer Privacy Act and other guidelines for Personally Identifiable Information (PII), may have to be followed for data management (NACTO & International Municipal Lawyers Association, 2019).

**Micromobility as an element of MaaS**

Including micromobility as an element of MaaS is an emerging concept that has not yet been fully integrated in the U.S. As mentioned in previous sections, FTA funded a grant for MnDOT to build a MaaS application and platform, which includes micromobility (NASEM, 2022a). Additionally, MnDOT is supporting the City of Minneapolis's Flex Pass project, which is the first step towards a single pass with access to all types of mobility options, including micromobility, for a flat fee (NASEM, 2022a). If successful, this pilot project can be expanded to the state level (NASEM, 2022a). Integration of micromobility services into a city's transit system will enable more usage by locals and tourists, either as subscription or ad-hoc business models (Malone, 2022). The age group of 18–34-year-olds is most likely to adopt MaaS subscriptions with an increase in usage predicted due to rising fuel costs globally (Zhang et al., 2022). Whim is a MaaS example that combines various transport modes and is used in Europe and Asia (MaaS Global, 2022). The regions Whim is available include:

- Helsinki, Finland
- Antwerp, Belgium
- Greater Tokyo area, Japan
- West Midlands region, England (Whim, 2023)

Accessibility is vital to MaaS so that all members can benefit, including older populations, parents with children, low-income households, and people with disabilities (Marlen et al., 2022). Additionally, legislation may be required to mandate inclusion of ridesharing companies in MaaS since they are profit-driven and would prefer to have their proprietary applications (Wears, 2021).

**Compliance Issues**

There is a lack of available literature on data compliance and federal and state compliance practices regarding micromobility. One e-scooter provider, Unagi Scooters (2022), has gathered and published state e-scooter laws for all 50 states and Washington, D.C. in 2019, 2021, and 2022. Unagi Scooters (2022) noted that based on their research, e-scooter laws are rarely enforced or followed closely due to the quickly developing nature of the landscape and ignorance of the state and local laws both by riders and enforcement. As more evaluation of these micromobility programs is conducted and more states and the federal government get involved with regulation, more compliance literature could become available.

# Future Research Needs

As micromobility continues to evolve, more research will be needed to track:

- Industry changes
- Innovations in micromobility system implementation, including public-private partnership models
- Adoption of state and local micromobility regulations
- Impacts of technology advancements
- Developments in system design and devices to expand user accessibility

Methodologies to support some aspects of micromobility implementation such as parking and compliance are still being tested and discovered. More robust safety data, including the impact of impairment and other behavioral trends, are important to collect, track, and communicate to address gaps in safety data to the benefit of micromobility program operators and communities. Consistency in accurately reporting safety data, particularly in coordination with police and hospital reports, must be addressed for a more comprehensive analysis and the development of responsive actions.

Ensuring micromobility is able to improve accessibility for different users and populations is critical to its widespread use and sustainability. This is a broad topic that encompasses design and availability of devices for people with limited mobility which is still not fully developed in the U.S. (Wright, 2020). Research on gender differences in micromobility adoption is limited and could be expanded. Further studies could potentially identify ways to overcome barriers to adoption of micromobility among Black/African American and Hispanic users.

As micromobility programs are implemented and existing systems mature, more documentation and analysis could be conducted to aid in understanding trends of the evolving nature of micromobility and development of best practices. This is more challenging due to the private company aspect of most programs, which is why it is important for communities to be proactive in collecting and sharing their micromobility system data.

# Conclusions

While relatively new to the U.S. transportation system, micromobility programs and personal micromobility devices provide ample opportunities to enhance current transportation networks. NCDOT is uniquely positioned to provide technical assistance to communities across North Carolina interested in implementing micromobility. NCDOT could leverage its role to promote clarity and consistency in how micromobility devices are defined, how regulations are developed and enforced, and how data is captured and managed. This literature review provides a starting point and summary for further NCDOT engagement in micromobility, including:

**Provide clearer definitions for micromobility devices and regulations:**

- Serve as the lead resource to define micromobility to stakeholders and local officials across North Carolina.
- Monitor and communicate state legislative changes and requirements.
- Work with state legislators to clarify regulations to support micromobility implementation, compliance, and fair, equitable use for diverse communities.
- Become a clearinghouse for federal regulatory information and guidance.

**Create consistent data collection and management standards:**

- Develop consistent data standards across business units and leverage data collection opportunities at different stages of planning and project development. For example, coordinate crash data with NCDOT Transportation Mobility and Safety Division to inform micromobility feasibility studies, design, or operational decisions.
- Publicize micromobility safety data through visually engaging or interactive formats (such as Geographic Information Systems) to provide insights to local communities interested in deploying micromobility along particular corridors or within relevant street networks.

**Promote micromobility awareness and education:**

- Facilitate annual “Micromobility Awareness Week” or similar events to educate public and private stakeholders of NCDOT’s role and responsibility and to promote IMD technical resources and guidance.
- Incorporate findings from national and state research within promotional opportunities including sharing emerging industry trends and changes in micromobility implementation.
- Seek opportunities to recruit national subject matter experts to present at North Carolina transportation conferences to reach a wider audience of stakeholders.

**Liaison between communities and vendors where appropriate to support implementation:**

- Engage with vendors to help community planners translate the administrative burdens, requirements, and safety concerns associated with micromobility implementation.

- Support micromobility implementation consistent with state safety standards and in concert with local transportation needs and goals.

**Conduct local feasibility analyses**

- Evaluate the feasibility and best fit for micromobility services based on local context, needs, and scale of use.
- Consider assessing service opportunities during the development of a Comprehensive or Metropolitan Transportation Plan update to leverage data collection and to assess how micromobility is responsive to demand forecasts. Coordinate other modeling and demand scenarios with Transportation Planning Division (TPD) as part of these plan updates.

**Issue pilot programs to test micromobility programs**

- Oversee, deploy, and pilot micromobility programs across diverse urban and rural communities to test equity, sustainability, safety, and operational concerns.
- Engage a growing community of micromobility users and advocates to promote pilot programs.
- Use stakeholder feedback to refine and strengthen state, local, and public-private coordination protocols, policies, and practices and to launch future programs.
- Host peer exchanges which allow participating communities to learn from each other.

**Seek funding opportunities**

- Identify funding opportunities which leverage federal, state, and local resources (such as grants) to advance and mature micromobility programs across North Carolina.
- Support additional research to explore innovative methods cities around the world use to oversee, administer, and fund micromobility programs which may be applicable to North Carolina communities.

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# Appendix B: Survey

The North Carolina Department of Transportation (NCDOT)'s Integrated Mobility Division (IMD) conducted research to inform IMD's efforts in defining its role and developing resources to aid North Carolina communities and organizations in managing and implementing micromobility. A survey was conducted to assess micromobility efforts, interest, and needs across the state as a part of the research effort.

The objectives of the survey were to inventory micromobility services in North Carolina, gauge interest in introducing or expanding micromobility systems, identify key benefits, document barriers and challenges, and determine priority areas and resources for NCDOT and IMD to aid communities in future micromobility planning.

# Survey Methodology

An online survey of select municipalities, metropolitan and rural planning organizations (MPOs and RPOs), and universities and community colleges across North Carolina was conducted from February 14 to March 24, 2023.

Organizations receiving the survey included North Carolina municipalities with a population greater than 15,000 as reported by the 2019 U.S. Census table, "Annual Estimates of the Resident Population for Incorporated Places in North Carolina," MPOs and RPOs, universities with enrollment greater than 1,500, and seven of the top ten community colleges by enrollment. The survey was sent to 128 organizations.

The survey was hosted on the online platform Survey123. It was comprised of 23 questions, with skip logic built in so that respondents were presented with 15 to 20 questions in total based on their responses. The survey focused on the following key areas:

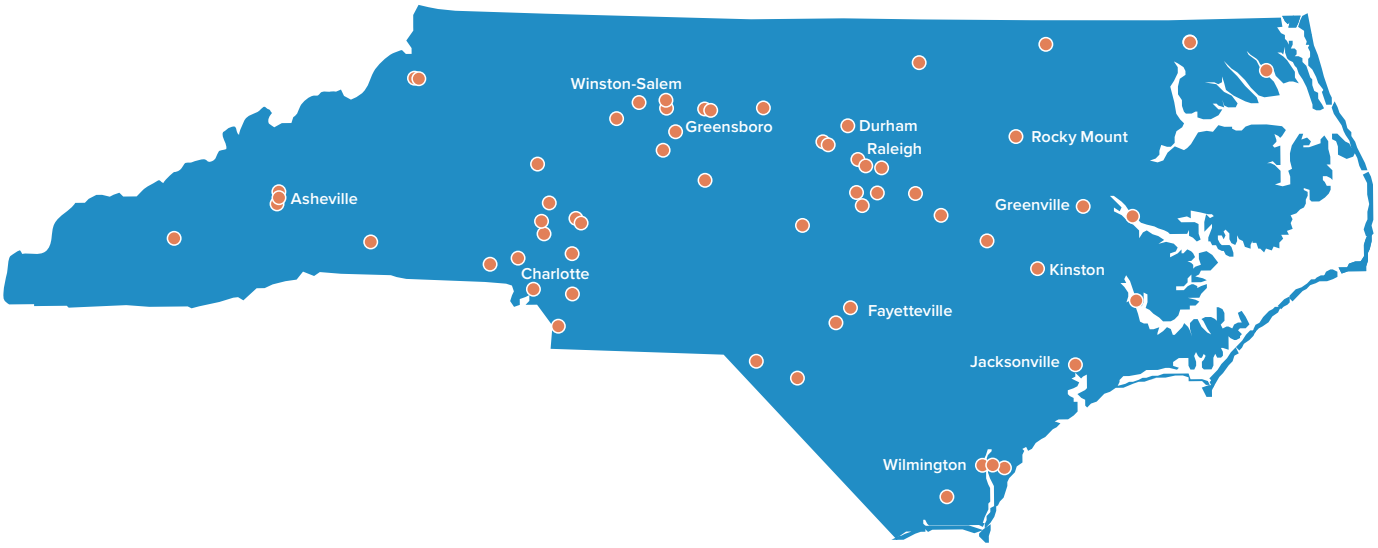
- **Existing Systems, Plans, Interest, and Efforts** – these questions assessed the responding organization's current status regarding micromobility and interest in developing a program.
- **Benefits and Challenges** – these questions identified respondents' views on micromobility benefits and challenges their community faces regarding implementing micromobility.
- **Resource Needs** – a question was asked to identify the types of resources respondents need to support micromobility efforts in their community.
- **Pilot Project Opportunities** – questions were asked about responding organization's interest in working with IMD in the future to deliver a micromobility pilot project to implement or expand service.
- **Other Comments** – the final question offered respondents an opportunity to provide any other comments on the topic of micromobility.

# Survey Results

The responses and results of the survey are presented in the following sections. A brief summary of the key results from each section of the survey is provided followed by charts and tables providing detailed information on the response to each question within that section. As previously noted, due to skip logic, not all questions were asked to all respondents; results for each question are interpreted based solely on those that responded to a particular question.

In total, 65 of 128 organizations responded to the survey, resulting in a 51 percent response rate. Nearly half of the respondents were municipalities (30), with the rest split between MPOs (15), RPOs (10), universities (8), and community colleges (2). Two "other" individuals representing a council of governments and a transit agency also responded to the survey.

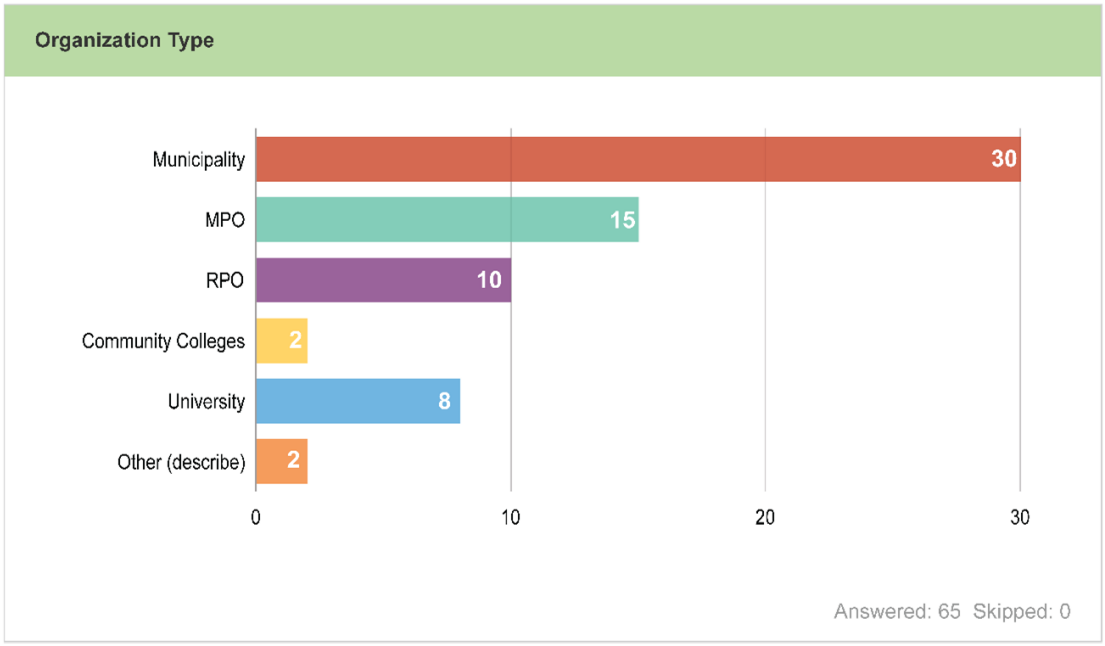
The following map shows the geographic distribution of respondents across North Carolina.




**Survey Respondents**

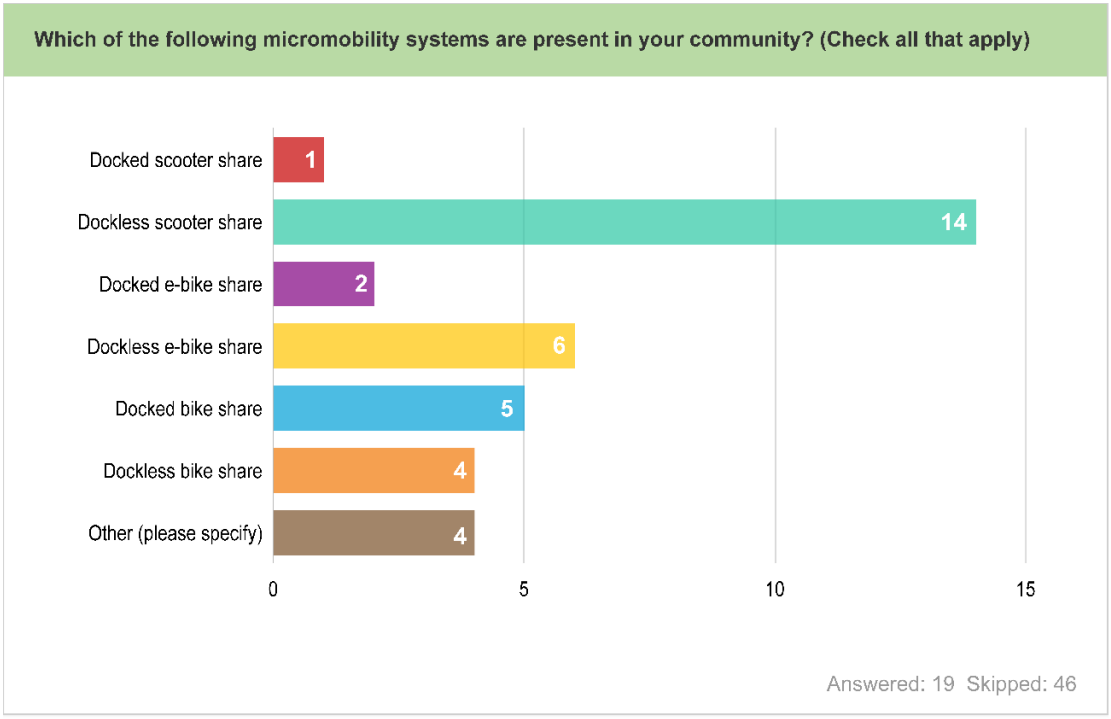
The survey gathered basic contact and organization information from respondents, including their organization name and type and their name, role/title, and contact information.

Individuals holding a wide variety of positions responded to the survey. Planning directors and transportation planners were among the most common positions represented. Other respondents held positions such as city manager, engineer, sustainability and transportation coordinator, and chief finance officer (CFO). The following chart illustrates the organizations represented by the survey respondents.

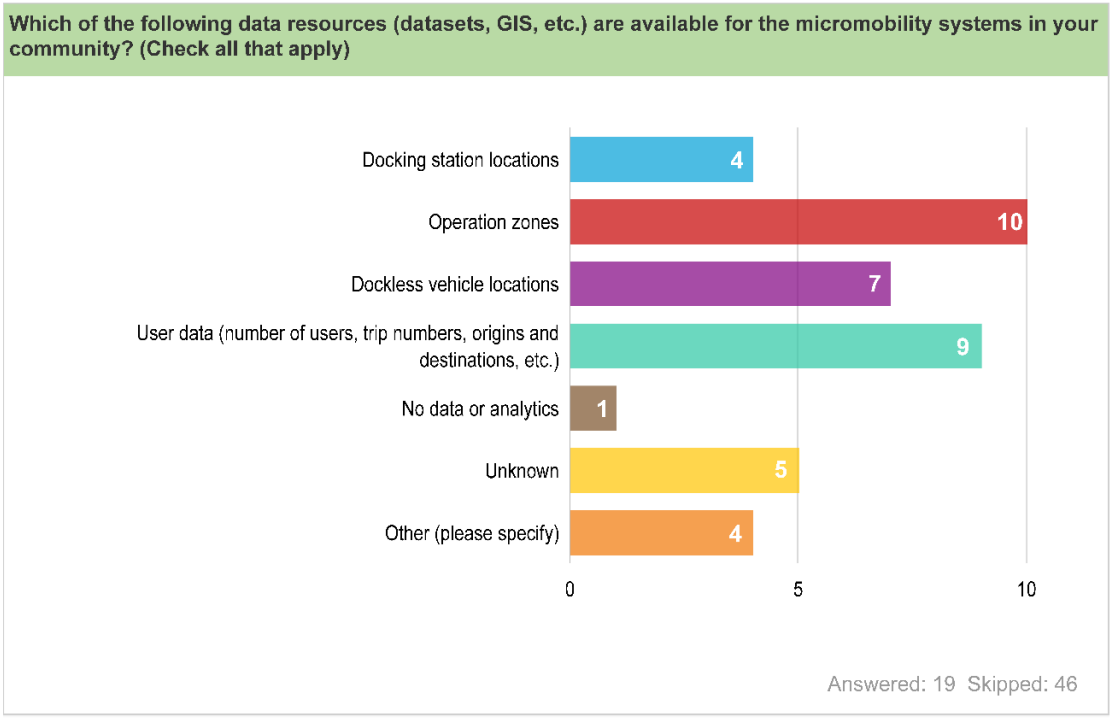


## Existing Systems, Plans, Interest, and Efforts

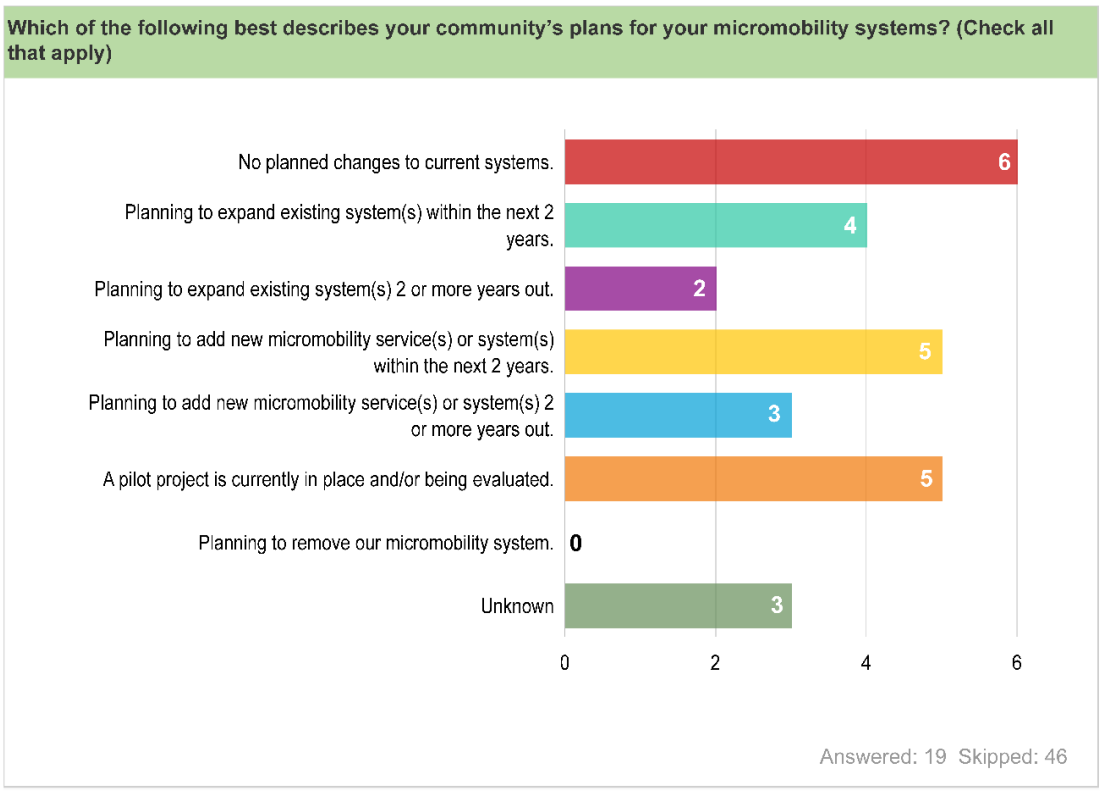
In this section respondents were asked whether micromobility was present in their community and then asked a unique series of questions based on their response.




Nineteen of the 65 respondents (29%) have a micromobility system present in their community. The most common of these micromobility systems were dockless e-scooter share (74%) and dockless e-bikeshare (32%). These existing micromobility programs are operated by a variety of vendors, with the most common noted as Bird, Spin, and Blue Duck.




The most common data resources that the communities with micromobility programs utilize are "operation zones" (53%), "user data (number of users, trip numbers, origins and destinations, etc.)" (47%), and "dockless vehicle locations" (37%). Only two respondents provided links to publicly accessible data resources on their micromobility programs: a Ride Report micromobility dashboard map and analysis for Durham, North Carolina and a dashboard for the Bull E-Bike Pilot in Durham, North Carolina. Three respondents mentioned that their data resources were not publicly available at the time. Other resources shared by respondents included a map of bikeshare stations on Duke University's campus and general mapping resources not specific to micromobility.




For respondents with micromobility programs, 32 percent said they had no planned changes to the system, 26 percent said they were "planning to add new micromobility service(s) or system(s) within the next 2 years," and 26 percent said "a pilot project is currently in place and/or being evaluated." The only answer choice that no respondents chose was "planning to remove our micromobility system."

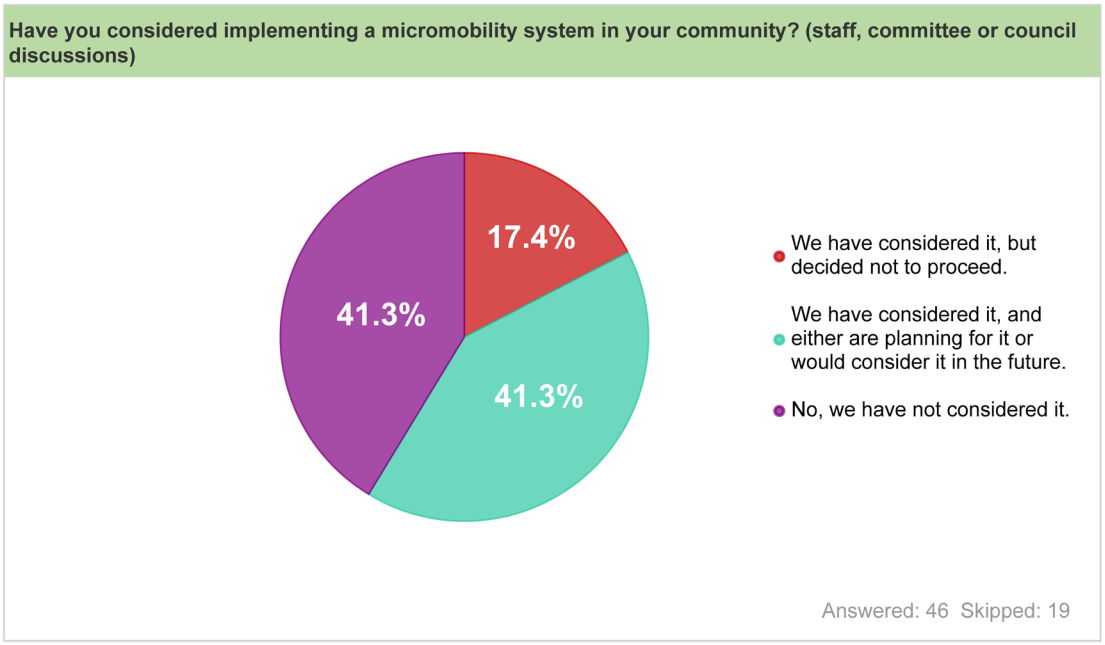
Respondents in communities with micromobility were asked to share challenges, best practices, and lessons learned in an open-ended response question, and 12 respondents provided an answer. The majority of responses to this question identified significant challenges due to parking issues, particularly micromobility devices blocking sidewalks, and other areas that need to be clear of obstructions. One respondent noted that it is a challenge to overcome the negative perception around micromobility due to the parking issue and micromobility devices are seen as "clutter." Another respondent tried to put "park here" decals in their downtown, but businesses would often remove them. A respondent who noted several challenges identified the lack of a clear definition of micromobility devices at the state level, balancing municipal needs with vendor needs, and user behaviors such as riding on the sidewalk as challenges. Respondents also noted issues with tracking micromobility crashes without a completed police report and the need for sustainable funding sources.

Lessons learned shared by respondents included:

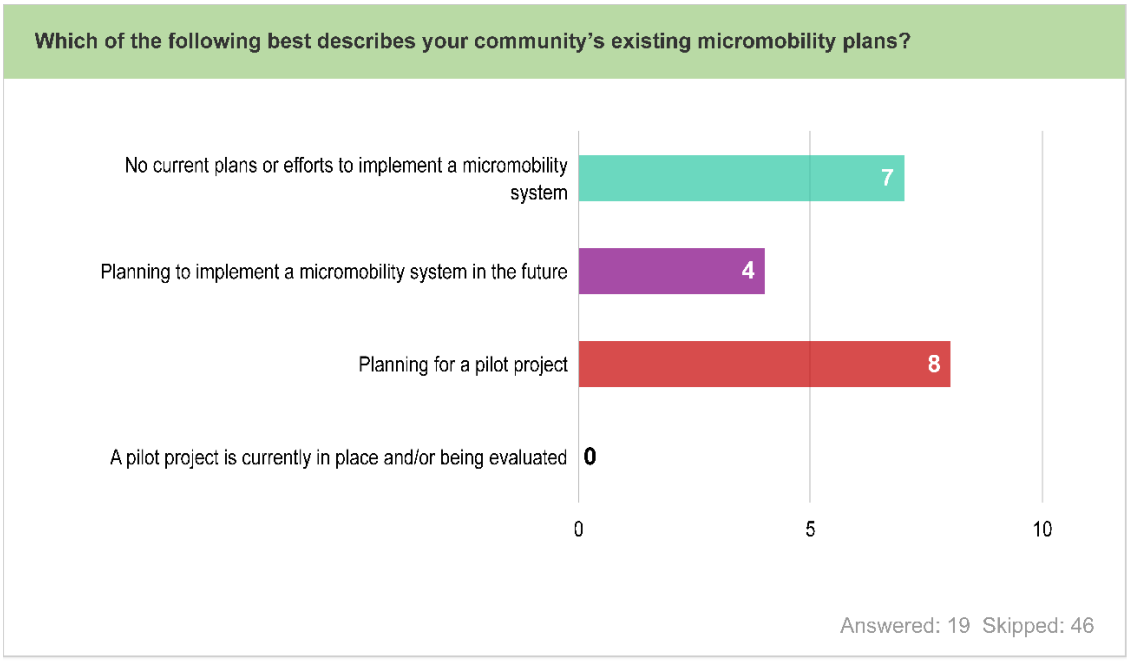
- Update local ordinances for micromobility
- Keep management approach and fee structure simple, especially for smaller programs
- Set a clear standard for vendors in the permitting and/or contracting process
- Create strong relationships with vendors to address questions of abandonment and/or misplacement of micromobility devices

- Engage with other communities and micromobility vendors to develop research together
- Limit the number of vendors
- Utilize a vendor with a local presence
- Coordinate with major employers
- Develop a sustainable funding source
- Have strong parking regulations, clear geofences, slow-zones, and no ride zones

Those who responded "No" to the question about whether micromobility was present in their community were asked if their community had considered implementing micromobility and, if they had, whether they were planning to move forward with it or would consider doing so in the future. Those who had considered it, but not proceeded, were asked why it had not moved forward. Those who were planning for or who would consider micromobility in the future were asked about the status of current or future plans.




Of the 46 respondents (71%) without micromobility systems present in their communities, 19 respondents (41%) have "considered it, and are either planning for it or would consider it in the future" and another 19 respondents (41%) "have not considered it." The eight respondents (17%) who considered micromobility but did not proceed provided free response answers describing why micromobility planning did not proceed. The most common reasons cited were cost, staffing shortages to manage the program, concerns about micromobility device parking and safety, lack of supportive physical infrastructure or local destinations, and lack of community and/or leadership interest. Two respondents who included infrastructure as a barrier mentioned historic streets and/or downtown areas that are not well suited to micromobility device parking and operation. Some respondents had internal discussions on the topic, or even conducted discussions with micromobility vendors in the past.



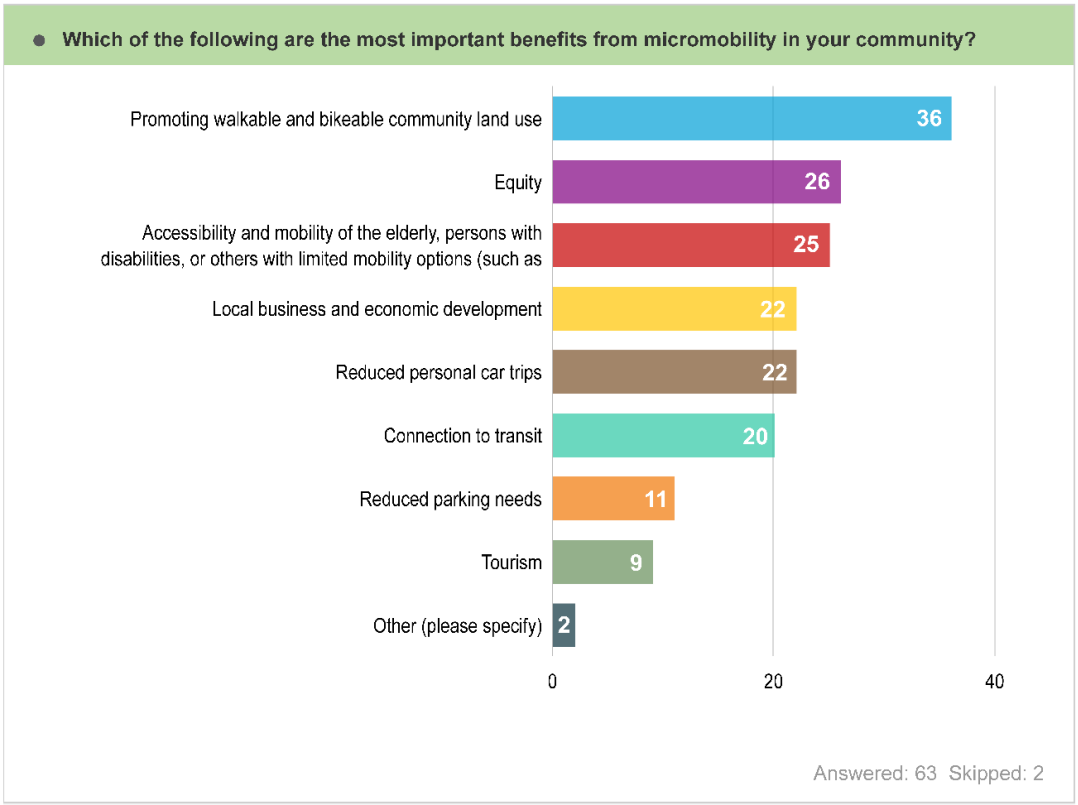

Of the 19 respondents who are planning to implement a micromobility program or would consider it in the future, eight (42%) are currently planning for a pilot project, four (21%) are planning to implement a micromobility system in the future, and seven (37%) do not yet have plans to implement a micromobility system.

## Benefits and Challenges

All respondents were asked to share their feedback on micromobility benefits and challenges from their perspective.

### Micromobility Benefits

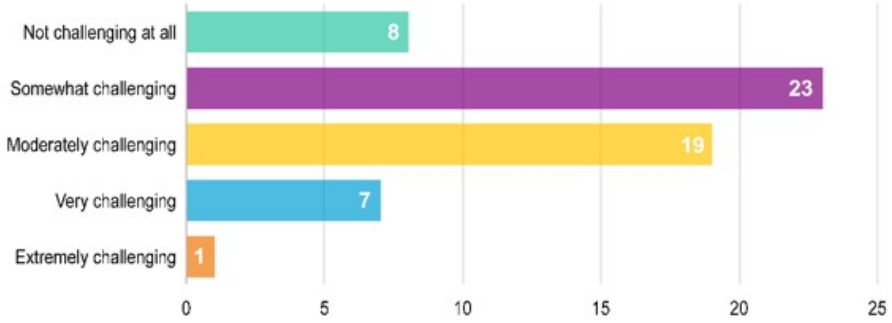
Respondents were asked to select the top three most important benefits from micromobility. The most popular answer was "promoting walkable and bikeable community land use," selected by 57 percent of respondents. "Equity" and "accessibility and mobility of the elderly, persons with disabilities, or others with limited mobility options (such as zero car households or school-aged children)" were the second and third most selected responses, at 41 percent and 40 percent, respectively. More than 30 percent of respondents also identified "local business and economic development" (35%), "reduced personal car trips" (35%), or "connection to transit" (32%) within their top three identified most important benefits of micromobility. Two respondents (3%) selected "Other (please specify);" the benefits noted were options for short trips that avoid traffic and access where transit alternatives are insufficient.




### Micromobility Challenges

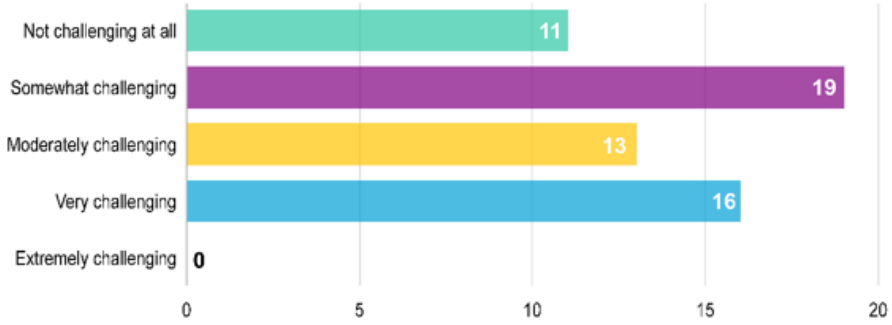
The survey provided respondents with a series of questions referencing common micromobility challenges and asked respondents to rate them on a 5-point scale from "not challenging at all" to "extremely challenging." Respondents could also select "N/A" if the topic did not apply to their community or organization; "N/A" responses were treated the same as a skipped question and were removed from analysis. In addition to these Likert-scale questions, respondents also had the option to provide a free response identifying other challenges.

**Local ordinances and regulatory challenges**



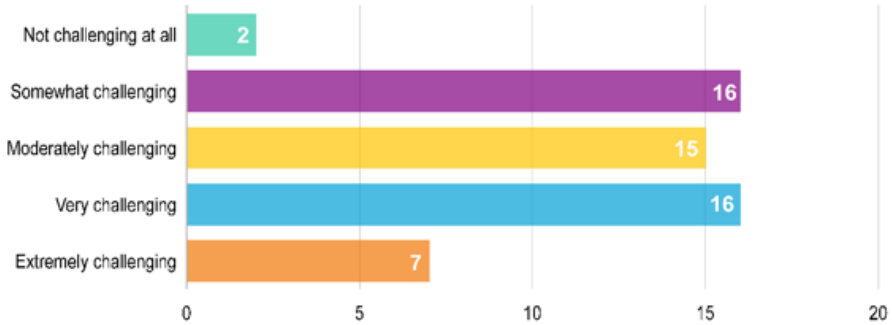

Answered: 63 Skipped: 2

**Parking for micromobility vehicles**



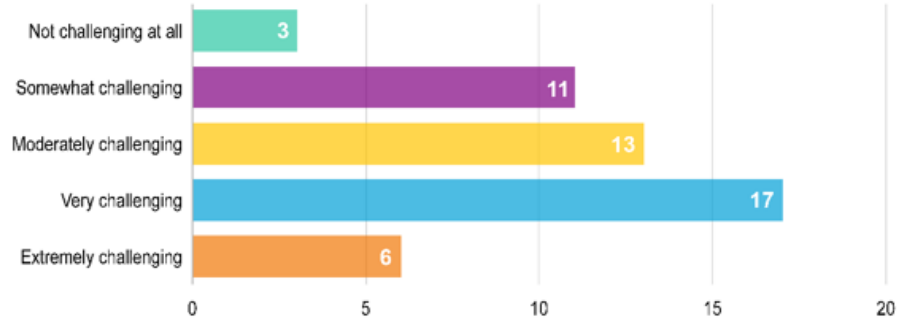

Answered: 64 Skipped: 1

**Infrastructure/design to support micromobility modes**



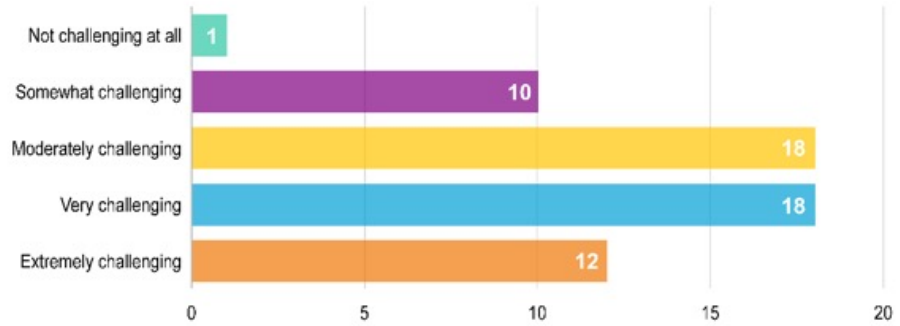

Answered: 62 Skipped: 3

● **Payment issues (sign ups, equity, payment integration)**



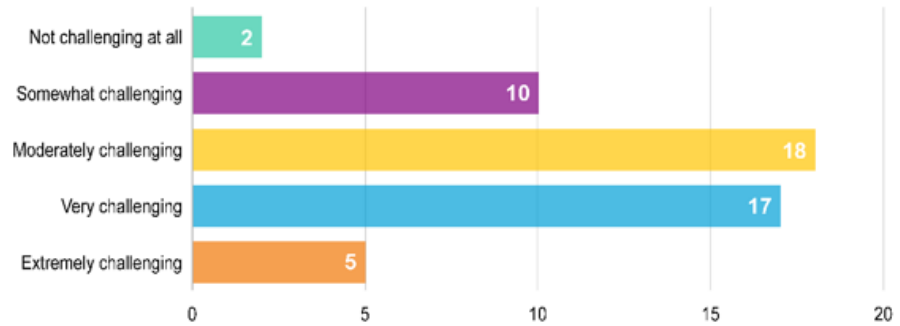

Answered: 63 Skipped: 2

● **Safety of riders and other road and sidewalk users**




Answered: 63 Skipped: 2

● **Micromobility vehicles blocking sidewalks and other facilities**




Answered: 64 Skipped: 1

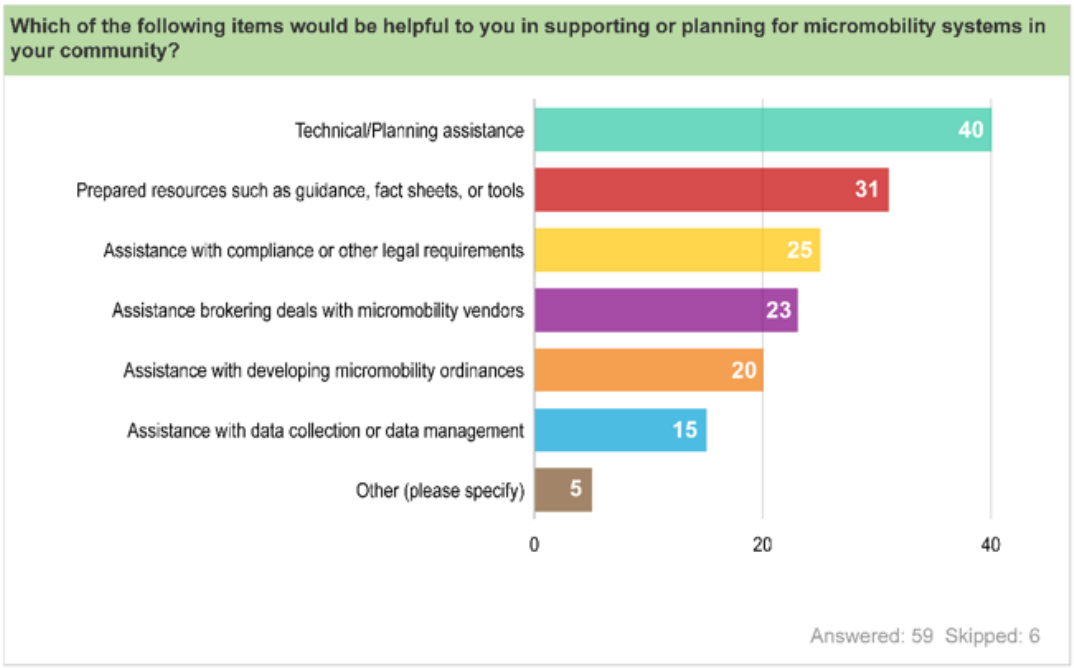
"Safety of riders and other road and sidewalk users" was the most challenging issue, with 51 percent of respondents rating it as "very challenging" or "extremely challenging," and another 31 percent rating it as "moderately challenging." The next most challenging issues were "payment issues (sign ups, equity, payment integration)" (46% "very" or "extremely challenging"), "micromobility vehicles blocking sidewalks and other facilities" (42% "very" or "extremely challenging"), and "infrastructure/design to support micromobility modes" (41% "very" or "extremely challenging").

Thirteen respondents provided a free response answer describing other challenges identified; a number of these were from universities. Responses on other challenges were wide-ranging while reflecting some common elements and included:

- The importance of allocating the right number of vehicles in an area
- Lack of existing supportive infrastructure and appropriate locations for docking stations
- Determining where micromobility devices can be allowed to ride
- Safety (including challenges with tracking scooters in crash data)
- Resolution needed around state legal definitions for micromobility devices (which affect tracking crash data)
- A need for policies that reflect community values
- Challenges securing funding
- Issues specific to rural communities, including "the economy of scale in rural areas"
- Lack of presence of micromobility generally
- The high speed at which the micromobility industry has grown and changed (including concerns for the long-term viability of any selected micromobility vendor)

## Resource Needs

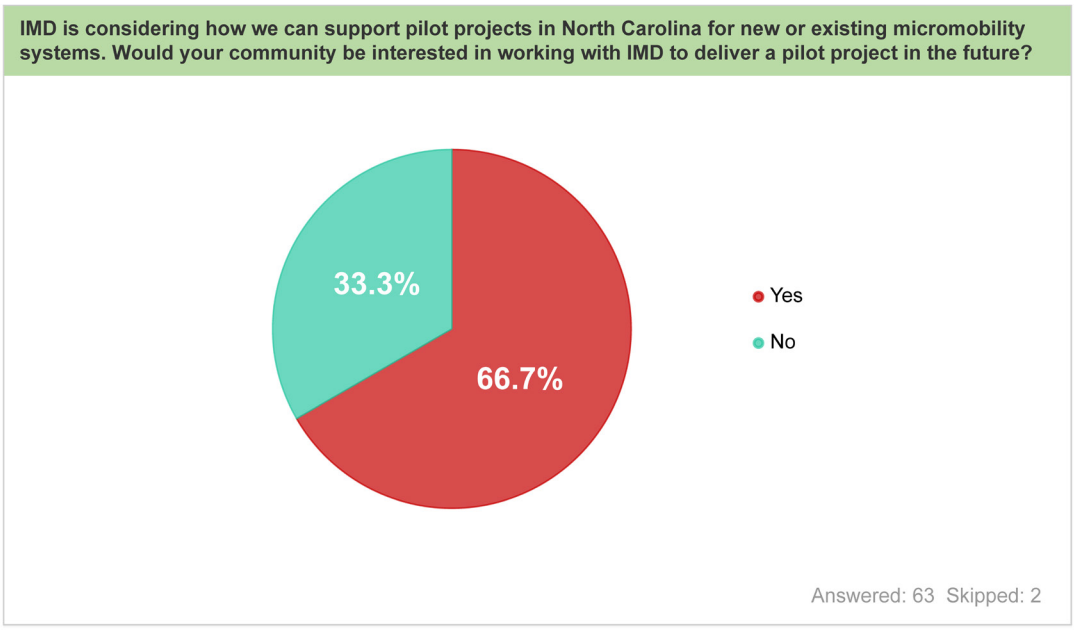
Respondents were asked to select up to three choices to identify items that would be most helpful in supporting or planning for micromobility efforts.




The most frequently selected answer was “technical/planning assistance,” selected by 68 percent of respondents. “Prepared resources such as guidance, fact sheets, or tools” and “assistance with compliance or other legal requirements” were the second and third most selected responses, at 53 percent and 42 percent, respectively. Nearly 40 percent of respondents identified “assistance brokering deals with vendors” within their top three resource needs, while approximately one-third of respondents identified the need for “assistance with developing micromobility ordinances.” Slightly more than one in four respondents identified “assistance with data collection and management” within their top three resource needs. Five respondents (3%) selected “Other (please specify);” four of these five respondents mentioned funding as a helpful resource, and one respondent mentioned that they may identify other needs during a pilot project.

## Pilot Project Opportunities

The survey asked whether respondents would be interested in working with IMD on a pilot project for new or existing micromobility systems.




Of the 65 total responses, 42 respondents (67%) said they would be interested in IMD's support for a pilot project, with 31 respondents providing further details or contact information for follow-up. These respondents include representatives from municipalities, universities, MPOs, and RPOs across the state. Interest ranges from respondents that do not currently have an idea or plan for a pilot project to those that have a full pilot project in mind. Among responses from those who provided a written description of future pilot projects, the most common projects respondents identified were shared bicycles and e-bikes.

Some respondents expressed interest in microtransit and shuttles, which underscores the importance of education by IMD to North Carolina communities on what micromobility encompasses and what it does not include.

## Other Comments

The final question of the survey prompted respondents to share any other comments with IMD.

Fourteen individuals provided a response to this question. Several responses noted low demand and/or interest in micromobility among the community and leadership in an area; one commenter cited the lack of presence of a "culture of sustainable transportation," while another indicated that education and promotion would be needed to generate interest in communities within their RPO region.

Other notable comments included a request for a resource outlining what is allowed in NCDOT right-of-way for micromobility, enthusiasm about creating regional partnerships (including MPOs, universities, and NCDOT), a suggestion that transit agencies be encouraged to extend micromobility to transportation disadvantaged populations, and a suggestion to look to programs in Georgia and Tennessee to compare similar programs and policies.