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Leveraging Mobility Data Analytics to Inform Mobility Hub Development in Florida
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FINAL REPORT

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Metric Conversion Chart

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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16. Abstract

Mobility hubs (MHs) can facilitate seamless transitions between various transportation modes, such as transit, ridehailing, and micromobility, enhancing multimodal travel and delivering socioeconomic benefits. To inform mobility hub planning and development in Florida cities and beyond, this project develops a multi-criteria, GIS-based MH site selection tool. The tool prioritizes factors such as multimodal travel needs, first-/last-mile connectivity, and socio-demographic considerations in the MH site selection process. Through an application of the tool in Gainesville, Florida, we have identified 17 potential MH sites, categorized into neighborhood, district, and regional levels. Survey findings reinforce the significance of MH to facilitate multimodal connectivity and reveal preferences for hub locations that align with residents' travel patterns. Key mobility hub features strongly desired by Gainesville travelers include parking, bike/e-scooter racks, and non-transportation amenities such as safety features and digital displays. We have further tested the tool in the City of West Palm Beach, and the results demonstrate its broader applicability. This research offers a strategic roadmap and practical guidelines for cities to enhance transportation networks and support urban development through the implementation of well-planned MHs. The research team's extensive collaboration with the City of Gainesville and subsequent funding from the U.S. Department of Energy to support the development of climate-controlled shelters at selected MH sites underscores the practical impact of this research.

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Executive Summary

Mobility hubs (MHs) are physical locations that allow travelers to seamlessly switch between various modes of transportation such as transit, ridehailing, and micromobility. These hubs, by enhancing connectivity and accessibility, contribute to an improved quality of travel and offer various socioeconomic benefits. As integral components of transport networks, mobility hubs play a crucial role in integrating new mobility technologies. While many cities and transit agencies have planned to develop MHs, an established methodology for selecting candidate sites for MH implementation is still lacking.

This project fills this gap by developing a multi-criteria mobility hub site selection tool and providing Florida cities and towns with a set of practical guidelines for implementing MHs. The main tasks performed include the following: 1) synthesizing the existing mobility hub identification processes used by cities and towns in Florida and beyond; 2) developing an analytical tool for Florida agencies to use for identifying and developing mobility hubs; 3) testing the tool in two Florida cities (Gainesville and West Palm Beach) with distinct land-use and socioeconomic contexts to ensure its broader applicability.

In **Chapter 1,** we conduct a comprehensive literature review on MHs, providing an overview of the state of the research and current trends. We synthesize the MH definitions, typologies, and site selection approaches, as well as user preferences and the potential impacts of MHs. In addition, we present six case studies, covering site selection, feature programming, stakeholder engagement, and performance evaluation of mobility hubs. Our synthesis has generated valuable insight regarding the conceptualization, development, and implementation of mobility hubs. Overall, the literature and practice review demonstrated that mobility hubs have potential to be an effective tool to move toward a sustainable transportation network, improve transportation access, and enhance community spaces. The key lessons learned emphasize the importance of flexibility, community engagement, ongoing evaluation, and iterative improvements to ensure MHs remain relevant and effective.

In **Chapter 2**, we develop a GIS-based multi-criteria analytical framework to identify optimal mobility hub locations based on a case of Gainesville, Florida. The proposed tool prioritizes five major factors for mobility hub site selection, including 1) accommodating multimodal travel needs and streamlining transfer processes, 2) integrating with existing bicycle and pedestrian infrastructure, 3) enhancing first-/last-mile connectivity, 4) promoting access to destinations, and 5) promoting socioeconomic justice. Our method is novel in several ways. First, it uniquely uses transit stops rather than area units as the basis for analysis, which can inform targeted and actionable infrastructure investment decisions. Second, it addresses the gap in existing methods by classifying mobility hubs into three levels—regional, district, and neighborhood—and identifies them sequentially, recognizing the different functions and scales of these hubs. Lastly, the tool includes a novel approach to quantifying first-mile/last-mile transit service gaps, which is crucial for improving transit connectivity. Using this tool and by considering six planning scenarios (i.e., enhancing transit, enhancing first-/last-mile connectivity, leveraging existing infrastructure, prioritizing disadvantaged populations, enhancing accessibility, and equal weights), we identified 17 potential hubs across different scales, with notable hubs in southwest and east Gainesville.

In **Chapter 3,** we further present results from a Gainesville survey that engaged a diverse group of individuals to understand considerations for hub locations from local travelers' perspectives. The survey focused on understanding their current travel behavior, opinions towards multimodal travel, perceived barriers in using transit, and the potential impact of mobility hubs on their travel patterns. Interactive maps were employed to gather residents' feedback on ideal locations and desired features for mobility hubs, and the crowdsourced mapping results were used to validate GIS-based analysis findings. The survey results revealed significant overlap between suggested hub locations from public input and the GIS-based analysis, validating the tool's accuracy. This alignment, along with insights into travelers' behavior and preferences, suggested strong interest in mobility hubs, with findings indicating bus and walking modes' popularity, the importance of amenities like parking and safety features, and preferences for hubs near high-population areas and campuses. The survey confirmed the potential of mobility hubs to enhance multimodal travel and emphasized the need for inclusive design that considers diverse community needs, including infrastructure for cyclists and wheelchair users.

Based on the GIS-based analysis (Chapter 2), survey results (Chapter 3), as well as a review of existing plans, and stakeholder feedback, we recommend mobility hub locations at regional, district, and neighborhood levels for the City of Gainesville in **Chapter 4**. Key hub locations include Shands Hospital as a regional hub, Butler Plaza and Rosa Park Transfer Stations as district hubs, and Gainesville High School as a neighborhood hub. The recommendations also stress the importance of considering community feedback, land availability, and environmental impacts in final site selections. Based on these results, the city staff and the research team have been actively collaborating to apply for funding opportunities for mobility hub implementation. In April 2024, the City of Gainesville received a grant from the U.S. Department of Energy to develop climate-controlled shelters at several identified MH locations.

To ensure the wider applicability of the mobility hub identification tool in Florida cities and beyond, we tested it in West Palm Beach (**Chapter 5**). Specifically, we replicated the steps described in Chapter 2, 3, and 4 for identifying mobility hubs in West Palm Beach. We identified five potential mobility hub locations in West Palm Beach, validated through GIS analysis, community surveys, and stakeholder feedback. The West Palm Beach Tri-Rail Station emerges as a prime regional hub, supported by both scoring and existing transit plans. Other recommended sites include Congress and Palm Beach Lakes, and Dixie and 23rd Street. The analysis suggests some locations, like Military and Hibiscus, may require reevaluation due to their lower strategic importance. Overall, we demonstrated that the proposed mobility hub identification tool and data gathering/analysis procedure is readily applicable to identify MHs in West Palm Beach after adjusting certain criteria and parameters.

We conclude the report with **Chapter 6**, discussing the findings and insights. The findings and recommendations from this report provide a strategic roadmap for the development of mobility hubs in Gainesville and West Palm Beach. Our research has produced a mobility hub site selection tool that can be readily used by other cities in Florida and beyond.[1] Combining a data-driven site selection process and extensive community/stakeholder engagement, analysts and researchers can use this tool to identify mobility hub sites for significantly enhance transportation networks, promote multimodal travel, and support sustainable urban development.

[1] https://jacobyan0.github.io/MobilityHub/

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1 Literature and Practice Review

1.1 Introduction

Recent years have seen rapid growth in transportation related technologies, which in turn have spurred an increase in travel options such as ridehailing and shared micromobility. In response, cities and transit agencies around the world are identifying ways to harness the benefits of innovative technology while minimizing risks. Mobility hubs offer one such strategy by serving as a platform that integrates different modes of transportation, supports first and last-mile connectivity, and provides supportive services (e.g., information kiosk) to travelers.

As mobility hubs are a relatively new concept, there is limited information available regarding their deployment. The purpose of this chapter is to synthesize the existing knowledge in the literature and review the current practice regarding mobility hub development and implementation. In addition to discussing the emerging mobility trends that shapes the development of mobility hubs, we review mobility hub typology and identification approaches, the data and methods commonly used for mobility hub site selection, and the performance metrics for evaluating mobility hubs. In addition, we review some recent examples of mobility hub projects and provide a summary of the main findings. The information provided in this chapter will lay the groundwork for the development of an analytical tool (Chapter 2) to help Florida cities and transit agencies make context-aware and data-informed decisions on mobility hub site selection and feature programming.

This chapter is structured as follows. In Section 1.2 Background: Public Transit in the Shared Mobility Era, we discuss the rise of shared mobility and ongoing initiatives to facilitate its integration with transit. In Section 1.3. Approaches for Mobility Hub Planning and Development, we introduce mobility hubs' definition, typologies, and functional elements and review the site selection methods and performance measures for mobility hubs. In Section 1.4. Case Studies of Mobility Hub Plans, we present six case studies of mobility hub development and implementation, covering both Florida and non-Florida projects. In Section 1.5. Summary and Lessons Learned, we summarize the key findings and make suggestions for future mobility hub projects in Florida.

1.2 Background: Public Transit in the Shared Mobility Era

The term “shared mobility” refers to mobility solutions which apply new technologies into existing transportation networks to create contemporary, shared-used transportation systems which are more sustainable, efficient, and convenient. Shared mobility concepts that have emerged and been developed in recent years include carsharing, ridesourcing or ridehailing, shared micro-mobility, mobility-as-a-service (MaaS), and microtransit. The rise of shared mobility options could have significant implications on transit: they could either substitute the use of transit or complement traditional transit options. Accordingly, there has been a growing interest to explore what factors shape travelers’ preference for various mobility options and how to proactively implement strategies and policies to promote the integration of novel, shared-used mobility options with conventional transit systems.

1.2.1 Rise of Shared Mobility Options

Shared mobility is a novel mobility concept intended to detach usage from ownership in transportation; it allows users to purchase the mobility service for a short period of time rather than purchasing the means of mobility itself. This shift from an owner-based model to a usage-based model increases the efficiency of modal use by reducing the amount of time the means of mobility are left unused and increasing the average occupancy rate (Terama et al., 2018; Machado et al., 2018).

As an intermediate between private and public transportation modes, shared mobility offers the advantages of private mobility (flexibility and comfort) while providing many of the benefits of transit (reducing traffic congestion, relieving parking pressure, reducing air and noise pollution, etc.) (Machado et al., 2018).

The flexibility of shared mobility can be partly attributed to its digital component; users typically book and pay for mobility services immediately when they are needed through a mobile application. The use of digital technologies in passenger transportation has opened the door for novel mobility systems, such as mobility as a service (MaaS) which will be discussed in detail in later sections. Although this digital integration may increase convenience for some users, others (such as technologically illiterate users or those without mobile data) may be left behind in the shift towards more technology-driven mobility trends.

Shared mobility models can be applied to virtually any mode of transportation, so there are quite a few different types of shared mobility in practice. Figure 1 displays the many modalities of shared mobility prevalent today.

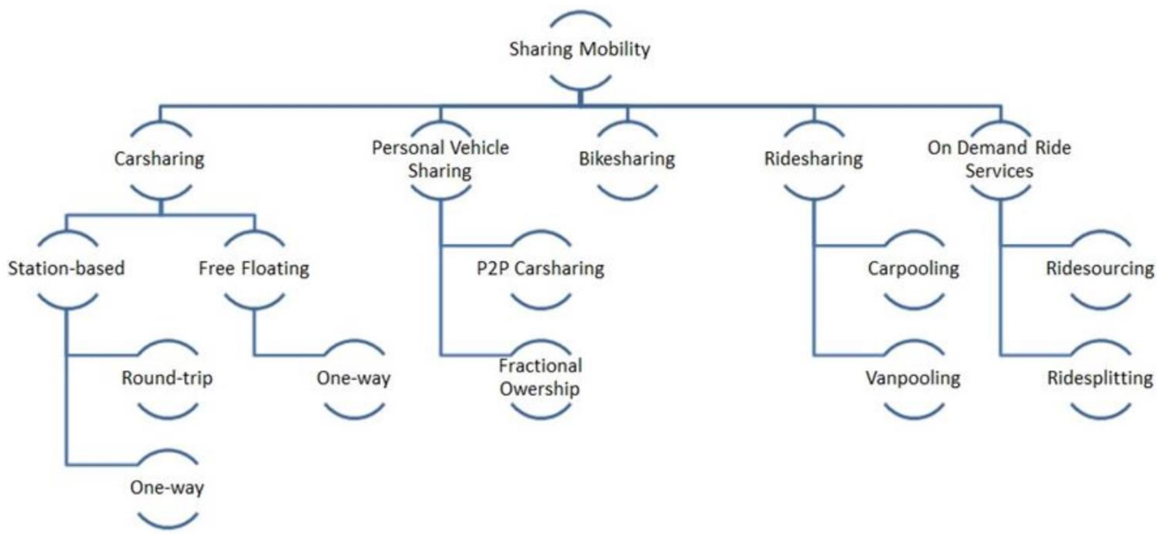


Figure 1: Overview of shared mobility modalities
(Source: Machado et al., 2018)

Over the past decades, there has been a significant growth in usage of new and shared mobility. For example, the portion of ride-hailing trips taken increased from 0.2% to 0.6% between the 2009 and 2017 National Household Travel Surveys, an increase likely attributed to the emergence of ridesourcing companies such as Uber and Lyft (Wang & Renne, 2023). Car share has experienced similar growth; the member-to-vehicle ratio for car share in the US drastically increased from approximately 7:1 in 1998 to 64:1 in 2005 and 94.5:1 in 2018 (Shaheen & Cohen, 2007; Shaheen & Cohen, 2020c). Bike sharing grew globally from just 17 programs in 2005 to 2,900 in 2019 (Oeschger et al., 2020). The increase in shared mobility can address first and last-mile gaps by extending the catchment area of transit and encourage multimodality (Shaheen & Chan, 2016).

Shared Mobility Service Models

There are multiple mobility service models through which shared mobility operates. The user may elect the model most practical for them based on factors such as trip duration, trip frequency, cost, convenience, and local availability. The U.S. Department of Transportation (Shaheen et al., 2020a) has highlighted four models that are available today:

- Membership-based models (self-service)
- Non-membership models (self-service)
- For-hire service models
- Peer-to-peer models (self-service)

Each service model has unique advantages. For example, membership-based models are best for frequent users of shared mobility because they may pay a flat fee for unlimited use of the mobility service; this is typically more cost effective than paying for the services prior to each use. However, these models are not practical for all users. For example, membership service models may not be practical for low-income individuals who may not be able to afford the upfront cost of a flat fee, tourists who will only need access to the mobility option for a short period of time, and residents who use shared mobility irregularly. ZipCar is one example of a membership-based car share service; it offers both monthly and annual memberships.

Non-membership models are similar to membership models in that a private mobility company owns the vehicle and handles other aspects of the rental process such as license and identity verification, insurance, and customer service. However, a key difference is that in non-membership models, mobility services are rented on a case-by-case basis. Share Now is an example of a European car share company which offers pay-per-minute services with no membership requirement.

For-hire service models are characterized by the hiring of a driver in addition to the vehicle. The driver may be an independent contractor (such as Uber/Lift drivers) or employees for a company (such as some taxi drivers). For-hire models are a more convenient service model because the user would not need to operate the vehicle themselves, rather they choose a pick-up/drop-off location and time. However, some users, especially women and older adults, may express safety concerns with for-hire services that do not arise with self-service models.

Peer-to-peer models are unique. Unlike other service models, the means of mobility are owned by an individual and rented to another individual through an interface operated by a mobility company. These models can help alleviate ownership and maintenance costs for the vehicle owner and reduce the amount of time that the vehicle remains unused. Additionally, peer-to-peer models usually have lower overall cost than other models. Peer-to-peer service models in the United States include Getaround, Turo, and HyreCar.

Car Share

The concept of car share as a mobility solution was first documented in Europe in the 1940s and the prevalence of car sharing networks rapidly increased beginning in the late 1990s (Shaheen & Cohen, 2007); today there are hundreds of thousands of vehicles and millions of users in Europe, Asia, and North America (Mindur et al., 2018). Like other shared mobility services, car share allows users to access a vehicle for short periods of time. There are various types of car share and users may pick the most practical one depending on their trip intention and the options available locally. Vehicles may be available at designated locations or free-floating, so pick-up and drop-off locations are widely available. This flexibility makes car share more convenient than traditional car rental. The most common types of car sharing are summarized below in Table 1 (Machado et al., 2018; Schade et al., 2014; Ferrero et al., 2018).

Table 1: Summary of Car Share Systems

Type of Share	Subcategory	Description	Benefits	Drawbacks
Traditional Vehicle Sharing	Two-way (station-based)	Means of mobility are rented and returned to the same location	Pre-determined pick-up/drop-off location Competitive rates	Not practical for certain types of trips (e.g., commuting)
	One-way (station-based)	Means of mobility are rented in one location and returned to another station owned by the same operator	Pre-determined pick-up location Drop-off location is somewhat flexible but must be at a station	Not practical for two-way trips Can lead to imbalance in vehicle availability
	Free-floating	Means of mobility may be rented from and returned to any location	Maximum flexibility for pick-up/drop-off Virtual access	May be difficult to guarantee pick-up at a designated time/place Availability may fluctuate
Personal Vehicle Sharing	Peer-to-peer	Means of mobility are temporarily rented from and returned to a private owner; this transaction may be made privately or through a peer-to-peer operating service	Passive income for owner Increased use of a pre-existing, underutilized asset Reduced costs for renters	Fixed pick-up and drop off locations Reservations required
	Fractional Ownership	Means of mobility are leased by a collective group of people, each of whom contribute to maintenance expenses	Grants access to vehicles that individuals could not otherwise afford	Owners must live near to each other May be difficult to replace an owner if they drop out

Micromobility

Micromobility refers to small, lightweight, and speed-limited transport modes which are operated by a single user. The International Transport Forum (2020) defined micromobility specifically as "vehicles with mass of no more than 250 kg (771 lb) and a design speed no higher than 45km/h (28mph)." The vehicles can be human powered (bicycle) or electrically powered (e-bikes, e-scooters, e-skateboards, and other similar micro-vehicles), and the definition of micromobility is intentionally broad so it can include new models as they are created and integrated into the transportation network.

The primary benefits of micromobility adoption are like other transit modes: reduction of car use, reduction of emissions, and creation of more efficient transportation options (Møller et al., 2020). The primary challenges in implementing micromobility options lie in lack of infrastructure for micromobility travel lanes and parking.

There are many types of micromobility. Private micromobility options (such as privately owned bicycles) have long been prevalent, while shared micromobility options have become popular in the last decade as a convenient alternative. This shift in mobility trends has paved the way for innovative mobility systems such as MaaS.

Shared micromobility

Shared micromobility has experienced rapid growth in recent years alongside car share. Shared micromobility systems give users short-term access to the transportation mode on an as-needed basis (Shaheen & Cohen, 2020a). Shared micromobility includes bike sharing and scooter sharing (including standing electric and moped-style scooters). Currently, the three types of bike share systems are station-based, dockless, and hybrid; shared scooters are operated using dockless systems. Each shared micromobility system has both benefits and drawbacks, which are highlighted in Table 2 (Kou & Cai, 2021).

Table 2: Summary of Shared Micromobility Systems

System	Description	Benefits	Drawbacks
Station-based bike share	Bikes must be picked up and dropped off at designated locations which have a fixed number of parking stations	Pre-determined pick-up/drop-off location Guaranteed bike availability	Returning to designated locations can increase travel time Full stations may make drop-off inconvenient Station capacity can restrict rebalancing efforts
Dockless bike/scooter share	Bikes/scooters may be picked up and dropped off at any location within a designated area	Flexible drop-off locations can reduce travel time Many bikes/scooters can be allocated to high-demand areas	Bikes/scooters on sidewalk can hinder mobility for pedestrians and become safety concerns Uncertain availability Varied dispersal of bikes/scooters makes rebalancing more difficult
Hybrid bike share	System which incorporates both docked and dockless bike share	Can be easily implemented by adjusting parking requirements in a preexisting station-based network	Bikes on sidewalk can hinder mobility for pedestrians and become safety concerns Varied dispersal of bikes makes rebalancing more difficult

Ridesharing

Ridesharing refers to the act of connecting passengers and drivers who are traveling along similar paths. Although often confused with ridesourcing, the two are different concepts; ridesourcing drivers typically work for profit while drivers in a ridesharing service seek to conserve resources and reduce travel costs by accommodating other passengers into their travel plans (Wang & Yang, 2019). Additionally, ridesharing is typically organized in advance while ridesourcing is typically purchased on-demand (Furuhata et al., 2013).

Chan and Shaheen (2012) identified three main types of ridesharing: acquaintance-based ridesharing (with family or friends), organization-based ridesharing (within formal organizations), and ad hoc ridesharing (casual carpooling). Ridesharing platforms allow drivers to post their travel plans and connect to riders with similar itineraries, allowing strangers to carpool. The two main trip purposes for ridesharing are commuting trips and long-distance trips.

There are many benefits of ridesharing: it can reduce travel costs, fuel consumption, emissions, and traffic congestion (Minett & Pierce, 2010). Ridesharing users experience many of the comforts associated with traveling by personal vehicle (flexibility, convenience, and security) while simultaneously experiencing the reduced costs of fixed-route transit. A barrier to widespread adoption of ridesharing is the need to coordinate itineraries between passengers, sometimes without use of a third-party operator (Minett & Pierce, 2010).

Ridesourcing

Ridesourcing provided by Transportation Network Companies (TNC) is a transportation approach that connects passengers who demand mobility services with freelance drivers who supply their labor and vehicle (Wang & Yang, 2019). Common ridesourcing companies in the United States are Uber and Lyft. An increase in TNCs has affected taxi services; in a 2015 study of New York City and Chicago, researchers found that Uber's growth was correlated with a decline in use of taxi services, indicating that Uber provides a more comfortable and convenient alternative for customers who typically complain and that taxi services improved (Wallsten 2015).

Existing literature indicates that ridesourcing has a negative effect on reducing VMT. A study conducted in the Capital region of the United States in 2021 found that ridesourcing did not cause a significant reduction on driving or annual vehicle miles traveled (Zou & Cirillo, 2021). In a survey of ride-sourcing users, 61% of respondents indicated that if Uber and Lyft were not an option for trips, they would not have taken the trip at all (Clewlow & Mishra, 2017). This finding indicates that ridesourcing is adding vehicles to the road and increasing VMT.

Ridesourcing has a complex relationship with transit; it can serve either as a complement or as a substitute for transit. For example, a study conducted in Chengdu, China, found that 33% of DiDi ridesourcing trips substituted transit trips, with more substitutions occurring in the city center where transit services are widespread (Kong et al., 2020). On the contrary, ridesourcing trips in the suburbs are more likely to be complementary to transit trips, as are ridesourcing trips taken during the night, when transit is out of operation (Kong et al., 2020). These findings indicate that, in certain contexts, ridesourcing has the potential to complement public transit (rather than substitude it) if designed correctly.

1.2.2 Integration of Shared Micromobility and Public Transit

Shared micromobility has the potential to improve first/last-mile connections between a transit stop and a destination, thus improving spatial accessibility to services and opportunities while simultaneously moving away from a car-oriented mobility network (Oeschger et al., 2020). An understanding of which factors contribute to the travel behavior of users can lead policymakers and mobility providers to make changes which promote transit and shared mobility integration. The factors found to have the heaviest influence on micromobility travel behavior are outlined in Table 3 (Oeschger et al., 2020).

Table 3: Factors Influencing Micromobility & Transit Integration

Factor	Description	Sources
Infrastructure	A continuous network of dedicated, protected lanes and parking facilities contributes to a sense of safety and increase users' willingness to use micro-vehicles	Cheng and Liu, 2012; Fan et al., 2019; Lee et al., 2016; Qin et al., 2018; Tobias et al., 2012;

		Weliwitiya et al., 2019; Zhao and Li, 2017; Zuo et al., 2020
Built Environment	Micromobility (MM) is most beneficial in pedestrian-friendly environments of mixed-use development	Cheng and Lin, 2018; Fan et al., 2019; Qin et al., 2018; Sagaris et al., 2017; Wu et al., 2019; Zuo et al., 2020
Technology	Real-time information regarding station occupancy and user-friendly applications are necessary to promote a positive user experience	Cheng and Lin, 2018; Fan et al., 2019; Ji et al., 2017, 2018; Ma et al., 2018a, 2018b
Planning	Master plans should include micromobility-friendly environments and micromobility and PT should be planned in a way that promotes their integration (i.e., MM station should be no more than 200m from a PT station to if intended for complementary use); social and socio-demographic considerations should be included in resource allocation	Kager et al., 2016; Krizek and Stonebraker, 2010; Lee et al., 2016; Marqués et al., 2015; Tobias et al., 2012; Zuo et al., 2020; Hochmair, 2015
Policies and Regulations	Implementation of policies which reduce modal conflict by reserving road space for micro-vehicles, penalizing individuals who block access to micromobility infrastructure, and prioritizing micro-vehicles at intersections will result in greater use of MM	Grosshuesch, 2020; Zhao & Li, 2017; Adnan et al., 2019; Ji et al., 2018; Ma et al., 2018b; Fan et al., 2019; Weliwitiya et al., 2019
Pricing and Incentives	Flexible pricing, ticket integration, government subsidies, discounts for certain trips can be used to encourage users to pair MM and PT	Ji et al., 2017; Ma et al., 2018b; Zhao and Li, 2017; Zuo et al., 2020; Böcker et al., 2020
Training and Educational Campaigns	Public education opportunities and workshops should be used in tandem with other improvements to increase users' confidence in operating micro-vehicles; some workshops can be targeted to certain user groups to tackle specific issues (e.g., technology illiteracy, poor riding skills)	Hamidi et al., 2019; Cheng & Liu, 2012; Zhao & Li, 2017

Shared mobility and transit integration relies on both digital and physical integration. Digital integration includes the incorporation of payment options, tickets, real-time information into a single application. This contributes to convenience; users may be deterred from connecting multiple modes in a single trip if they must have a separate application and ticket for each mode. Physical integration refers to the infrastructure and built environment which contribute to safety and spatial accessibility. Multimodal transit is impractical without supporting infrastructure such as dedicated bike/e-scooter lanes, sidewalks, parking facilities and station proximity because users will be apprehensive of modes that they deem unsafe or inconvenient. In recent years, much work is under way to facilitate digital and physical integration, specifically through the development of mobility as a service (MaaS) and multimodal mobility hubs.

The Concept of Mobility-as-a-Service

Mobility as a Service (MaaS) is an innovative transportation concept invented and popularized in the past decade. It was first defined in 2014 as "a mobility distribution model in which a customer's major transportation needs are met over one interface and are offered by a service provider" (Esztergár-Kiss & Kerényi, 2020, p. 2). Since then, it has been defined many ways but is generally considered to be the integration of multiple mobility options into a single platform which allows users to plan, book, and pay for trips using one interface (Jittrapirom et al., 2017; Arias-Molinares

& García-Palomares, 2020; Durand & Harms, 2018). MaaS is characterized by the purchase of mobility services through a central platform rather than the purchase of the means of mobility (Kamargianni et al., 2016). Mobility on demand is another name commonly used to identify the same concept.

The conceptualization of MaaS has been increasingly studied in recent years resulting in the identification of key attributes of MaaS. These attributes are listed in Table 4. While each researcher defines MaaS in slightly varying ways, each element stems from one of the three Bs: bundles, budgets, or brokers (Hensher, 2017).

Table 4: Key Characteristics of MaaS

Source	Key Characteristics
(Jittrapirom et al., 2017)	Integration of transport modes Tariff options One platform Multiple actors Use of technologies Demand orientation Registration requirement Personalization Customization
(Kamargianni et al., 2016)	Ticket & payment integration Mobility package Information & communication technologies integration
(Mulley et al., 2018 &)	Transport on demand Subscription service Potential to create new markets

Through MaaS, multiple modes of transportation including transit, shared mobility, ridesourcing, ridesharing, and micro-mobility are used to create a customized mobility package for each customer. These packages can be paid for on a trip-by-trip basis or using a subscription type service that charges a monthly fee (Jittrapirom et al., 2017; Durand & Harms, 2018). In a 2020 study, these packages were tailored for users according to city-specific characteristics such as demographics, cost of living, modes available, weather conditions, and environmental impact (Esztergár-Kiss & Kerény, 2020).

Mobility-as-a-Service in Practice

MaaS pilots have been launched to further understand the practicality of the concept, implementation challenges, and necessary improvements. Few pilots have led to permanent deployments; one exception is Whim, a MaaS program launched in Helsinki, Finland in 2017. In a 2017 study, Li and Voege determined that there are several necessary conditions for a city to successfully operate MaaS. These conditions include:

- Range of transit and shared mobility services that are widely available
- Real-time data from transport operators
- Transport operators' willingness to use a third party to sell their service
- Electronic ticket and payment options for transport services

MaaS developments implemented in northern Europe, namely in Sweden and Finland, have been compared to determine how initiatives materialize under unique operating systems. Sweden's six-month pilot of MaaS was launched in 2013 using a platform called UbiGo to integrate the purchase of all transportation services as part of the Go:Smart project; two similar programs were created in Finland beginning in 2015 – one intended for commuters and another for tourists which allowed customers to subscribe to transit, car rentals, and taxis (Smith et al., 2018). In 2020, UbiGo offered a package for households in Stockholm access to transit, bike share, car share, rental cars, and taxis (Shaheen & Cohen, 2020). These services represent Level 3 of integration as defined in a topology created by Sochor et al. (2017). Figure 2 displays the typology and provides examples of companies that fall under each level of integration.

Figure 2: Levels of integration of MaaS
(Source:Sochor et al., 2017)

Implementation Challenges of Mobility-as-a-Service

There are several challenges to implementation of MaaS schemes. One key challenge is the modal conflict that arise when several different modes are competing for road space. In many cases, micromobility users are expected to share the road with cars, vans, and buses. However, on roads without dedicated, protected bike/e-scooter lanes, users may feel unsafe on the road and be forced on to the sidewalk. This can result in safety concerns for pedestrians, who may feel unsafe sharing the sidewalk with motorized vehicles. Additionally, dockless micromobility options are often parked haphazardly after use and can block the right of way for pedestrians. This is not only a safety hazard, but can also be aesthetically unpleasing and drive negative opinions regarding micromobility use. Therefore, successful implementation of MaaS relies on supporting infrastructure and policies which promote responsible use of both shared and private mobility options.

Another challenge that has slowed the widespread adoption of MaaS is related to the business model. MaaS may not be as profitable for the mobility operator as expected and purchasing bulk mobility services from one entity may restrict mobility for users. After the MaaS pilot UbiGo in Sweden, researchers investigated mismatches between operator expectations and results; they found that the operator did not profit from volume purchasing of transit because of subsidies, and travelers' low car usage resulted in lower revenue than expected (Sochor et al., 2015). Additionally, users expressed some dissatisfaction with the inflexibility of UbiGo. The exclusivity of mobility services offered through UbiGo prevented users from exploring various providers of the same mode and the prepaid subscription service resulted in excessive spending in some cases (Sochor et al., 2015).

A fundamental component of MaaS is the integration of several travel modes into a single service; each trip may include a unique combination of mobility types such as shared mobility, micromobility, transit, and ridesharing. Therefore, it is essential that there is infrastructure which supports the integration of modes and allows users to easily switch from one mode to another, but this infrastructure is lacking in many places. One approach to remedy this challenge is the multimodal mobility hub.

1.3. Approaches for Mobility Hub Planning and Development

1.3.1 Mobility Hub Definition

A mobility hub is a physical location that facilitates the seamless integration of multiple modes of transportation including transit, shared mobility, and micro-mobility (Engel-Yan & Leonard, 2012; Geurs & Münzel, 2022; Arnold et al., 2023; Anderson et al., 2017; Aono, 2019; LA Urban Design Studio, 2016). Key words that appear in mobility hub definitions across the literature are "seamless," "integrated," and "connected", which highlight the mobility hub's role in coordinating multiple transportation services. However, definitions of mobility hubs typically have two distinct parts: one highlighting the connection of various transport modes and another highlighting the supporting services found within built environment surrounding the mobility hub (Engel-Yan & Leonard, 2012; Blad et al., 2022; Seker & Aydin, 2023; Kruszyna & Makuch, 2023). Thus, the mobility hub is a multidimensional concept; it has the potential to include both communal components and digital components in addition to its' mobility components. The digital aspect of a mobility hub is mainly regarding digital integration, i.e., booking, planning, and paying for multiple modes using a single interface, which complements the physical component. Other characteristics of mobility hubs discussed in the literature are recognizability (Arnold et al., 2023; CoMoUK, 2019; Czarnetzki & Siek, 2022) and placemaking (Aono, 2019; CoMoUK, 2019; Metrolinx, 2011). The elements of mobility hubs are summarized in Table 5.

Table 5: Elements of Mobility Hubs

Source	Dimensions
Engel-Yan & Leonard, 2012	Transport Role Placemaking Role
Monzón et al., 2016	Function and Logistics Local Impacts
CoMoUK, 2019	Mobility Components Mobility-Related Components Non-Mobility & Urban Realm Improvements
Geurs & Münzel, 2022	Physical Integration Digital Integration Democratic Integration

Based on the elements discussed in the literature, we propose the following definition of mobility hubs**:** *A mobility hub is a location that facilitates the seamless integration of multiple modes of transportation. It is anchored by a transit stop and equipped with infrastructure to support shared mobility such as micro-mobility, carsharing, ridesourcing, and other shared* *modes. It provides a range of amenities and services which enhance the experience of multimodal travel and contribute to a sense of place*.

Multiple dimensions of mobility hubs distinguish hubs from other transit nodes, such as park-and-rides or train stations. While traditional park-and-rides may also facilitate multimodal integration, mobility hubs distinguish from them in the following aspects: inclusion of shared mobility options, presence of additional facilities and amenities, and digital integration of planning and payment services (Blad et al., 2022).

Mobility Hub versus Transit-Oriented Development

Mobility hubs and transit-oriented developments (TODs) have many similarities. Both are initiatives with similar objectives: to promote use of sustainable modes of transportation, reduce dependence on single-occupancy vehicles, and improve user experience while traveling. Mobility hubs and TODs may employ similar strategies to achieve these goals. For example, integration of multiple modes of transportation and integration of transportation with the surrounding development are both priorities for mobility hubs and TODs. Additionally, both initiatives encourage compact, mixed-use development and walkability to increase transit access.

Despite these similarities, mobility hubs and TODs serve different purposes in the transportation system. Mobility hubs are transportation facilities that can be established at any transit stops to facilitate multimodal integration; and TOD is a land-use planning approach that centers on major transit stops such as rail stations, encompassing more than just transportation facilities. Renne and Appleyard (2019) note that the TOD has multiple meanings including a visionary idea, a place, and a project. Mobility hubs are often a project within a TOD (Abd El Gawaad et al., 2019) or a tool to improve transit usability and passenger experience within TODs (Seoudy et al., 2022). Put simply, the mobility hub creates a transportation node through careful infrastructure planning, while TODs are the surrounding districts that are created through spatial planning (Rongen et al., 2022). The mobility hub is often a component part of the TOD but have wider applicability across the transit network than TODs.

1.3.2 Mobility Hub Typology

Mobility hubs can be classified according to several characteristics such as passenger volume, location context, modes of transit, and available services and amenities. There are various classifications of mobility hubs in the literature based on various criteria such as urban context, spatial scale, or size of the mobility hub. Each type of mobility hub serves a unique purpose in the transportation network, and all are necessary to provide a complete experience for users.

One method of classification for mobility hubs is created by breaking down the mobility hubs according to their purpose in the transportation network and the context in which they are situated. The Shared Use Mobility Center (2019) presented a way to classify mobility hubs according to their functions:

Branches	Trunks
Points of entry into transit networks	Hubs within the core transportation network

and their connections to:

Destinations	Local Areas
Points of interest	Places without a clear destination

Branch hubs are typically served by a limited number of connecting routes located outside of the city center and serving primarily as first/last mile connections (Shared Use Mobility Center, 2019). On the other hand, trunk hubs are found in areas served by multiple high-frequency transit routes and are typically located in dense, walkable areas which have the potential to support non-motorized mobility (Shared Use Mobility Center, 2019). Destinations hubs have a clear sense of place because of their proximity to major attractions while local hubs may lack major destinations other than the transportation connections they provide (Shared Use Mobility Center, 2019; Arseneault, 2022). Both destination and local hubs can be either branch or trunk varieties.

A hub's typology can be identified using a combination of its function, context, and the number of available amenities. Table 6 displays the description of three typologies (Neighborhood, District, and Regional) which have emerged. The name of typologies varies across the literature and in the planning practice, but understanding each hub's function and context allows for a more general classification to be made.

Table 6: Classifications of Hubs Across the Literature

Typology	Neighborhood	District	Regional
Function	Branch-Local	Trunk-Destination	Branch-Destination
Brief description	Minor transit stations with some transit modes and parking facilities	Significant transit stations with several modes and amenities and consistent travel demand	Transportation depots with multiple modes, amenities, and access to major destinations and surrounding areas
Other names	Commuter transit centers, suburban transit nodes, suburban mobility hubs, basic hubs	Large interchanges, urban hubs, modern transport hubs	Intercity terminals, urban transit nodes, emerging urban growth centers
Generic examples	Park-and-ride with additional amenities	Transit centers near cultural attractions or educational institutions	Train or bus stations with multiple terminals

Below, we detail examples of Neighborhood, District and Regional hubs from examples taken from around the world. However, the hierarchy of what constitutes a Neighborhood, District, or Regional hub may vary from one metropolitan region to the next. A Regional hub in a small metropolitan area will of course differ from a Regional hub in a metropolitan area with population in the tens of millions.

Neighborhood Hubs

Neighborhood mobility hubs, sometimes classified as suburban transit nodes (Engel-Yan & Leonard, 2012), suburban mobility hubs (Bell, 2019), or commuter transit centers (Pitsiava-Latinopoulou & Iordanopoulos, 2012) are characterized by their function to facilitate access between suburban residential areas and employment areas. These hubs are busiest during peak hours, when they have a large inbound flow of trips as residents commute to the city center for work. They offer parking facilities, a single transit mode, and basic amenities such as weather protection and information. They may also include shared mobility.

Figure 3 highlights an example of a neighborhood mobility hub in Bremen, Germany (Aono, 2019). These hubs are specifically intended to promote car share but including cycling and walking paths and proximity to transit. They are located approximately every 300 meters, providing residents with small-scale hubs that are widespread throughout neighborhoods.

Figure 3: Mobil.punkt station in Bremen, Germany
(Source: Aono, 2019)

District Hubs

District hubs (Engel-Yan & Leonard 2019; PBOT 2020; Bell 2019) are distinguished by a consistently high demand by a variety of user groups, ample mobility options, numerous amenities, and minimal parking facilities. These hubs are often in proximity to major destinations such as cultural attractions, educational institutions, and employment-dense areas.

Figure 4 displays Willshire/Vermont Metro Station in Los Angeles, California (LA Urban Design Studio). This hub is in a dense area of LA, nearby several points of interest including Koreatown, Willshire Center, and several educational institutions. It is accessible by multiple subway lines, bus routes, and micro-mobility options. The station has bike racks, bike lockers, and displays artwork by local artists inside.

Figure 4: Willshire/Vermont Metro Station in Los Angeles, California
(Source: LA Urban Design Studio, 2016)

Figure 5 displays Maverick Station in Boston, MA. This hub features car share, bike share, pick-up/drop-off zone, placemaking elements, furniture, signage, Wi-Fi, power, and information about community events. These elements were intended to enrich a popular commercial area with high transit availability. These amenities improve the travel experience for the large number of multimodal travelers moving through this station area.


Figure 5: Maverick Station in Boston, Massachusetts.
(Source: Elkins & Waterfield, 2021)

Regional Hubs

Regional hubs, also known as urban transit nodes urban transit nodes (Engel-Yan & Leonard 2019), provide highly demanded interregional connections with an assortment of transit options from both public and private providers, complemented by shared and micro-mobility, parking facilities, and abundant amenities. These hubs are so large in scale that they may be located just outside of the city center, underground, or integrated into buildings. They can attract further development in the catchment area.

One example of a regional hub is Kipling Transit Hub in Ontario, CA displayed in Figure 6 (Aono 2019). This massive hub facilitates the integration of subway, trains, buses, and automobiles while providing safe infrastructure for cyclists and pedestrians such as underground walkways and above ground bridges. The streets surrounding the hub have been redesigned to include dedicated bike lanes and bike parking.

Figure 6: Renderings of a proposed mobility hub in Ontario, Canada
(Source: Aono, 2019)

Figure 7 displays Stratford Station in London, UK, another regional hub example. This multi-level station provides space for the integration of many transport modes including bus, train, and national rail, and light rail. There is bike parking, car parking, seating, shopping, Wi-Fi, refreshment facilities, and more. The station has 17 platforms to allow for easy transfer between modes and was a key travel hub during the 2012 Olympic games.

Figure 7: Stratford Station in London, United Kingdom
(Source: Metrolinx, 2011)

1.3.3 Mobility Hub Elements

A variety of methods have been employed to determine which mobility services and additional amenities should be included at a mobility hub. Anderson et al. (2017) selected modes for each mobility hub using a qualitative approach which considered three factors: topography, proximity of hub to transportation infrastructure, as well as socioeconomic and land-use characteristics of the neighborhood surrounding the hub. A qualitative approach was preferred over a quantitative approach due to the complexity of representing some relationships.

In a case study of Gainesville, Florida, Arcadis (2019) took a quantitative approach for mobility hub programming. They used a combination of indicators such as population density and distance to nearest hub to determine suitable modes. The recommended modes for each density and distance are highlighted in. Light individual transportation refers to bikes, scooters, and other micromobility modes.

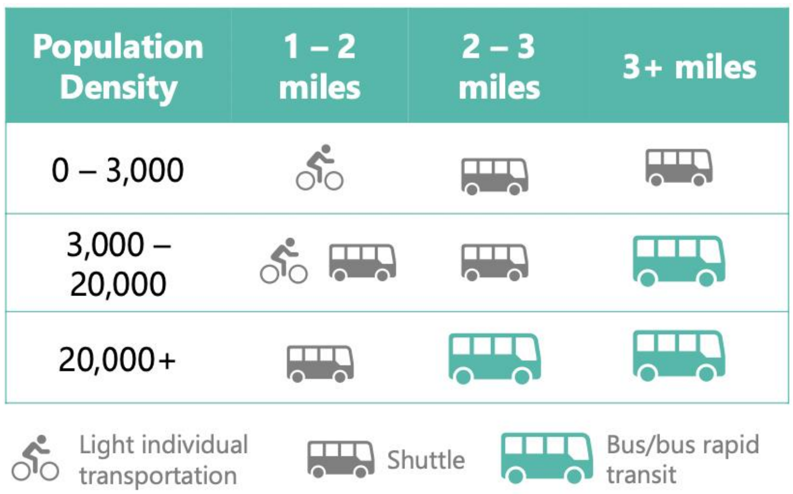


Figure 8: Best Modes for Mobility Hubs in Gainesville, FL
(Source: Arcadis, 2019)

Planners in Lisbon, Portugal, used a combination of desktop research, expert interviews, and community engagement to gauge what elements should be included at each hub (Oudbier et al., 2021). Research revealed what mobility and non-mobility elements are typically included at mobility hubs. This information was then used to conduct a collaboration session between experts from mobility operators and Lisbon City Council in which participants selected features of mobility hubs for each of six different characters representing Lisbon's population. Community engagement was conducted at the mobility hub pilot location to allow potential users to narrow down which features they would like to see. The top amenities chosen were considered for implementation.

The elements included at mobility hubs may be selected depending on the hub's urban context and function, user preferences, or a combination of both. The modes included at each mobility hub depend on the services available in each city, but in general, mobility hubs should offer some form of shared mobility to facilitate first and last-mile access to the transit station anchored at the mobility hub. All mobility hubs should include basic amenities such as weather protection, information, and security; larger hubs may offer additional amenities and placemaking features such as lockers, Wi-Fi, charging stations, nearby food/retail, etc.

1.3.4 Site Selection Methods

A few mobility hub location selection processes have been detailed in the literature. Site selection methodologies for mobility hubs can be conducted using quantitative analysis, qualitative analysis, or mixed-methods processes. Quantitative analysis typically follows a two-step process: identification of site selection criteria and evaluation of criteria, while qualitative analysis depends on input from experts or stakeholders. Mixed-methods analysis makes use of both approaches when selecting optimal hub locations.

Identification of Criteria

Criteria considered during the site selection process for mobility hubs are very similar to site selection criteria for transit stations and other transit facilities which have been more thoroughly studied. Transportation facilities in the U.S. are often intended to maximize traveler ridership, reduce usage of single-passenger vehicles, and improve connections with both existing and future transit modes (Mohajeri & Amin, 2010; Horner & Groves, 2007). Because these goals are very similar to those of multimodal mobility hubs, site selection criteria often overlap. However, a key difference between the criteria for mobility hubs and other transit facilities is that mobility hubs must have adequate supply of land to support multiple transportation modes. They should be located near or at a transit stop, but also be able to provide infrastructure to support shared-use mobility options (e.g., bicycling parking and pick-up/drop-off zones), depending upon the context. Therefore, one aspect often considered (depending on the scale of the hub) is the land available for car parking, bike and e-scooter parking, ride hail pick-up/drop-off, and more in addition to the transit station. Consequently, another factor in locating mobility hubs may be the presence of supportive infrastructure for various shared mobility options such as a continuous network of dedicated, protected bike and e-scooter lanes, sidewalks and crosswalks etc.

Criteria attributes can be measured using a series of indicators. Typically, an area around each hub is defined (ex. 0.5-mile radius) and indicators are assessed within the area. The characteristics of the catchment area are an important factor to consider when finding suitable locations for mobility hubs and other transit facilities because many passengers will not travel significant distance to reach a public transport facility if they have other mobility options (Landex & Hansen, 2006). Therefore, it is important to consider the characteristics of the population and the land-use within the catchment area to maximize the use, access, and benefits of mobility hubs for users. Common criteria categories, subcategories, and attributes used to evaluate hub locations are displayed below in Table 7.

Table 7: Criteria Categories, Sub-Categories, and Attributes

Criteria	Sub-Criteria	Attribute
Socio-demographic Patterns	Population statistics	• Population density • Population growth trends • Age, race, gender, education, & disability status • Percentage of non-English speakers
	Socioeconomic status	• Percentage of high and low-income households in surrounding area • Households in each income quartile • Number of vehicles per household
Destinations	Employment Access	• Number of jobs • Number of high-income jobs • Employment trends • Commuting volume
	Access to non-work destinations	• Total number of POIs • Number of POI categories • Average travel time between hub and POIs • Number of transfers required to reach POIs
Travel patterns	Transit connections	• Number of transit stops • PT route frequency • Number of buses passing by • Distance to intercity PT station
	Multimodal connection	• Number of first/last mile trips by various modes • Number of transfer trips
Economic Factors	Costs	• Land acquisition costs • Land development costs
	Land use and development	• Land use • Land ownership • Site size/design • Potential to support projected development
Infrastructure	Vehicle infrastructure	• Availability of bus lane • Transit shelter • Vehicle parking space
	Active transportation	• Presence of sidewalk • Presence of bike lane • Micromobility parking space

Criteria evaluation for mobility hubs resembles location planning for other transit facilities and generally makes use of a statistical model, a spatial analysis, or a combination of both to determine candidate hub sites. Non-quantitative data derived from stakeholder interviews and community engagement may also be considered in the methodology.

Multi-Criteria Decision Analysis

The siting of mobility hubs should consider various factors such as land use patterns, accessibility, infrastructure availability and socio-economic factors. This requires a multi-criteria decision analysis (MCDA) for identifying the location of mobility hubs, as it allows decision-makers to consider multiple factors simultaneously and objectively evaluate potential sites. The MCDA usually includes the following steps. The first step of MCDA is to define units of analysis, which are usually census block groups and tracts or geographical grid cells. The criteria and weights are determined based on stakeholder objectives (e.g., first-mile and last-mile transit connection, equitable access, and resilient to environmental disasters). Analytic Hierarchy Process (AHP) is a commonly used method for determining criteria weights for transit facilities (Mohajeri and Amin, 2010; Anderson et al., 2017; Blad et al., 2022; Wey, 2015; Aydin et al., 2022). The indicators of these weighted criteria are calculated and measured, and a hub selection algorithm is implemented to compute the suitability scores for mobility hubs.

Most studies implemented MCDA to site locations for mobility hubs. Blad et al. (2022) implemented GIS-based MCDA method to solve the location selection problem for regional shared mobility hub. They identified five common criteria (potential demand at a certain location, hub implementation costs, generalized travel costs from and to the hub, link to surroundings, and societal impact) with nine measurable attributes for evaluating the siting of mobility hubs. Their relationship is summarized in Figure 9. The score and weights of different criteria are decided from the perspective of the different stakeholder groups: end-user (traveler), operator, and government. The results are presented in multiple heat maps based on scenarios with varying stakeholder weight importance. This methodology is applied to Rotterdam, Netherlands as the case study region and the results are displayed in Figure 10.

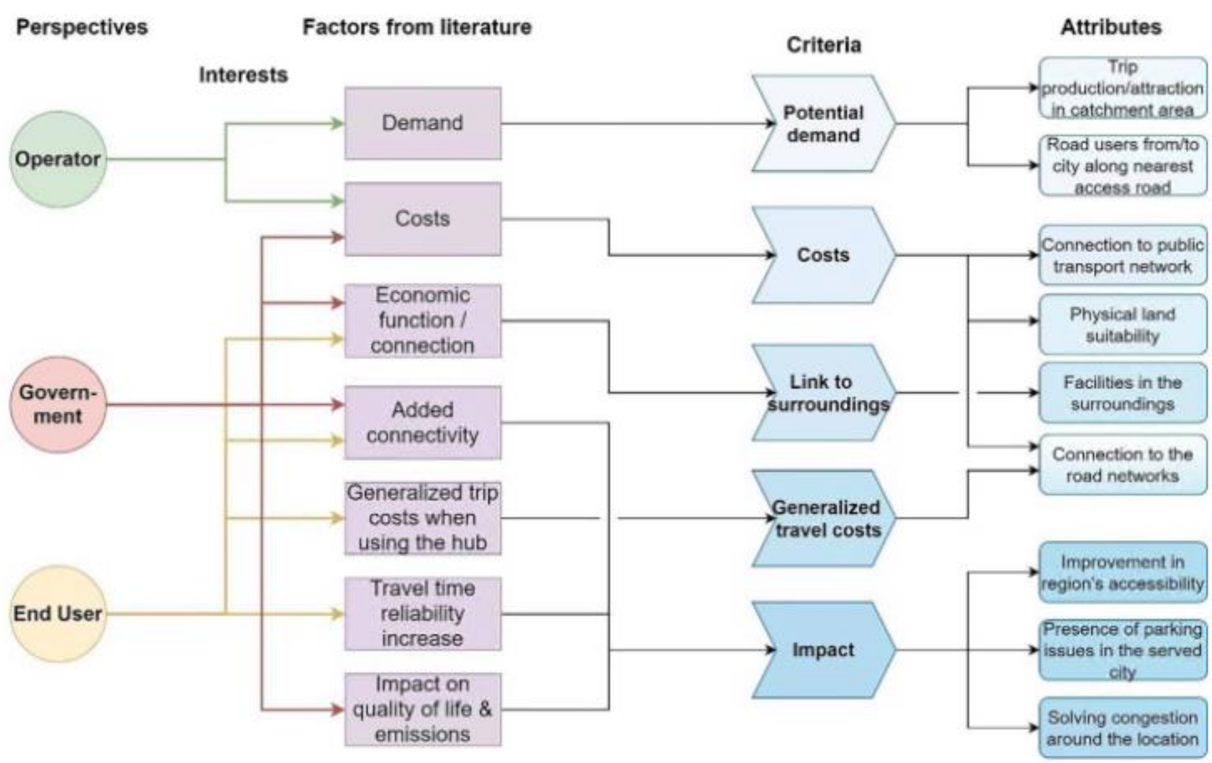


Figure 9: Criteria and measurable attributes to site mobility hubs
(Source: Blad et al., 2022)

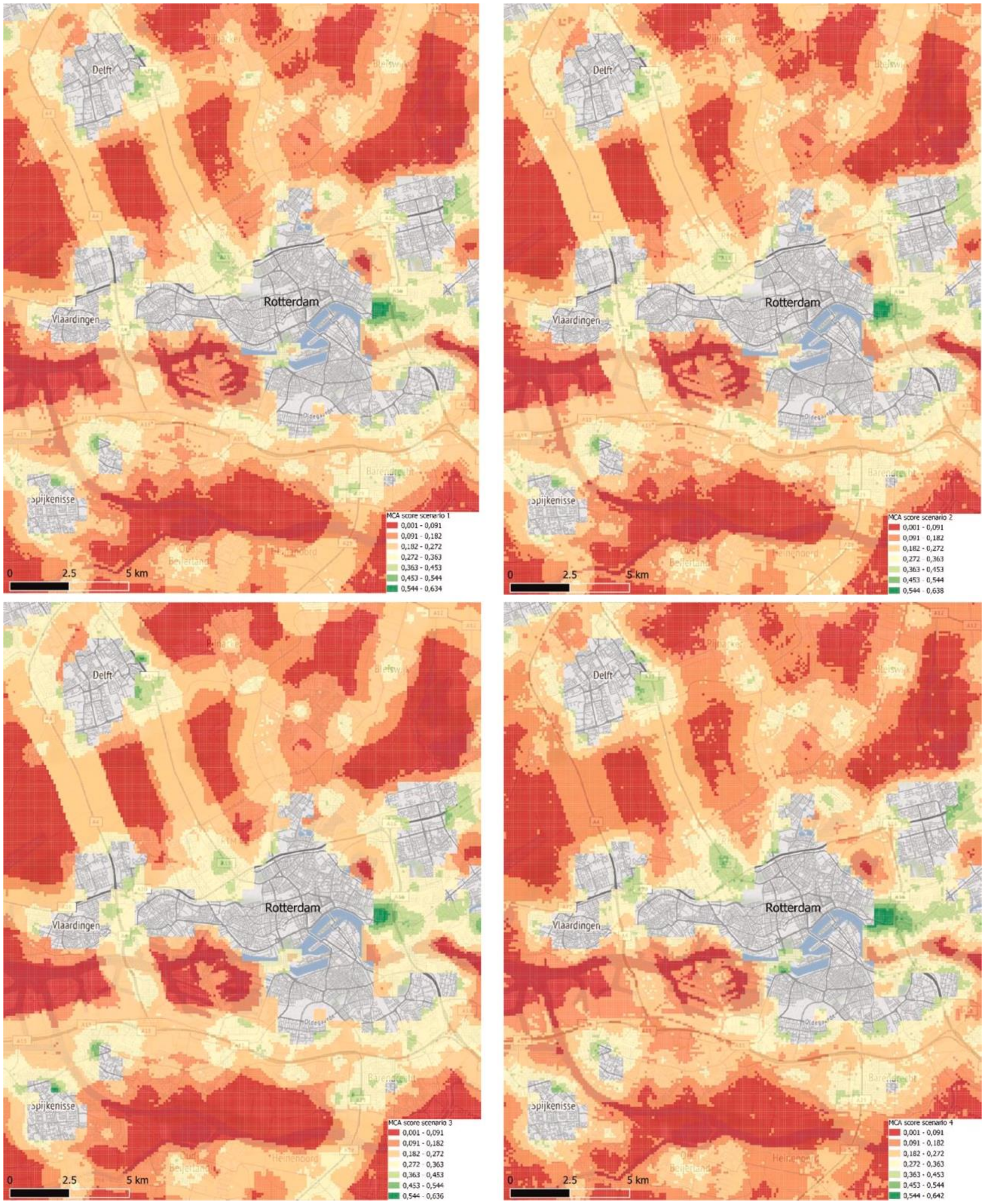


Figure 10: Output of the application of the methodology under four different scenarios. (Source: Blad et al., 2022)

Anderson et al. (2017) proposes a generalizable AHP framework to determine the optimal spatial distribution of mobility hubs, which meets a set of service goals (e.g., first- and last-mile transit connection, equitable access, and resilient to environmental disasters). This framework includes 4 steps as Figure 11 shows: (1). Process and scale the data for the variables of interest. (2). Construct indexes to aggregate multiple variables. (3). Construct different scenarios as weighted sum of indexes. (4). Decide the siting of mobility hubs from multiple criteria. This methodology framework was applied to the city of Oakland as a case study and allows transportation planners to advance various qualitative values in their practice, including equity and resiliency.

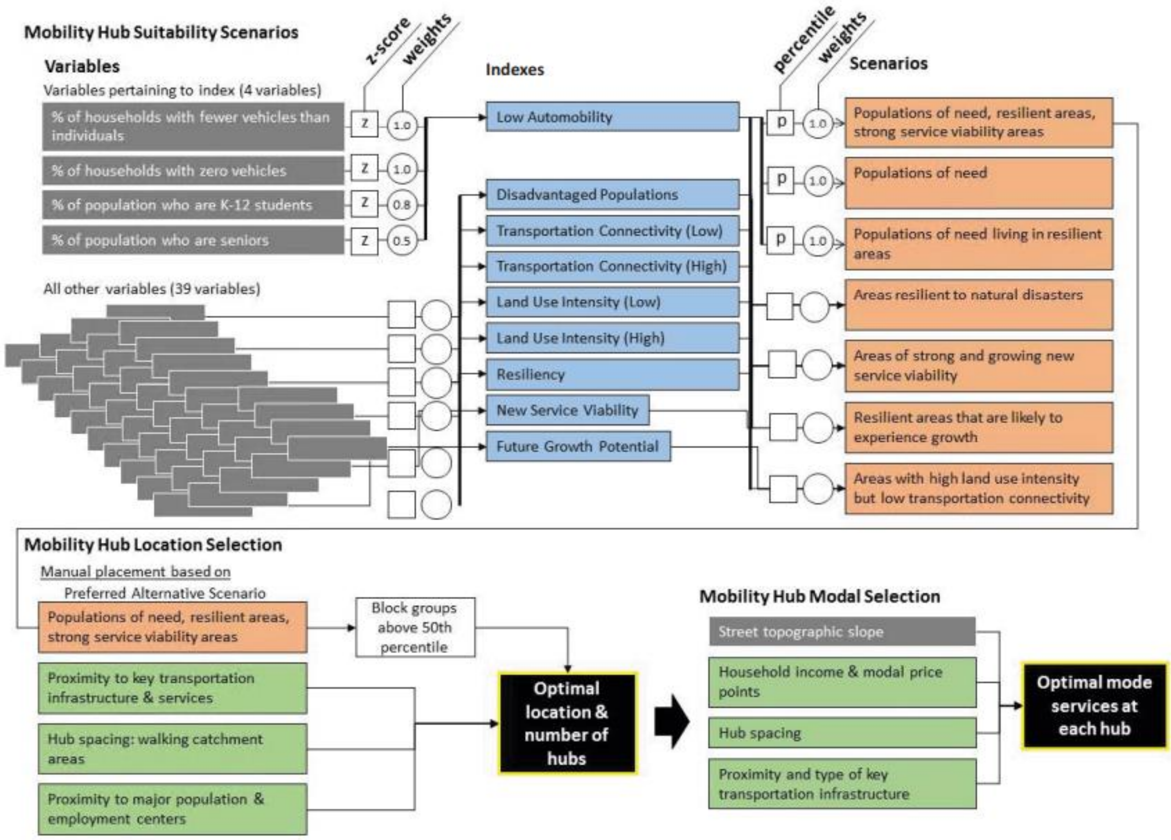


Figure 11: Methodology for suitability analysis workflow diagram for scenario development, optimal hub locations, and hub modal distribution, with example indexes and scenarios. (Source: Anderson et al. 2017)

Tran & Draeger (2021) presented a new evaluation framework to locate and assess the sustainability and equity impacts of hubs in cities in Figure 12. Socioeconomic and demographic data are spatially organized into catchment area cells. These data provide the basis for (1) calculation of network statistics, (2) implementing a new hub selection algorithm. Compute the suitability scores for mobility hubs and weighted by different scenarios, (3) performing catchment area analysis to compute travel times to hubs. As Figure 13 shows, Portland, Seattle, and Vancouver were chosen as case study for siting the mobility hubs under different scenarios that prioritize (1) current mode split, (2) high transit capacity, and (3) multimodal service. The results show how municipalities can strategically invest in transit and multimodal options to promote the spatial equity to mobility hubs.

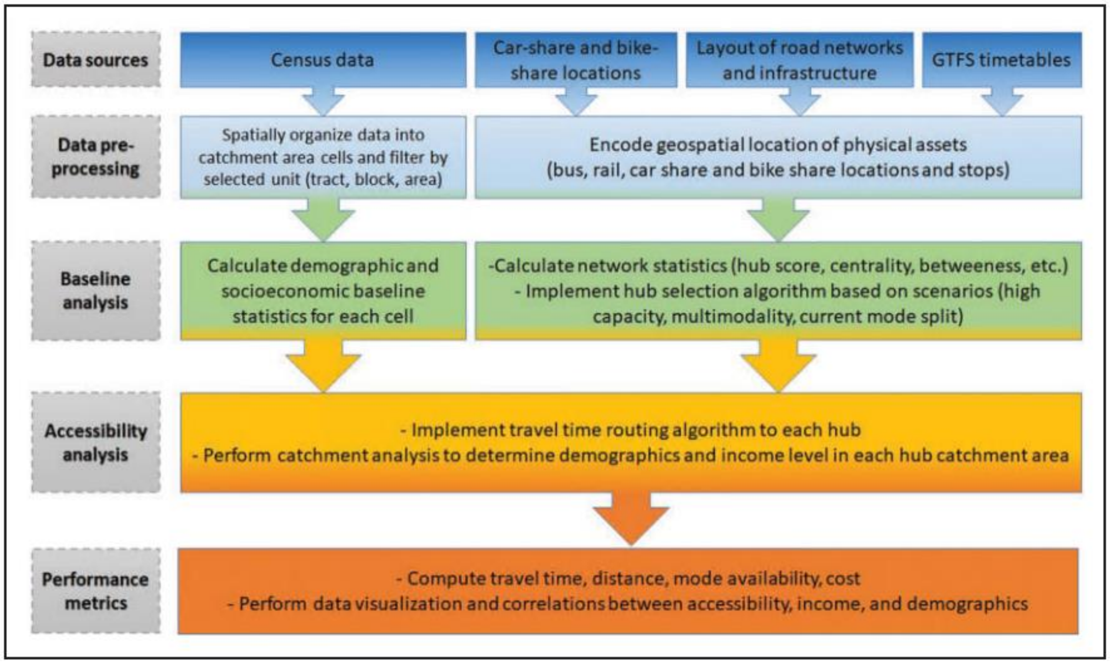


Figure 12: Mobility hub data integration framework and evaluation workflow.
(Source: Tran & Draeger, 2021)

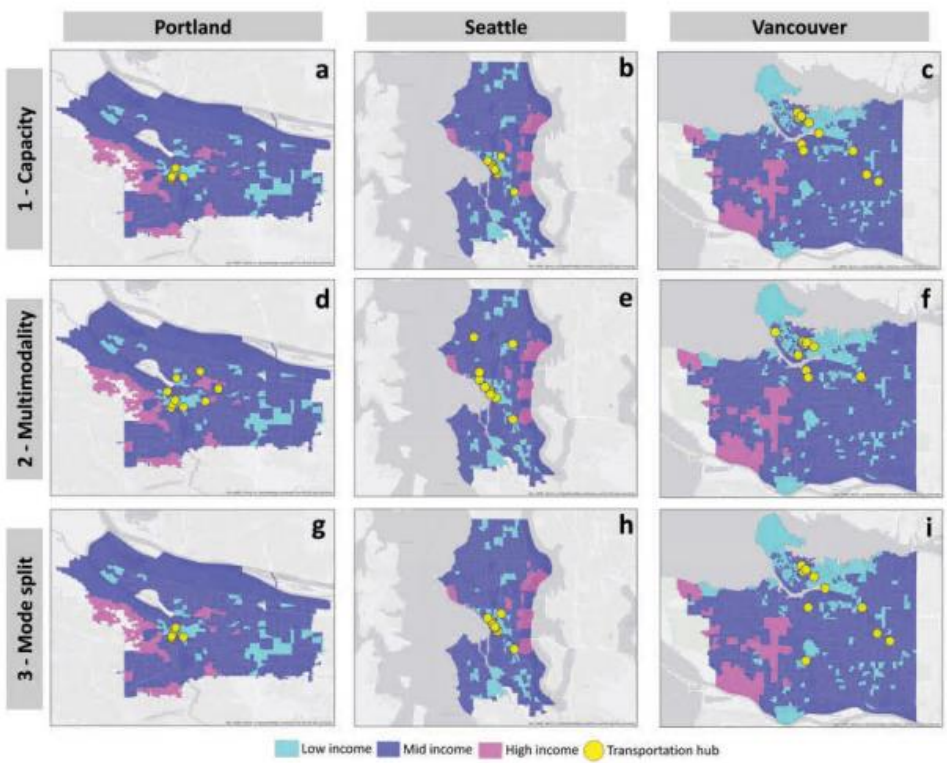


Figure 13: Hub scenarios for Portland, Seattle, and Vancouver based on different scenarios.
(Source: Aydin et al., 2021)

Aydin et al. (2022) applied MCDA method under uncertainty. Interval type-2 fuzzy AHP and WASPAS are used to decide the criteria weights and find the suitability scores of identified locations; the methodology is outlined in Figure 14. This framework is applied to Anatolian side of Istanbul to identify the best location for a new mobility hub location. Four candidate locations are predetermined, and they were evaluated based on four main criteria (Public Interest, Structural Suitability, Demographic Patterns, and Accessibility to the Center) and related sub-criteria. The best location to build the new modern mobility hub is finally selected according to the developed integrated MCDM approach.

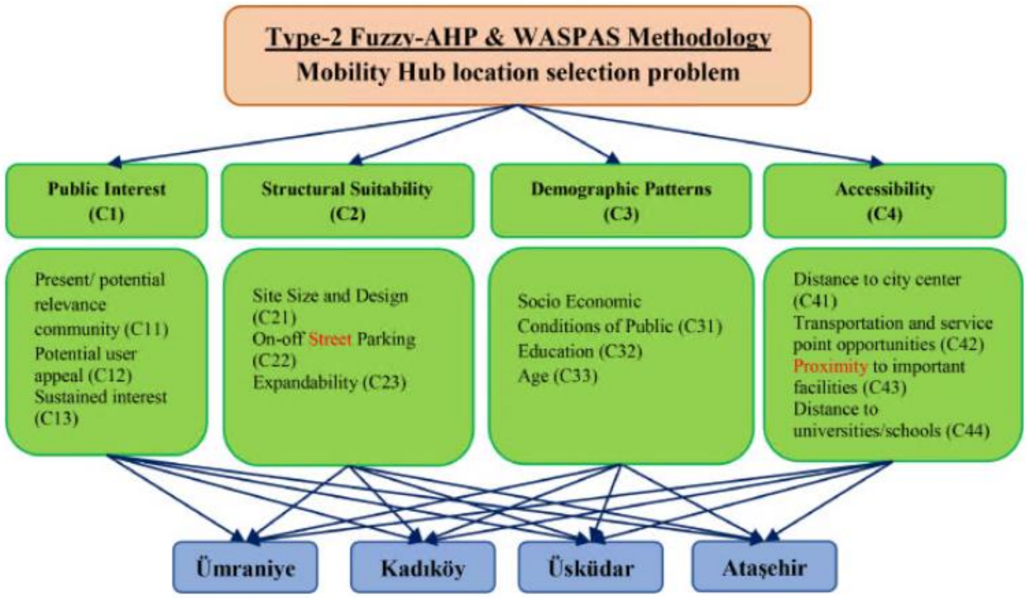


Figure 14: Hierarchical Structure of mobility hub location selection
(Source: Aydin et al., 2021)

Suitability Analysis

Suitability analysis is another commonly used method to evaluate candidate locations for mobility hubs. Data used in the analysis varies on a case-by-case basis but typically includes traffic data, land usage and ownership, topographic data, population distribution, economic considerations, and more. Data are analyzed by indicators, grouped by category, and merged into a single layer per criterion. Each layer may be weighted differently depending on the intentions of the planners. The result of this methodology is multiple heat maps which highlight the candidate locations that emerge from each scenario. Another approach to suitability analysis is to establish minimum criteria and display the areas meeting all criteria.

In a case study of Gainesville, Florida, Arcadis (2019) conducted a suitability analysis using 27 layers of data divided into five groups which represent different characteristics of the city: physical, economic, demographic, access, and behavior. The unit of analysis was 450 ft by 450 ft tiles; each tile was scored from zero (least suitable) to six (most suitable) for each layer. The scores were aggregated for each category and multiplied by the given weight for each scenario. Five scenarios were created to assess the candidate locations for various objectives: complements to current infrastructure, improving commuting, leveraging existing infrastructure, improving equity, and equal consideration. The heat maps for each scenario are displayed in Figure 15.

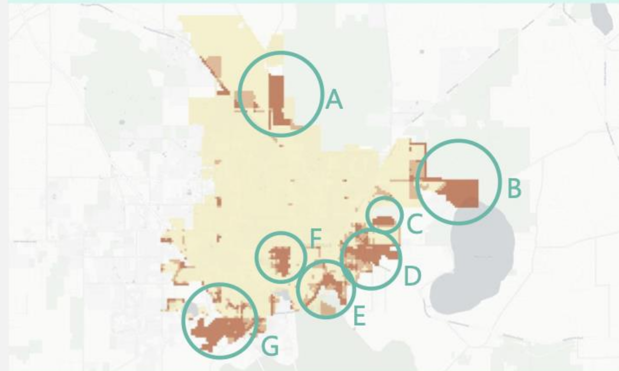
Scenario Planning

As results show, each layer group emphasizes different potential sites for mobility hubs. As such, scenario planning is necessary to account for city priorities, needs and focus. There are five scenarios used in this project: 1) Equal consideration of all inputs; (2) Complements to current infrastructure; (3) Improving commuting; (4) Leveraging existing infrastructure; and (5) Improving equity.

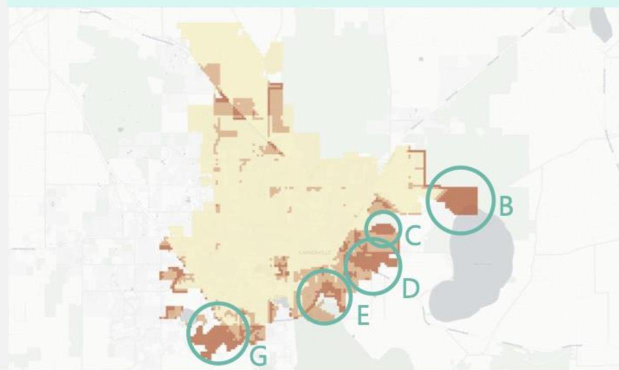
For each scenario, hot spots were defined as tiles with higher aggregated values relative to their surroundings. These clusters were marked as mobility hub candidates. Locations identified as hot spots across scenarios are noted as especially strong candidates.

Equal Consideration	Same weight for all layer groups
Complement Infrastructure	Accessibility is the focus
	More weight on Access layers
Improve Commuting	More weight on Economic layers
Leverage Infrastructure	More weight on Physical layers
Equity	Focus on disadvantaged population
	More weight on Demographics layers

1. Equal Consideration



2. Complement Infrastructure



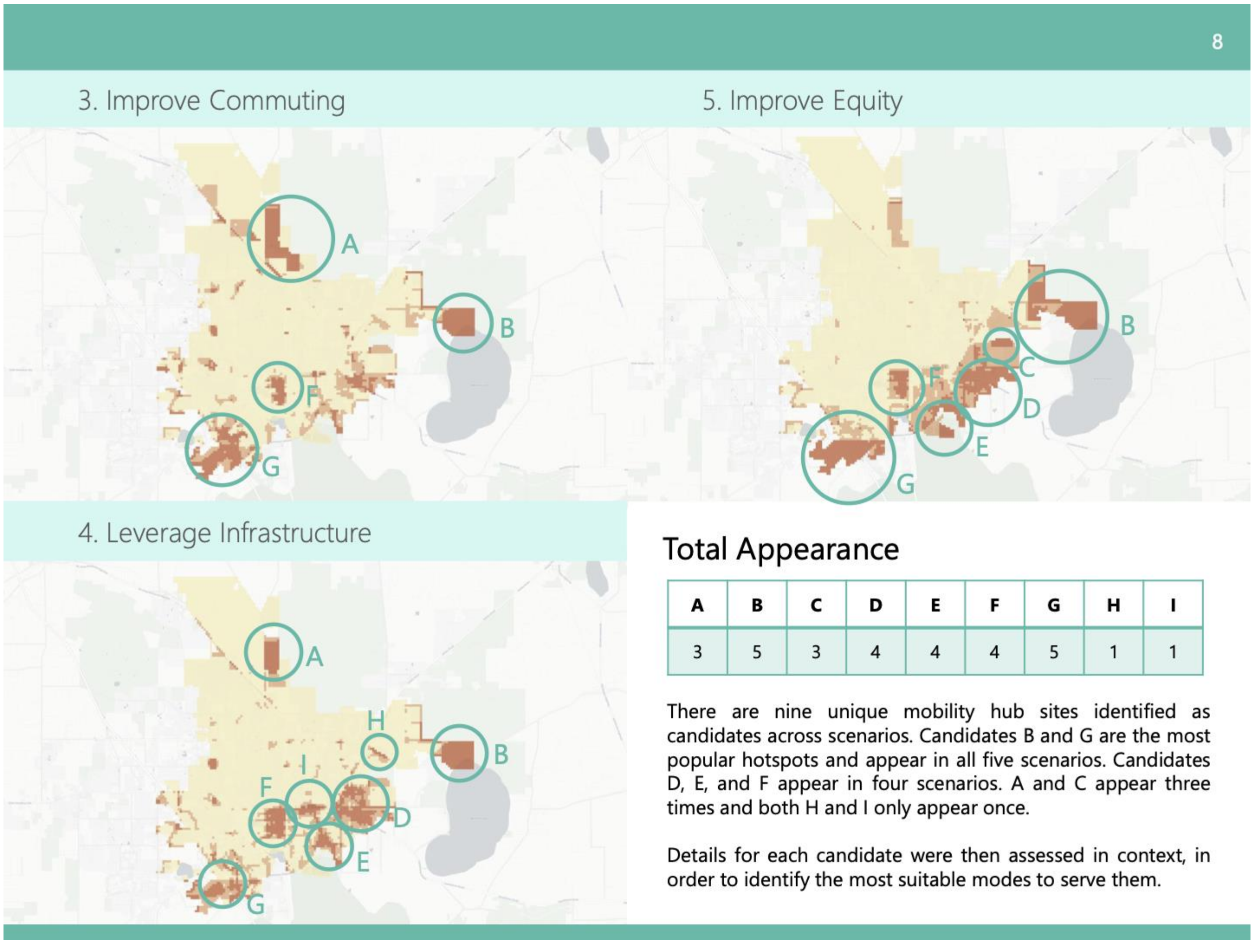


Figure 15: Heat maps and candidate mobility hub sites in Gainesville, FL for each scenario. (Source: Arcadis, 2019)

Optimization Models

The use of optimization models may be employed in the site selection process for mobility hubs. While the specific model varies from researcher to researcher and city to city, they often have similar objectives. For example, Frank et al. (2022) and Yu et al. (2013) both constructed indices to measure the location's accessibility, connectivity, population served, and costs, among other factors. These indices were part of a larger decision support tool that can assist policy makers in the transportation planning process.

Frank et al. (2022) used two optimization models (displayed in Figure 16) to guide location planning of a hub in a case study of the rural region of Heinsberg, Germany. One optimization model evaluated accessibility to points-of-interest; the number of POI categories that can be reached within a travel time threshold was measured and weighted by the population. The second optimization model considered accessibility to workplaces. The function considered a ratio of travel time by car to travel time by transit and/or new mobility for commuters; average accessibility was computed by weighting work-place accessibility by commuting volume. The researchers concluded that hubs could improve access both to POIs and workplaces, but different locations are selected when prioritizing access to one destination over another.

$$max \quad Z^{\mathrm{POI}} = \frac{\sum_{i \in V} \sum_{p \in \mathscr{P}} n_i a_{ip}}{\sum_{i \in V} n_i \left| \mathscr{P} \right|}. \qquad max\, Z^{\mathrm{WP}} = \frac{\sum_{i \in \mathscr{V}} \sum_{j \in \{\mathscr{V} | i \neq j\}} \sum_{s \in S_{ij}^{\mathrm{WP}}} w_{ij} r_s x_s}{\sum_{i \in \mathscr{V}} \sum_{j \in \{\mathscr{V} | i \neq j\}} w_{ij}}$$

Figure 16: Function to maximize accessibility to POIs (1) and workplaces (2)
(Source: Frank et al. 2019)

Mixed-Methods

Mobility hub site selection may include both quantitative and qualitative analysis. Qualitative analysis typically incorporates input from stakeholders in the site selection process. For example, Blad et al. (2019) conducted interview with stakeholders from the operator, government, and end-user perspectives to gather insight trade-offs between criteria for stakeholders. The researchers then used an AHP to determine criteria weights for five different scenarios: three prioritizing a different stakeholder, one of equal importance, and one with cost-criterion weighted heavily. This approach allowed the researchers to compare which scenarios incorporate the stakeholders' interests most effectively.

Community engagement is another method used to guide site selection for mobility hubs. A mobility hub pilot conducted in Minneapolis was characterized by a community-driven approach and the effort to incorporate community feedback throughout the development and implementation of mobility hubs (City of Minneapolis Public Works, 2019). The city collaborated with Transportation for America and Arcadis to conduct a suitability analysis which resulted in 12 candidate locations. Then, the locations were filtered by neighborhood groups; the location of two hubs shifted after consulting with community organizations who provided insight on the community's needs. The author notes that a data-driven approach is useful for identifying initial candidate locations, but mobility hubs should not be implemented until the community perspective has been incorporated into the final site selection (City of Minneapolis Public Works, 2019).

Site Selection Summary

Table 8 highlights the methodology for location selection for a few types of transit facilities and the key considerations that guided the planning process. The process for site selection of other transit facilities is very similar to mobility hub site selection; the key difference for site selection of different transit facilities is found in the determination of criteria and development of indicators.

Table 8: Location Planning for Various Transit Facilities

Reference	Facility	Methodology	Special Considerations
(Yu et al., 2013)	Transit Hub	Two-phase optimization technique; calculation of passenger attraction criterion and mathematical model	Accessibility, connectivity, served population per construction cost ratio, and smallest overlapping areas
(Toronto Parking Authority, 2022)	Bike-Share Stations	Four-phase spatial analysis process: development of priority input layers, scenario creation, scenario selection, and development of implementation schedule	Expand bike share in Neighborhood Improvement Areas, compliment transit expansion, connect satellite areas with core network
(Tavassoli & Tamannaei, 2020)	Bike-and-Ride system	Mathematical model and sensitivity analysis	Maximizing competitiveness of Bike and Ride with private cars

(Wey, 2015)	Metro Station	Fuzzy AHP and data envelopment analysis model	Smart growth principles to guide location planning
(Mohajeri & Amin, 2010)	Railway Station	AHP and data envelopment analysis	Distance from station to PT, safety, compatibility with environment, alignment with present and future growth
(Horner & Groves, 2007)	Rail Park-and-Ride	Preventative inspection model to simulate network flows	Optimization of flow to maximize removal of traffic by intercepting vehicles early in journey

Table 9 summarizes the methodologies used to determine optimal locations for mobility hubs in the literature. The methodologies often have multiple steps including both qualitative and quantitative analysis to identify candidate sites, narrow down candidate locations, and validate the results.

Table 9: Site Selection Processes for Mobility Hubs

Reference	Methodology	Data Sets	Special Considerations
(Aydin et al., 2022)	Interval Type-2 Fuzzy AHP; Interval Type 2 Fuzzy Weighted Aggregated Sum Product Assessment; sensitivity analysis	N/A; Experts in the field used their assessments of each criterion in model	Proximity to educational institutions, shopping, and residential areas; accessibility to city center, potential to improve connectivity to PT
(Anderson et al., 2017)	AHP	Demographic data, vehicle ownership, distance to points of interest, proximity to PT, vulnerability of land	Equity, resiliency, and first/last mile connections, distance between hubs, proximity to transit and services, proximity to major population centers
(Blad et al., 2022)	AHP and GIS-Multi-Actor Multi Criteria Analysis	Local demand, transfer demand, distance to road networks, land suitability, nearby facilities, population served, parking pressure, congestion	Stakeholder perspectives were considered in criteria weight allocations
(Frank et al., 2021)	Two mixed-integer optimization models	Population nodes, travel time, POIs, potential travel itineraries, travel demand, commuting volume	Maximizing access to points of interest and employment centers
(Petrović et al., 2019)	Suitability analysis, optimization algorithm, solution assignment	Traffic flows, urban plans, statistical yearbook, data number of citizens served, fixed terminal locations, minimum distance between hubs, number of hubs	Number of citizens in the catchment area, freedom for decision-makers to prioritize certain criteria within the model

Several key research gaps still exist pertaining to siting of mobility hubs. While it is widely recognized that mobility hubs are most effective when located at or near transit stops with high ridership activity, few studies have considered the location and quantity of transit stops as primary criteria for determining the placement of mobility hubs. To address this gap, it is essential to analyze bundles of transit stops rather than areal units like census tracts or block groups when siting mobility hubs. Furthermore, there is a limited number of studies that specifically target the first mile/last mile gaps to enhance transit connectivity. Additionally, mobility hubs can be built at various levels, including the neighborhood, district, and regional scales. However, existing methods often overlook the typology of mobility hubs and instead focus only on one level. Future study should consider the hierarchical expansion of mobility hubs from neighborhood to district and regional levels.

1.3.5 Stakeholder Perspectives

One important part of mobility hub planning is to consider stakeholders perspectives during the decision-making process. The main stakeholder groups in transportation planning are the public, the government, transit and shared mobility providers.

The public represents the largest stakeholder group in the planning process, and includes both users and non-users. Particular attention should be paid to transit-dependent populations and historically marginalized groups. Community outreach may take many different forms, including online surveys, workshops, interviews, public forums, and more. Outreach efforts seek to find the public's perspective on hubs and what changes can effectively influence mobility patterns. It is important to understand user behavior in order to select the most impactful sites. Non-user support is also important in order to grow ridership as well as to secure public support. Governments' interests typically center around improving accessibility and connectivity to underserved areas, reducing costs, mitigating traffic congestion, and lowering emissions. Transit providers tend to focus on increasing transit ridership and improving traveler experiences, whereas shared mobility operators seek to increase profits and ensure consistently high demand. Each stakeholder may have competing interests which must be deliberately balanced.

Community Engagement

Community engagement should be an integral part of any city planning process, and mobility hubs are no exception. Engagement can include any process which supports communication between planners, local government, transit operators, community leaders, current transit and shared mobility system users, landowners, and potential users of the hub (Arseneault 2022). Common forms of engagement include surveys, information sessions, and workshops.

To implement mobility hubs in Austin, Texas, the city partnered with local organizations to secure the right to use the land owned by commercial entities (Holland et al., 2018). These organizations included Mission Possible and Eureka Holdings, both of whom played significant roles in the development of the mobility hubs in the city (Holland et al., 2018).

The Town of Cutler Bay (2020) formed a stakeholder advisory committee to facilitate public involvement in the process of designing, locating, and implementing mobility hubs. They also hosted multiple community engagement workshops to inform the residents of the existing transit networks and to get their feedback regarding the future plans (Town of Cutler Bay 2020).

In Minneapolis, city officials partnered with local organizations to select ambassadors which facilitated the distribution of surveys and resources and hosted community events to improve awareness of mobility hubs and to survey the population's confidence with different modes (Elkins & Warfield, 2021). 69% of the individuals surveyed noted that places to sit, bright colored signs, wayfinding information, and easily accessible parking for micromobility would make them more likely to use buses, bikes, scooters, or walking to reach their destination (Elkins & Warfield, 2021).

1.3.6 Mobility Hub Evaluation and Performance Metrics

There is currently no standard methodology for evaluating mobility hubs, and performance metrics for mobility hubs have not been thoroughly discussed in the literature. Some researchers have proposed a list of performance indicators for mobility hubs (e.g., Pappers et al., 2022; Metropolitan Transportation Commission, 2021), but these indicators do not form a comprehensive evaluation framework. Since mobility hubs are more widely implemented in Europe than in North America, there have been more discussions on performance evaluation of mobility hubs in European cities.

Mobility Hub Evaluation Framework

Abd El Gawaad et al. (2019) developed a tool for assessing mobility hubs' impact on the surrounding built environment. This model included analysis from a variety of perspectives, including the morphological dimension (how the hub fits into the context of the surrounding environment), social & perceptual dimension, functional & environmental dimension, administrative & economical dimension, and political & planning dimension. However, the focus was more on the surrounding area than the mobility hub itself. There was no indicator to measure multimodal trip generation, digital integration, or user satisfaction with the hub. This suggests the need for development of mobility hub specific performance indicators in future work.

Duran et al. (2022) proposed an iterative evaluation framework in which evaluation of the mobility hub takes place continually throughout the set-up and planning of a mobility hub as objectives and priorities may change due to evaluation. This evaluation framework is illustrated in Figure 17 and includes arrows pointing to and from each stage representing the cyclical nature of planning, evaluating, and replanning. The evaluation considers a variety of perspectives including citizens' evaluation, policies and governance evaluation, stakeholders' evaluation, and data-based evaluation.

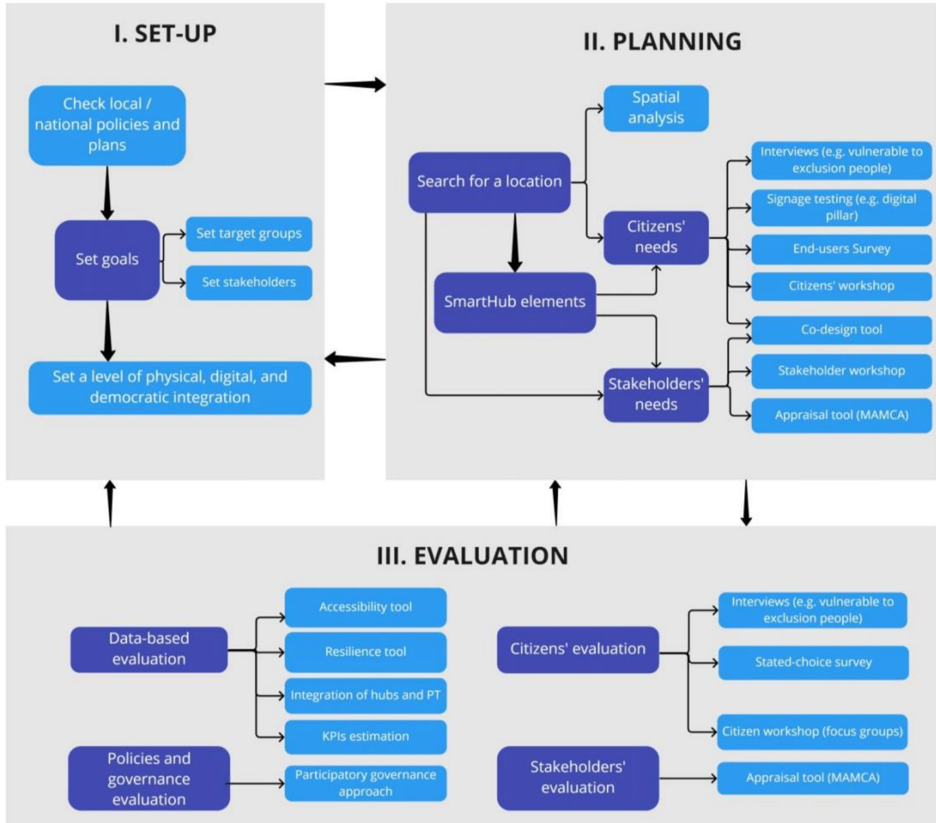


Figure 17: Development and evaluation framework for smart mobility hubs
(Source: Duran et al., 2022)

Methodologies used to evaluate other transportation initiatives such as intermodal facilities, TODs, and MaaS can be applied to mobility hubs with some necessary modifications. One approach to performance evaluation is using performance indicators to measure the impact of mobility hubs.

Mobility Hub Key Performance Indicators

Performance indicators can be developed to measure the mobility hubs' ability to meet the objectives set before implementation. Comparison of performance indicators before and after hub implementation can be useful in gauging the hubs' impact and provide guidance for adjusting the hub after implementation. To successfully evaluate the performance of mobility hubs, one must first develop performance indicators which are specific to the objectives of the mobility hub before assessing the mobility hub's performance with respect to each indicator. Though specific mobility hub objectives differ on a case-by-case basis, performance indicators typically fall into one of several categories including mobility components, mobility-related components, and non-mobility components. Performance indicators can be measured in a variety of ways including observation, analysis of third-party data, and surveys. Performance indicators can be classified as either inputs or outputs. Inputs are what the various transportation agencies provide: parking spaces, bus frequency, electronic passes, while outputs are the results on travel behavior and opportunity: passenger trips, transfers, improvements to accessibility, traveler satisfaction. There are several different approaches that can be taken to develop performance indicators, but a well-rounded evaluation framework will consider the mobility hub's performance regarding each of its objectives with an emphasis on user experience.

Indicators for mobility components can be developed from performance evaluation of other transport interchanges. At a minimum, evaluation of mobility components should include variables to measure availability of transit, availability of additional modes, ease of transfer, and modal integration. Mobility components should be evaluated regardless of the scale of the mobility hub.

Mobility-related components refer to the availability of services that facilitate use of the mobility hub including information technology services, supportive infrastructure, and information. These components can vary greatly depending on the scale of the hub; large-scale hubs will have significantly more amenities and require more indicators than smaller hubs. Travel behavior variables may also be considered a mobility-related indicator; this includes the number of travelers passing through the hub, waiting at the hub, and making modal transfers. Evaluation of non-mobility components may be difficult to conduct because indicators for concepts such as user experience, environmental impact, and economic impact can be complex. However, it is essential to evaluate this aspect of the hub to understand its impact on the community. Surveys are a method for gathering data on the quality of travelers' experiences and other non-mobility components of mobility hub performance.

Pappers et al. (2022) developed a list of core key performance indicators (KPIs) to evaluate the performance of mobility hubs as part of the SmartHubs project. The Core KPIs were developed through the process of analyzing performance indicators for other transportation facilities, conducting a series of expert surveys, and rating the feasibility and usability of each indicator. The Metropolitan Transportation Commission (2021) also developed a set of KPIs and metrics to assess mobility hub performance. The KPIs from both sources are presented in Table 10.

Table 10: KPIs for Mobility Hub Evaluation

Category	Sub-Category	Performance Indicator	Source
Mobility Components	Transit	Transit frequency	1
		Number of daily boardings and alightings	2
	Other modes	Number of modes available	1
		Number of vehicles per mode	1
		Number of shared mobility trips starting and ending at mobility hubs	2
	Mobility Hub Network	Number of hubs in the network	1
		Integration of hubs with local/regional/national transport policy	1
Mobility-Related Components	Physical Infrastructure	Number of parking spaces adapted for micromobility	1
		Availability of pick-up/drop-off zones for ridesourcing, ridesharing, etc.	1
		Proportion of secure bicycle parking	1
		Average daily bike parking utilization rate	2
		Availability of ticket machines	1
	Digital Integration	Possibility to buy one ticket for several modes	1
		Availability of digital ticketing for each service provider	1
		Possibility to digitally plan a trip with any/all modes available at the hub	1
		Possibility to unlock vehicles and facilities using smartphone, code, card, etc.	1
		Number of applications/subscriptions necessary for full use of hub and its services	1
	Information	Presence of display with explanation of mobility options available	1
		Presence of a digital map of modal options	1
		Availability of real-time information for transit	1
		Availability of real-time information for shared mobility	1
	Safety	Annual collisions, serious injuries, and deaths	2
Non-Mobility Components	Accessibility	Presence of information for people with disabilities	1
		Accessibility of digital mobility services and facilities for people with disabilities	1
		Accessibility of transport modes for people with disabilities	1
		Accessibility of hub facilities for people with disabilities	1
	Community Involvement	Involvement of vulnerable-to-exclusion groups in design process	1
		Number of in-person participation opportunities	1
	Placemaking	Spaces adapted to pick up packages	1
	Environmental Impact	Arrival mode share to hub	2
		Trip reduction	2
	Household Characteristics	Average household vehicle ownership	2
		Percent of income spent on transportation	2
	User Experience	Customer satisfaction	2
	Economic Impact	Private investment in public mobility	2

Note: Source 1 is Pappers et al., 2022. Source 2 is Metropolitan Transportation Commission, 2021.

Future Development of Mobility Hub Evaluation Criteria

Evaluation criteria for transit stations may be used as a foundation for establishing evaluation criteria for mobility hubs. However, evaluation of mobility hubs should incorporate specific metrics or performance indicators which focus on the infrastructure, supportive services, and amenities located at mobility hubs in addition to typical metrics for transit stations. It is crucial to pay attention to the generation of multimodal trips and ease of transfer even though they may be difficult to measure. These factors play a significant role in assessing the impact of mobility hubs as they reflect the ability of mobility hubs to provide seamless integration between modes.

The KPIs outlined in Table 10 are derived from evaluation of mobility hubs in the planning practice and do not represent a comprehensive set of performance indicators. Depending on the size, context, and objective of the mobility hub, additional indicators may be necessary, or some indicators listed may not be applicable. Additionally, some indicators may fall into multiple categories.

There are several subcategories and indicators missing from this list. For example, there are no indicators to measure multimodal trips, ease of transfer, or spatial accessibility. Transfer distance, coordination between transport services, and time use at interchange are variables that have been used to measure movement within an urban transport interchange (Hernandez et al., 2016). Trip generation, modal split, and number of multimodal trips should also be included in the list of KPIs to assess mobility hubs' impact on travel patterns. Another omission from this set of KPIs are indicators to measure travel time to essential POIs and the possibility for users with no smartphone or credit card to access the mobility services.

Additionally, the subcategory for user experience should include multiple indicators. There are many dimensions to customer satisfaction that cannot be measured in one indicator. User satisfaction with transport facilities – including multimodal transportation hubs – has been studied and often consists of conducting surveys which cover multiple aspects of the facility (Chen et al., 2014; Hernandez et al., 2016; Lois et al., 2020; Zhang et al., 2020; Chauhan et al., 2021). One or more measures of travel safety should be included, as that has been found to be an important aspect with regards to user experience (Hernandez et al., 2016; Lois et al., 2018; Chauhan et al., 2021; Elkins & Warfield, 2021).

While it is desirable to develop a comprehensive list of KPIs, this must be balanced against the ease and frequency of data collection to support KPI monitoring. It is important to maintain regular observation of KPIs; the Metropolitan Transportation Commission (2021) recommends analyzing the KPIs monthly. Continuous evaluation allows for early identification of areas of weakness and prioritization of hubs in need of special attention.

1.4. Case Studies of Mobility Hub Plans

1.4.1 Florida cases

1.4.1.1 North Miami

Local Context

The City of North Miami and IBI Group have developed a The North Miami Mobility Hub and TOD Strategic Plan (2018) to improve connection within the Tri-Rail Coastal Link corridor and promote transit-oriented development. North Miami is situated between Miami and Fort

Lauderdale and surrounded by multiple regional roads including Interstate 95, US Highway 1, Florida Turnpike, West Dixie Highway, and US Hwy 441.

The city is served by the Tri-Rail commuter corridor (Opa-locka station), the Miami-Dade County Metrobus, and the NoMi local shuttle service. 18 Metrobus routes serve North Miami, but headways at peak hour can be up to 60 minutes, and there are no transit stations within the city. The NoMi local transit circulator has four routes with 60-minute headways. Existing shared mobility services in the city include car-sharing (ZipCar), bike-sharing (LimeBike), and taxisharing (Jitney Service).

Planned initiatives to improve transit connections within the region include the Tri-Rail Coastal Link and Strategic Miami Area Rapid Transit (SMART) Plan. Other proposed projects included additional open areas and public parks, transportation improvements, streetscape improvements, and mixed-use development.

The city has identified one location for a mobility hub along the planned Florida East Coast (FEC) Passenger Rail line near the NE 125th/123rd St. Station. The Tri-Rail Coastal Link will operate on this railway, providing connection to Jupiter, West Palm, Fort Lauderdale, and Miami via transit. The planning area for mobility hub development is displayed in Figure 18.

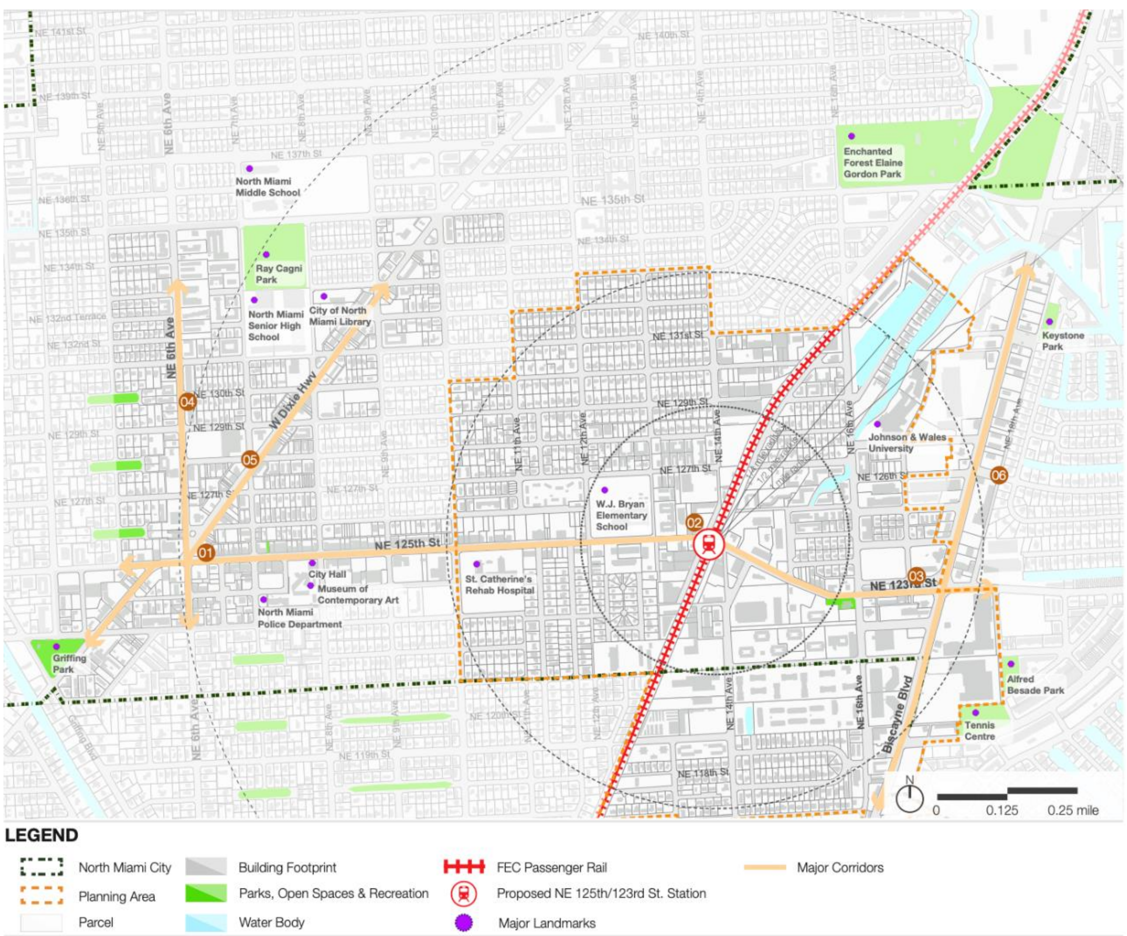


Figure 18: North Miami Mobility Hub and TOD planning area boundary
(Source: North Miami Mobility Hub and TOD Strategic Plan, 2018)

Vision and Objectives

Establishing a mobility hub in North Miami is part of a greater effort to foster Transit Oriented Development (TOD) and enhance transit connectivity in the area. The City Council hopes to promote TOD within the quarter mile surrounding the station. The principles used to guide the planning and design of the TOD are:

- First and last mile connectivity
- Multimodal integration
- Creative placemaking & open space network
- Economic catalysts
- Transit supportive area
- Parking management
- Age-friendly neighborhoods
- Innovation & Technology Integration
- Resilient NoMi

The mobility hub objectives and TOD principles go hand-in-hand. Implementation of projects that support these principles – including the mobility hub – will contribute to the development of North Miami into a "TOD city."

Typologies

The NoMi Mobility Hub is currently the only planned mobility hub in North Miami, so there is not an established typology for mobility hubs in the city

Site Selection

The NoMi Mobility Hub location was selected after the South Florida East Coast Corridor Study proposed the Tri-Rail Coastal Link as a passenger rail service between Jupiter and Miami. This location was seen as a potential mobility hub location due to the proposed high-frequency rail service, the development surrounding the planned rail station, the number of trips generated in the area, and the connection to other transit systems. The City Council called for a transit center within a quarter mile of the proposed NE 125th/123rd St. Station to maximize connectivity in the area. The mobility hub is just one part of a greater TOD initiative in North Miami developed by the IBI Group and the City of North Miami.

Implementation

A phased implementation approach for The NoMi Mobility Hub & TOD has been outlined, but it is expected to take at least twenty years to reach completion because the plan depends on collaboration between a variety of stakeholders. The planners recommended the development of a Steering Committee which can oversee progress of implementation and foster community engagement. The hub implementation strategy consists of:

- Key programming and policy initiatives to attract development
- Promotion of projects which will serve as a catalyst for activity and investment
- Improvements to transportation infrastructure and amenities

Implementation progress is monitored by a steering committee consisting of transit operators, planning organizations, private entities, corporations, community-based organizations, and more.

1.4.1.2 Broward County

Local Context

Broward County and the Broward County Metropolitan Organization (MPO) detailed their mobility hub concept in 2009 as an innovative way to integrate transportation and land-use objectives in their 2035 Long Range Transportation Plan (LRTP) (2009). The plan was revisited in 2018 to critique the hub identification methodology and redefine the mobility hub typology.

Broward County is served by the Broward County Transit (BCT) system which includes bus, community shuttle service, and four transfer terminals. The bus system consists of express routes, breeze routes, and fixed-route regular service. The Express Bus connects a few free commuter park-and-rides to Miami-Dade County during weekday peak hours. Two Breeze routes run during weekday peak hours as well, stopping occasionally at major intersections. The fixed-route service operates over 30 routes throughout the entire week. Community shuttles connect to fixed-routes and operate within 18 municipalities Broward County. There are 52 routes and headways vary by municipality from 30 minutes to two hours.

In addition to BCT, Broward County is serviced by passenger rail including the Brightline and Tri-Rail. Seven of the 18 Tri-Rail stations are in Broward County, and the service operates seven days a week with headways ranging from 20 to 60 minutes. The Tri-Rail connects to BCT, Miami-Dade County's Metrobus and Metrorail, and other local transit systems.

Broward County has planned initiatives for high-capacity transit to respond to projected future demand for service. Transit services include Rapid Bus and Light Rail Transit, which are characterized by short headways, transit signal priority, off-board fare collection system, low-floor transit vehicles, and real-time passenger information.

Vision and Objectives

Several principles drive Broward County's current and planned transportation initiatives. The driving goals for Broward MPO's transportation developments are:

- Move people and goods
- Create jobs
- Strengthen communities

Mobility hubs can contribute to these goals by promoting transit ridership, decreasing travel time and cost, encouraging new development and private investments, and creating a sense of place.

Typologies

The three types of mobility hubs identified for the 2035 LRTP are Gateway Hubs, Anchor Hubs, and Community hubs. Each serve a unique purpose in the transportation network, and their characteristics are summarized in Table 11.

Table 11: Broward County Mobility Hub Typologies as defined in 2035 LRTP

Type	Description	Recommended Infrastructure Upgrades	Recommended Amenity Upgrades
Community Hubs	Areas served by Rapid Bus services which attract more local trips than regional trips	Pedestrian linkage improvements within a quarter-mile radius Bicycle linkage improvements within one-mile radius	Partially enclosed shelters Real-time information Lighted waiting areas Timed transfers for connecting to transit services

Anchor Hubs	Areas served by at least one high-capacity transit line with moderate to high boarding/alighting and located near a major point of interest	Surface or structured parking Pedestrian linkage improvements within a quarter-mile radius Bicycle linkage improvements within one-mile radius Integration with surrounding development Access priority to bike/pedestrian and transit patrons	Enclosed or partially enclosed shelters Real-time information Unique architecture and signage Lighted waiting areas Accommodations for bikeshare programs Pre-board ticketing Kiss-n-ride and taxi areas Free phone for taxi services
Gateway Hubs	Areas served by at least two high-capacity transit or rail lines with high boarding/alighting and surrounded by higher density mixed-use developments	Surface or structured parking Pedestrian linkage improvements within a half-mile radius Bicycle linkage improvements within a two-mile radius Integration with surrounding development Access priority to bike/pedestrian and transit patrons	Enclosed shelters Real-time information Unique architecture and signage Restrooms and community spaces as appropriate Public art Secure and weather protected waiting areas Accommodations for bikeshare/carshare programs Pre-board ticketing Taxi bays

The 2018 Revisit & Update Mobility Hubs (Broward MPO, 2018) defines additional parameters for classifying mobility hubs. This new typology considers the land and activity context surrounding the site in addition to its existing transit connectivity because some planned transit initiatives that were used to define gateway, community, and anchor hubs were not implemented (e.g., Bus Rapid Transit). Three aspects of the mobility hubs' context were considered: Existing Transect, Future Land Use, and Transit Activity. Each hub may have a unique typology depending on the combination of each of the three factors. The typology is summarized in Table 12.

Table 12: Broward County Mobility Hub Typologies as defined in 2018 Mobility Hub Revisit

Existing Transect	Future Land Use	Transit Function
Suburban Residential **Suburban Commercial** **Urban General** **Urban Core**	Activity Centre Commerce Transportation Community Recreational Open Space Conservation Agricultural Irregular Residential Estate 1 Residential Low 2 Residential Low 3 Residential Low 5 Residential Low-Med Residential Med 16 Residential Med-High Residential High Residential High 50 Residential	Rail Station Bus transfer facility Park and ride, Streetside transfer location

Site Selection
In the 2035 LRTP (Broward MPO, 2009), candidate locations for mobility hubs were given a score between zero and three for each of the following criteria:

- Critical Connections
- Existing Developed areas
- Local Request/Support or other Plan Designation
- Public-Private Partnership Opportunities
- Tax Increment Financing Opportunities

However, these criteria were reevaluated in 2018, as it was determined that they were no longer appropriate due a variety of reasons including lack of funding for the proposed transit network and lack of quantifiable data. New minimum criteria for candidate locations were established in the Revisit & Update Mobility Hubs (MPO, 2018).

For a place to be considered a candidate location for a mobility hub, it must meet at least one of the following minimum criteria:

- Two or more transit routes within one-half mile
- Park & ride terminus
- Rail station
- Transfer center

Locations meeting the minimum criteria were then assessed on their "readiness." Broward County placed an emphasis on readiness for mobility hub candidate locations following the unsuccessful implementation of many mobility hubs between 2009 and 2018. Readiness is divided into two categories: network readiness (peak service frequency and ridership) and market readiness (estimated trip generation based on existing and planned land uses). The choice to include only these two criteria was made after meetings with stakeholders who believed that a simple evaluation methodology could be easily understood and replicated. Sponsor readiness (likelihood of receiving promotion/funding) was briefly considered as a criterion but removed due to lack of quantifiable data.

Each candidate location was scored according to its market readiness and network readiness. Market readiness was assessed using a land-use analysis to estimate the current number of daily trips generated and potential trip generation within a one-half mile radius of the candidate location. The number of daily trips is calculated by multiplying the total units for each land use by the ITE trip generation rate. For potential trips, a probability factor was included to consider the stage of projects' development (proposed, planning review, approved, permitted, construction, completed).

Network readiness score accounted for 50% of the composite score and included a ridership factor and an availability factor; the ridership score was given a weight of 35%, while the transit frequency was given a weight of 15%. The scores were calculated using the daily ridership of all routes stopping within a half mile of the candidate location and the number of buses per hour at peak frequency.

Candidate locations were considered all of those that meet the minimum criteria. Each candidate location was scored according to its market and network readiness. A composite score was assigned to each hub based on the sum of the individual scores, with equal weight given to network readiness and market readiness. After normalization, each hub had a corresponding score between 0 and 100. Finally, the locations were ranked; with the highest scoring location being ranked 100, the lowest scoring location being ranked 0, and the remaining hubs were given a rank which corresponded to their scores. The candidate locations and their composite scores are displayed in Figure 19.

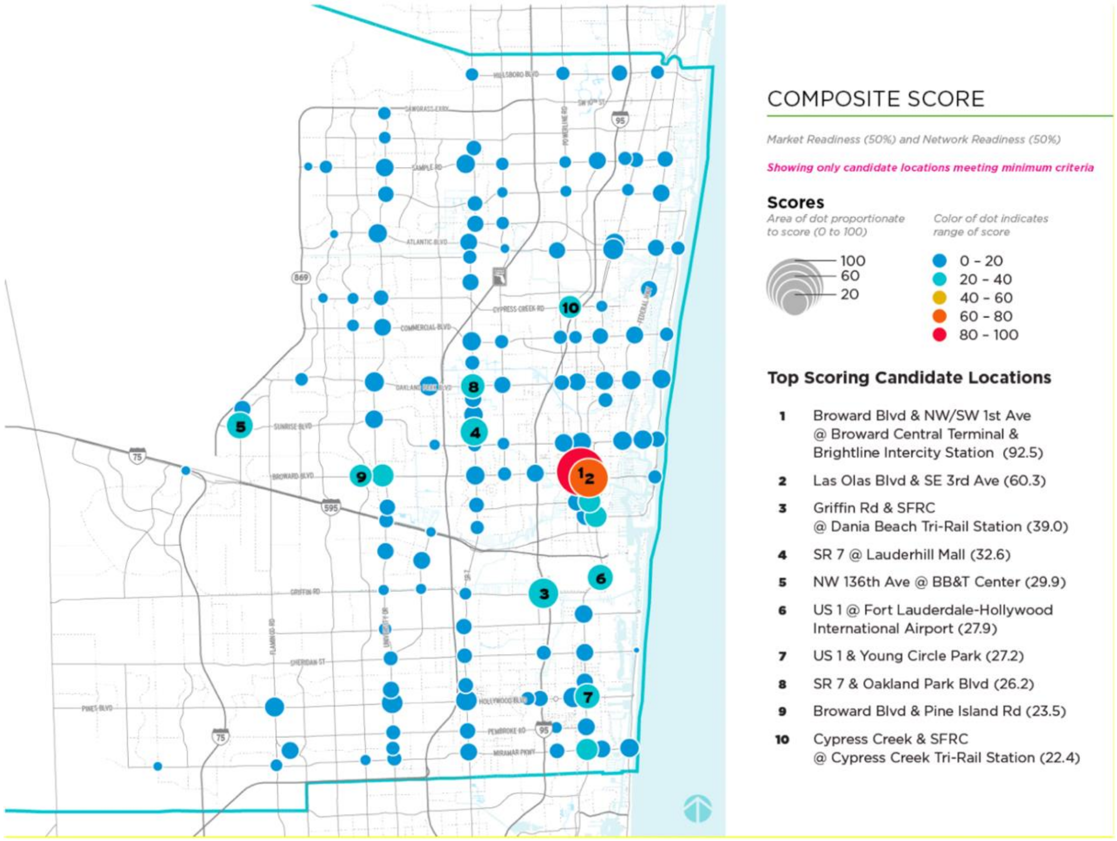


Figure 19: Map of Candidate Locations for Mobility Hubs in Broward County (Source: Broward MPO, 2018)

Implementation

Broward MPO has partnered with local initiatives to pursue funding for mobility hub implementation. Of the 175 candidate locations identified, seven are currently in the process of being implemented including Coral Springs, Cypress Creek, Downtown Fort Lauderdale, Hollywood, Pembroke Pines, Plantation, and Sunrise. Implementation status ranges by hub; some have master plans pending while others are already under construction. The mobility hub implementation strategy is outlined below:

1. Identify roles and responsibilities for implementation
2. Conduct stakeholder and community engagement to gauge desired elements and standards
3. Review possible sources of funding and public-private partnerships
4. Review possible advertising to expedite implementation and decrease operational costs
5. Develop policies for mobility hub implementation and operation
6. Develop a request for proposals for establishment of shared mobility services (e.g., carshare and bikeshare)

The Downtown Fort Lauderdale Mobility Hub was the first hub planned, funded, and completed by the Broward MPO in collaboration with the City of Fort Lauderdale and the Federal Transit Administration. The mobility hub is comprised of four blocks surrounding the BCT Central Terminal and the Brightline Inter-City Passenger Rail Station. The total cost of implementation was \$3.5 million and included improvements to pedestrian and cyclist infrastructure, road conditions, drainage, and parking. Figure 20 displays the improvements made to NW 1st Ave.

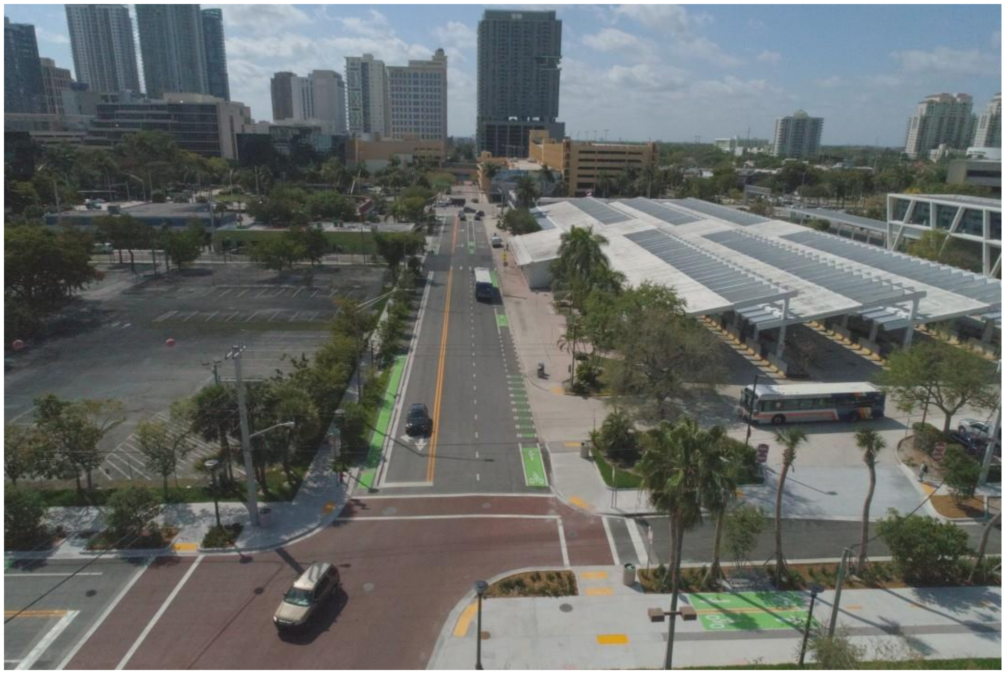


Figure 20: Aerial view of Downtown Fort Lauderdale mobility hub
(Source: Broward MPO, 2022)

1.4.1.3 Cutler Bay

Local Context

The Town of Cutler Bay partnered with MARLIN engineering to create a network of mobility hubs in connect the South Dade Transitway and Cutler Bay (Town of Cutler Bay, 2020). The overwhelming majority of the town's residents (95.5%) travel outside of the community for work, with many jobs concentrated near the U.S. 1 / South Dixie Highway Corridor.

There are two options for transit in Cutler Bay: GO Connect (free on-demand transit) and Miami-Dade Metrobus. Both services are completely free but have limited weekend/nighttime service. 11 Metrobus routes provide service in the town, with one route as a dedicated town circulator. Additionally, there are some shared-use paths that serve as pedestrian/bicycle infrastructure.

Vision and Objectives

By identifying 12 existing mobility hubs, recommending upgrades, and conducting stakeholder engagement, the city hopes to inspire mode shift to more sustainable transportation. The overall goals are to:

- Improve safety
- Improve mobility
- Improve connectivity

Typologies

The proposed mobility hubs were classified according to characteristics including existing transit routes and ridership, accessibility by various modes, population and jobs within catchment area, and potential for future development. The hubs were given a score, and three types of mobility hubs emerged: neighborhood hubs, community hubs, and regional hubs. The hubs are summarized in Table 13.

Table 13: Mobility Hub Typologies Identified in Cutler Bay

Type	Description	Recommended Infrastructure Upgrades	Recommended Amenity Upgrades
Neighborhood Hubs	Small scale hubs serviced by at least one transit route, near residential uses	Enhancing sidewalks, shared-use paths, crosswalks,	Safety, shelter, information, and micro-mobility features Optional: retail and other placemaking features
Community Hubs	Medium scale hubs serviced by one of more transit routes, near residential and retail uses	Refining sidewalks, landscaping, ADA accommodations, and crosswalks Creating shared use paths and complementary accessories such as bike signals, parking, and wider sidewalks	Real-time information, security features, and placemaking details Expanding shared mobility options
Regional Hubs	Large scale hubs serve by two or more transit routes, near residential and retail uses	Refining sidewalks and landscaping Adding lighting, parking information, and a linear park	Shared mobility, real-time information, security features, and placemaking details

Site Selection

The criteria assessed to prioritize mobility hub locations in Cutler Bay is displayed in Figure 21. Each hub was given a score for each criterion. Non-quantitative criteria were designated low, medium, or high.

Figure 21: Criteria used for prioritization of mobility hubs in Cutler Bay

CRITERIA	MEASURE
Number of Transit Routes	Number of Existing Routes
Future Transit Potential	Low (1), Medium (5), High (10)
Existing Ridership	Average Monthly Ridership
Accessibility by Walk	Sidewalk Network Completeness (1, 5, 10)
Accessibility by Bicycle	Bicycle Facility Completeness (0, 1, 5, 10)
Accessibility by Vehicle	Number of Park & Ride Spaces
Population	Existing Population within ½-Mile
Employment	Existing Jobs within ½-Mile
Redevelopment Potential	Vacant Parcels & Existing Development within ½- Mile – Low (1), Medium (5), High (10)
Transit Oriented Development Potential	Existing Land Use & Zoning with ½-Mile – Low (1), Medium (5), High (10)

(Source: Town of Cutler Bay, 2020)

The hub with the highest score was considered a regional hub (33), with community hubs having the next highest scores (10-24) and neighborhood hubs having the lowest scores (5-11).

Figure 22 displays the spatial distribution of the mobility hubs that emerged using this site selection process.

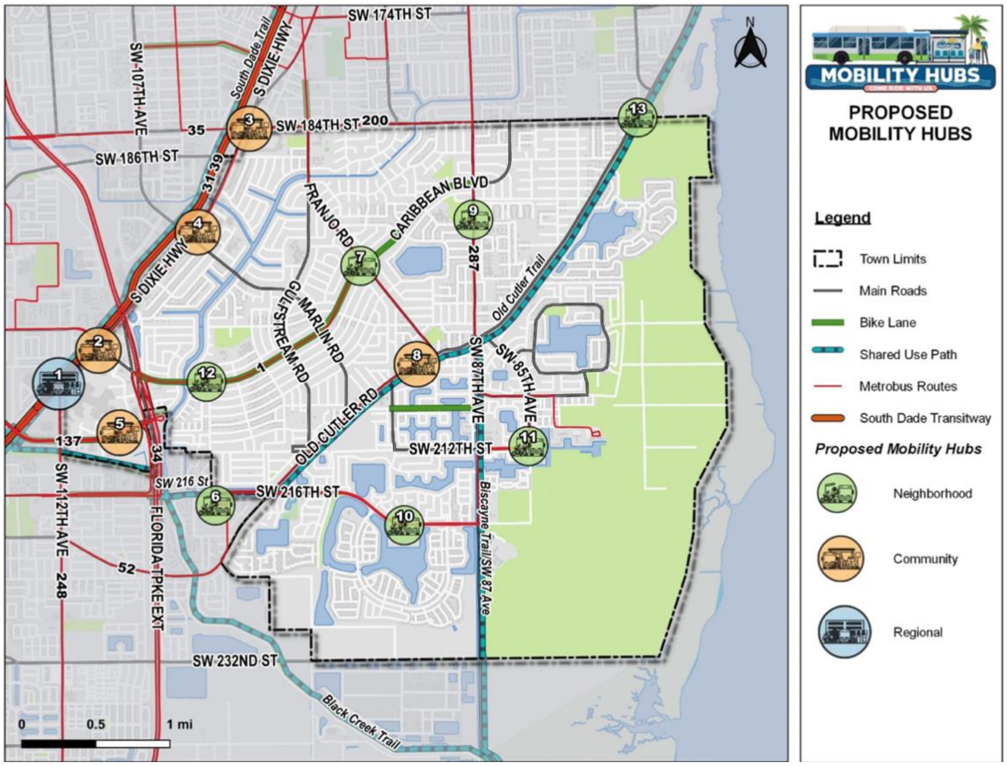


Figure 22: Proposed Mobility Hub Locations for the Town of Cutler Bay
(Source: Town of Cutler Bay, 2020)

Implementation

The Town of Cutler Bay collaborate with both public and private entities to provide the recommended upgrades for mobility hubs. The town requires new developments to integrate mobility hub features and provide incentives for existing development to do the same. A "mobility fee" which can be imposed on new development or redevelopment could be adopted and used to fund hub implementation as well. The Town has funding from dozens of sources including the federal government, HUD, EPA, state government, private foundations to facilitate hub implementation.

A Stakeholder Advisory Committee (SAC) was formed to facilitate the public involvement process in the study. Three public workshops were held to distribute information regarding the existing transit networks and future plans; participants were asked for feedback in the form of an online survey. They were given an opportunity to address their concerns and provide recommendations for service improvement. The sessions were given at different times and in Spanish to accommodate residents with different needs. Most of the publics' recommendations included extending service hours, improving reliability, and adding signage.

1.4.2 Non-Florida cases

1.4.2.1 Boston

Local Context
East Boston was chosen to be the focus of Boston's mobility hub pilot because it isolated from the main city by the Boston Harbor (City of Boston, 2021). Although residents of East Boston have greater access to transit than residents of other neighborhoods, the transit is not high-quality and does not fulfill all the residents' needs.

East Boston is connected to other neighborhoods by the Massachusetts Bay Transportation Authority (MBTA) Blue Line. There are also six MBTA bus routes servicing the neighborhood, connecting to nearby neighborhoods and the subway.

Vision and Objectives
For a mobility hub to have the most significant impact on the transportation network, it must have a variety of components that contribute to its function as a multimodal transit center and a community space. The City of Boston considers the purpose of a mobility hub to:

- Improve access and mobility
- Enhance place
- Provide information

Planners considered these factors while designing the mobility hubs and ensured that all elements in the mobility hub design contribute to these goals.

Typologies
Three types of mobility hubs were identified, each playing a unique role in the transportation network and the community of East Boston. The typologies are summarized in Table 14.

Table 14: Mobility Hub Typologies Identified in East Boston

Type	Description	Recommended Infrastructure Upgrades	Recommended Amenity Upgrades
Points	Small, minimalistic hubs which are essential to fill gaps in the transportation network by providing first/last mile connections	• Shared mobility • Bike parking	• Information • Seating
Squares	Neighborhood oriented hubs located near popular transit routes and providing a gathering place for residents	• Bike and pedestrian improvements • Traffic calming measures	• Seating • Wi-Fi • Phone charging • Information
Gateways	Highly frequented hubs located near key transit stops and major public institutions/points of interest	• EV charging • Ride hail pick-up/drop-off • Shared mobility • Bike parking	• Parklets • Public art • Placemaking • Branding • Information

Site Selection
The city collaborated with consulting companies to develop site selection criteria and methodology. The following criteria were used to prioritize sites for mobility hub development in East Boston:

- Transit route frequency
- Mode options and connections
- Walkshed residential populations
- Commercial, social, and civic destinations

Sites with the most transportation access and the most equity considerations were deemed more suitable for a mobility hub. A total of eight pilot hubs were identified: two gateway hubs, two squares, and four points. The locations of the mobility hubs are displayed in Figure 23.

Figure 23: Map of Mobility Hub Pilot Locations in East Boston
(Source: City of Boston, 2021)

Implementation
The East Boston mobility hub implementation was divided into 4 phases:

1. Community engagement/site selection,
2. Concept development,
3. Refinement, and
4. Design document completion and implementation.

With the implementation of the eight pilot hubs, East Boston gained three bikeshare stations, 33 bikeshare bikes, 14 bike racks, 14 car share spaces, four smart benches, two pick-up/drop-off locations, and many placemaking amenities. Throughout the design and implementation process, the city collaborated with private transportation providers, transit agencies, city and state departments, community groups, and neighborhood associations to incorporate various stakeholders' interest into the hub design.

1.4.2.2 Minneapolis

Local Context

The first mobility hub pilot in Minneapolis was conducted in 2019 to assess the feasibility of a network of mobility hubs as a long-term solution to increase access to sustainable transportation options in the city (City of Minneapolis Public Works, 2019). A key characteristic of this mobility hub pilot was its community-driven approach; community engagement happened at every stage of the pilot to ensure that the mobility hubs were shaped directly by the community.

Minneapolis is served by Metro Transit, which offers a network of buses, light rail, and commuter trains providing connections within the city, to City of Saint Paul and the airport. The bus service operates over one hundred routes across frequent local buses, all day local buses, all day express buses, bus rapid transit, and rush hour buses. There are two light rail lines and one commuter rail line. In addition to Metro Transit, the city has on-demand micro-transit and shared mobility services including e-scooters, bicycles, and cars.

Vision and Objectives

One of the foremost principles of the pilot was to foster community involvement in the planning and implementation processes to build a strong foundation for a greater mobility hub network. The goals for the pilot were:

- Pilot strategies for co-locating mobility options in the public right-of-way.
- Understand barriers to utilizing shared modes and other non-automobile transportation options.
- Create a system of visual cues to identify hubs as cohesive, inclusive spaces and centers of mobility options.

Typologies

Mobility hub typologies were not explicitly mentioned in the Minneapolis mobility hub pilot. However, the neighborhood context and existing conditions were noted for each hub. These characteristics are highlighted in Figure 24.

	Existing Conditions			Neighborhood Context		
Pilot Sites	**Transit [1]**	**Bike + Ped [2]**	**Right of Way [3]**	**Public Institutions**	**Commercial**	**Residential**
Penn & Lowry Ave	**BRT:** C Line	●●○○○	●●●●●		✓	Low-mid density
Fremont & Lowry Ave	**HFB:** Rt 5	●●●●○	●●●○○	Library		Low-mid density
Farview Park	Rt 22	●●●○○	●○○○○	Park		Low-mid density
West Broadway & Emerson Ave	**HFB:** Rt 5; Rt 14, 22	●●○○○	●●●○○		✓	Mid-high density
Uptown Transit Center	Bus-Only Lane Pilot; **HFB:** Rt 6; Rt 12, 17, 21, 23, 53, 114, 612	●○○○○	●●○○○	Library	✓	Mid-high density
Midtown Global Market	Bus-Only Lane Pilot; **HFB:** Rt 5, 21	●●○○○	●●●●○		✓	Mid-high density
Lyndale & 29th Share Street		●●●○○	●●●○○		✓	Mid-high density
Franklin & 11th St		●●○○○	●●●●○		✓	Low-mid density
24th St & Central Ave	**HFB:** Rt 10	●●●○○	●●●○○		✓	Low-mid density
22nd St & Central Ave	**HFB:** Rt 10	●●●○○	●●●○○	Library	✓	Low-mid density
18th St & Central Ave	**HFB:** Rt 10	●●●●○	●●○○○	Senior Housing	✓	Low-mid density

BRT= Bus Rapid Transit; HFB= High Frequency Bus service; Rt = Route
1=less safe, 5=most safe Considerations include pedestrian crossing safety, north/south bike connections, and east/west bike connections.
1=less Right-of-Way, 5=most Right-of-Way

Figure 24: Site Characteristics of Mobility Hubs in Minneapolis
(Source: City of Minneapolis Public Works, 2019)

Site Selection

The city collaborated with Transportation for America and Arcadis to identify locations for mobility hubs. They combined 32 different layers of data in five different groups:

- Physical (transportation and points of interest)
- Economic (employment and development)
- Demographic (race, income, education, etc.)
- Access (spatial access to employment, recreation, and food)
- Behavior (current travel behavior and friction)

Each layer was given a different weight depending on the scenario; the three scenarios used in Minneapolis were: equal focus, commute focus, and equity focus. The hotspots that emerged in each scenario were considered candidate locations for mobility hubs; opportunities for implementation were concentrated in northern, southern, and northeastern sections of the city.

12 mobility hubs emerged from this process; however, the data-driven locations were not the final locations for mobility hubs. Neighborhood groups provided feedback on the locations before final site selections were made. Final mobility hub locations are shown in Figure 25.

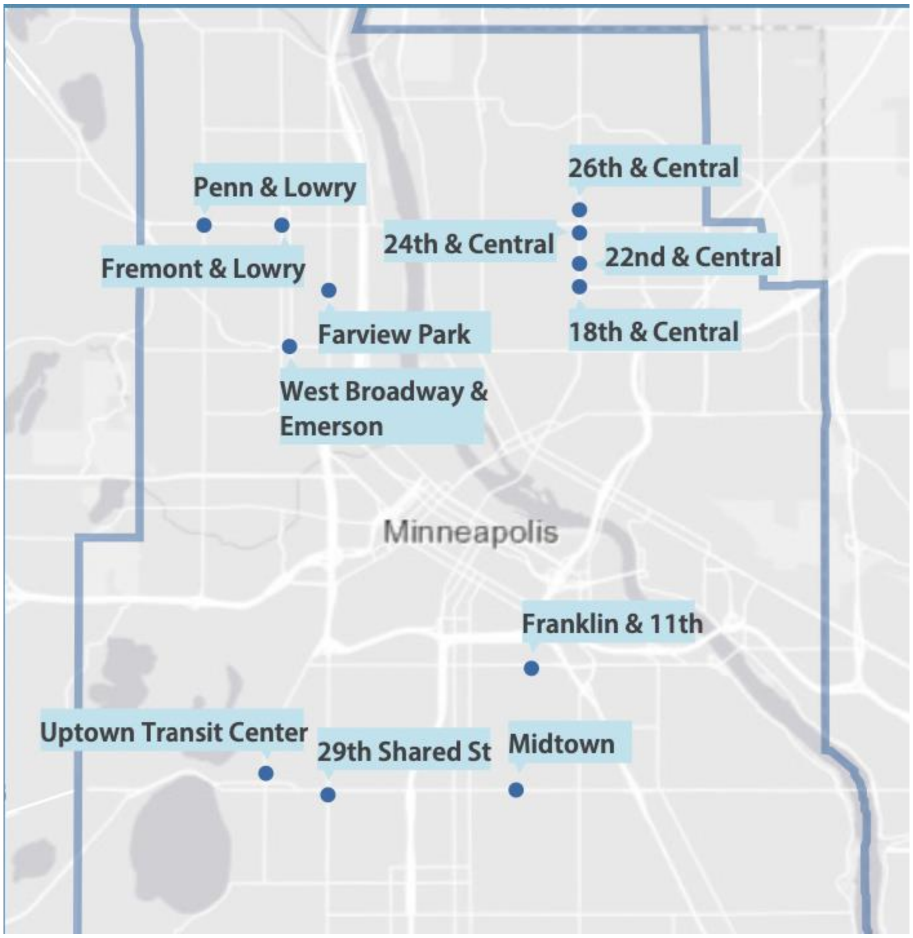


Figure 25: Mobility Hub Locations in the 2019 Minneapolis Pilot
(Source:City of Minneapolis Public Works, 2019)

Implementation

Implementation relied on partnership with agencies, mobility providers, and community organizations. The implementation approach was community driven and iterative to produce mobility hubs that best serve the community and promote the pilot's goals.

Minneapolis used a variety of strategies to monitor the progress of the mobility hub implementation including:

- Conducting surveys (both online and at mobility hubs)
- Participating with and gathering feedback from partners
- Collecting mode use data from transit and shared mobility operators
- Collecting origin/destination data from shared mobility operators
- Collecting boarding data from Metro Transit
- Regularly observing, adjusting, and improving pilot sites

The positive feedback regarding the 2019 Mobility Hubs Pilot inspired the move forward with a 2020 pilot which added an additional 13 hubs, creating a network of 25 mobility hubs spanning 14 neighborhoods (City of Minneapolis Public Works, 2020).

1.4.2.3 Lisbon

Local Context

Lisbon is one of several cities in which the European Institute of Innovation and Technology (EIT) has implemented mobility hubs known as SmartHubs. These hubs are intended to "test and validate economically viable mobility hub concepts that foster modal shift to sustainable transportation and more efficient use of urban space" (Berndsen, 2022).

Lisbon is served by several means of transit, including six trams, 172 bus routes, four metro lines, five commuter train lines, five ferries, and three funiculars. EMEL, the municipal organization responsible for mobility and parking in Lisbon, collaborated with EIT to launch mobility hubs with an emphasis on bike share to facilitate short-distance trips including first/last-mile access to transit. Shared mobility options in Lisbon include shared micromobility, EV car share, and ride hailing.

A pilot mobility hub was launched in 2021 with the goal of facilitating last-mile solutions by upgrading parking stations for shared bikes and e-bikes. This pilot was monitored and adjusted throughout 2022.

Vision and Objectives

The following objectives guided the work completed during the 2021 pilot (Oudbier et al., 2021):

1. Select the best location for the implementation of the pilot mobility hub, by using a multi-criteria methodology
2. Monitoring the use of the pilot mobility hub
3. Explore, through a co-creation process, different combinations of mobility and value-added services to upgrade the mobility hub at a later stage

These objectives are intended to lay the foundation for creating a network of mobility hubs and help fulfill EMEL's long-term solution for promoting shared mobility and multimodality.

Typologies

Two types of hubs are identified as part of the network of mobility hubs: in-city hubs and neighborhood hubs. However, as EMEL emphasizes a flexible approach as opposed to a "one-size-fits-all" approach, there is not a standard description for these types of hubs. Therefore, each mobility hub has a unique combination of services which are adapted to fit its' site and role in the transportation network.

Site Selection

Site selection for Lisbon's mobility hub pilot was completed using a multi-criteria methodology. Preliminary considerations included that the pilot would be implemented at an existing or planned bike share station operated by GIRA and the methodology should highlight locations underserved by the current bike share system.

Two key criteria considered in the methodology were the bike share stations planned to operate in 2021, and the neighborhoods deemed most open to accepting new mobility services. 11

data sets were proposed for the multi-criteria analysis, but limiting factors meant the final calculation was completed using four variables:

- Population density (P)
- On-street car parking spaces occupancy rate (E)
- Underground stations (M)
- Cycle paths (C)

A score for each spatial unit was calculated by adding the individual scores for each variable. For the final calculation, population density and car parking were weighted 30% each while underground stations and cycle paths were weighted 20% each. The result of this methodology is displayed in Figure 26.

The final location was selected by considering the parcels with the highest scores, the planned bike share station, and the neighborhoods more likely to accept the new mobility service. Bike share station no. 550 scored high due to its proximity to an underground station with two lines and its connection to cycle paths. The station is located in the Lumiar parish, and its surroundings include off-streetcar parking, bus stops, and a major bus terminal. It was selected to be the site for the mobility hub pilot due to its potential to promote multimodality.

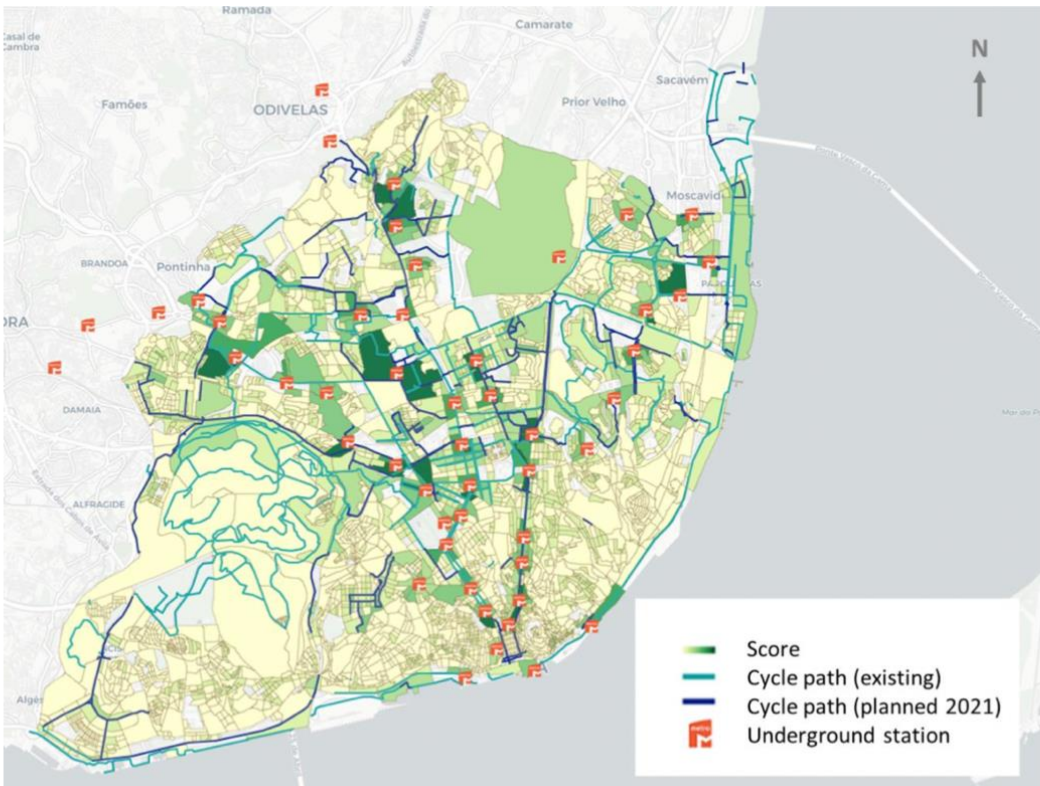


Figure 26: Map of Lisbon displaying scores for implementation of a mobility hub
(Source: Oudbier et al., 2021)

Implementation

The beginning of implementation of the hub was marked by the opening of the bike share docking station which has capacity for 20 bikes and e-bikes. Data from GIRA is used to monitor the hub's performance. Station no. 550 more highly frequented than other bike share stations, and a large share of trips occur on weekdays during peak hours. The station's users include a high percentage of young adults due to its proximity to several schools.

A three-step methodology was employed to decide which mobility services and non-mobility components should be implemented at the mobility hub: desk research, one co-creation session, and public engagement.

Desktop research of mobility hub case studies revealed that while there are no universal guidelines for hub design, services can be classified as either mobility modules or complementary service modules. Mobility modules include transportation related amenities such as parking, shared mobility charging stations, and pick-up/drop-off zones. Complementary service modules include all non-mobility amenities which increase comfort and convenience, such as lighting, seating, and placemaking features.

A co-creation session took place with participants from EMEL and Lisbon City Council to narrow down which services and amenities should be included in the public engagement session. Participants were to construct models of mobility hubs for each of six personas which reflect potential users of the mobility hub; the services and amenities included in each model varied according to the needs of the persona.

Community engagement was conducted at the pilot site using an interactive magnetic board in which users could select the services and amenities they would like to see at this location. Users could pick up to 10 components and were instructed to select the top three most important; no distinction was made between mobility amenities and complementary amenities at the time. 274 participants were surveyed, 92 of which were bike share users. The distribution of selected modules is displayed in Figure 27.

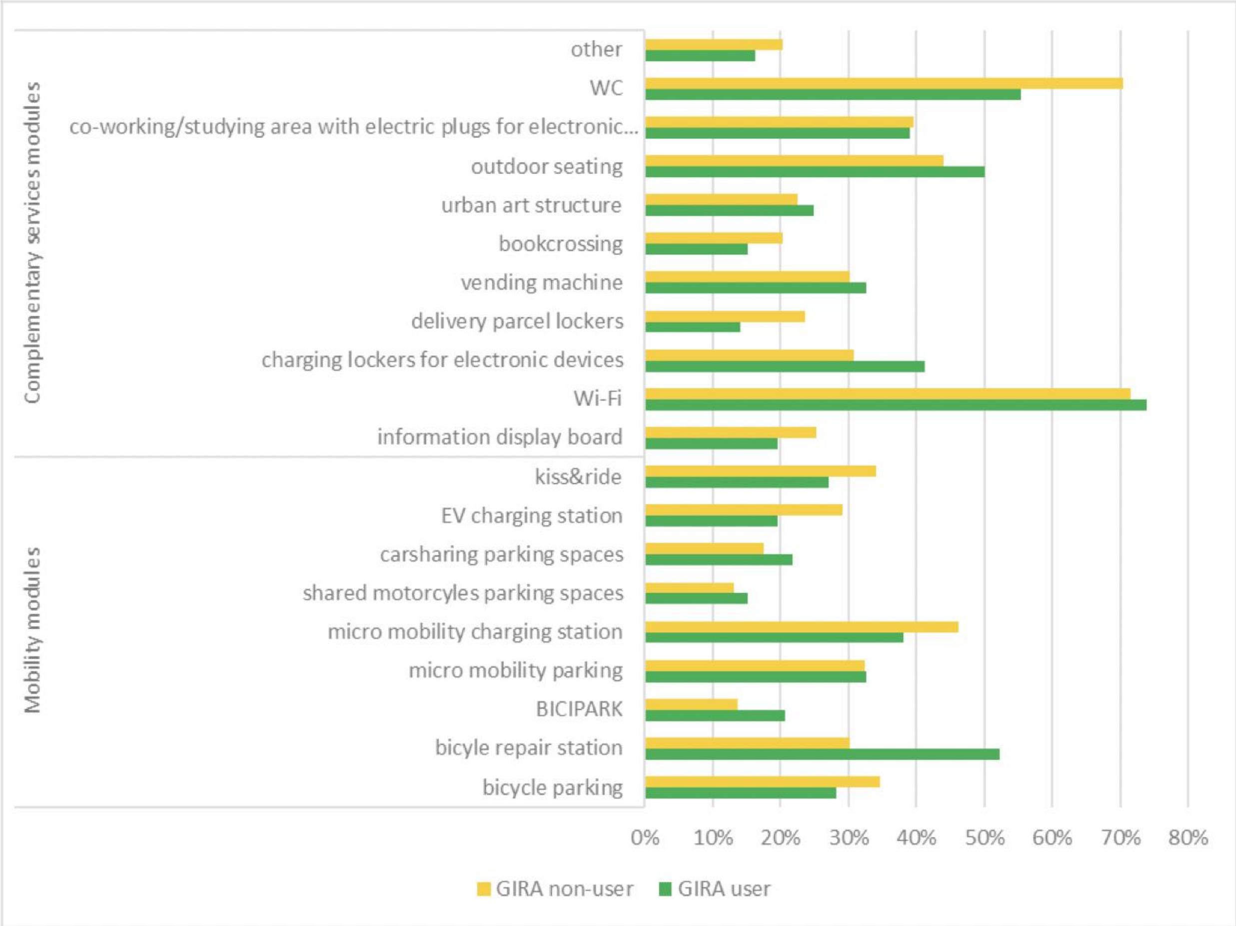


Figure 27:Comparison of selected services and amenities by type and per GIRA user vs. GIRA non-user
(Source: Oudbier et al., 2021)

The top five services and amenities selected by participants were:

- Wi-Fi
- Restroom
- Outdoor seating
- Micromobility charging station
- Co-working/studying area with electric plugs for electronic devices

It is important to note that of the five services and amenities selected by the most participants (Wi-Fi, restroom, outdoor seating, micromobility charging station, co-working/studying area with electric plugs for electronic devices) only one is a mobility amenity, indicating that there is a strong desire for non-mobility components. These top components were consistent regardless of status as a GIRA bike share user, age group, or persona of participants.

Implementation of the hub is ongoing, and goals include incorporation of upgrades which reflect the findings from the co-creation session. There have been delays to implementation because of physical restrictions at the site including construction at the Campo Grande bus terminal, but there are plans to include a bicycle repair station.

1.4.3 Summary of Case Studies

There are several key similarities and differences between the case studies. First, all case studies focused on integrating new mobility initiatives with transit and included multi-step processes for designing, locating, and implementing mobility hubs. This shared focus demonstrated a recognition of the importance of coordinated transportation systems and the potential benefits of mobility hubs.

One key difference between case studies lies in the distinct vision and objectives established for mobility hubs. It is crucial to establish clear objectives regarding the function of the mobility hub in order to guide the process of developing and implementing the mobility hub, and all case studies stress the potential of mobility hubs to facilitate connectivity and improve multimodal travel. However, some case studies have further emphasized the role of mobility hubs in creative placemaking. These cities have focused on identifying not only where to build mobility hubs but also what services and amenities (e.g., bicycle parking, information kiosk, Wi-Fi) to be placed in each hub. In addition, the vision and objectives inform the criteria being used for quantitative assessment of suitable locations for developing mobility hubs, which vary significantly across the case studies being studied here.

Another key difference was in the approach for site selection of mobility hubs. While almost all cities couple the use of a data-driven approach with some level of community engagement, they differ in the extent to which each approach is emphasized in the site selection decision-making.

Data analyses are useful for generating initial results, but it is important to receive community feedback before finalizing locations for mobility hubs. Engaging with the local community allows for a better understanding of the specific factors which can influence the success of mobility hubs. In other words, both approaches can provide insightful information for locating mobility hubs, and a comprehensive framework should balance both approaches.

In summary, the case studies demonstrate the importance of establishing clear objectives and incorporating a comprehensive approach to site selection when planning mobility hubs. By setting specific objectives, cities can ensure that mobility hubs align with the goals of their communities. Also, combining data-driven insights and community-driven inputs can ensure that the mobility hubs are well-suited to the local context and contribute to the overall goals of improving transit connectivity and enhancing the transportation experience for residents and visitors.

1.5. Summary and Lessons Learned

In this chapter, we proposed a definition for mobility hubs and a generic typology which considers the hub's size and function after synthesizing the existing literature and state-of-art practice. Additionally, we discussed site selection, feature programming, stakeholder engagement, and performance evaluation of mobility hubs. Finally, we presented six case studies from within Florida and outside of Florida. This analysis has provided a comprehensive view of the knowledge and current practice regarding mobility hub planning. Our research has generated valuable insight regarding the conceptualization, development, and implementation of mobility hubs. We summarize the lessons learned and provide suggestions for future mobility hub projects below.

One of the key lessons learned is the importance of flexibility throughout the entire process of developing and implementing mobility hubs. The ability to adapt to changing circumstances and appeal to stakeholders with various interests is crucial for successful outcomes. The case studies have shown that mobility hub locations can evolve based on new trends in transit ridership, a changing mobility landscape (e.g., changes in new mobility options), and community feedback. It is evident that a one-size-fits-all approach does not work for mobility hub development, and it essential to customize mobility hubs based on neighborhood characteristics and needs. Moreover, mobility hubs should be designed to accommodate future modes of transportation as they emerge, ensuring their long-term relevance and effectiveness.

Community engagement emerged as another crucial factor for the success of mobility hubs. Involving residents and stakeholders throughout the process fosters a sense of ownership, ensures the hubs meet local needs and preferences, and increases acceptance and utilization. Stakeholder feedback and community input can be sought through surveys, workshops, and public consultations to inform decision-making and enhance the overall user experience. Community engagement was an integral part of the site selection process for a few of the case studies of mobility hub development in the practice but is not typically included in site selection methodologies in the academic literature.

Methodologies used for mobility hub site selection in academic publications tend to be complex, multi-step processes which involve extensive data analysis and multi-criteria decision analysis. These methodologies often include numerous data sets and can allow for the prioritization of various goals, such as multimodality, equity and resiliency (Anderson et al., 2017), and accessibility to workplaces and points of interest (Frank et al., 2022). By contrast, the site selection processes used in planning practice are typically simpler, often consisting of a scoring system using several layers of data. This approach may be used in tandem with a community engagement initiative in order to incorporate user feedback into the siting of mobility hubs, which is crucial for developing mobility hubs which reflect the characteristics and needs of the neighborhood in which they are located.

Ongoing evaluation and monitoring of mobility hubs is crucial to assess their effectiveness, identify areas for improvement, and adapt to changing transportation needs. It is crucial to continuously monitor mobility hubs and incorporate feedback from users and to ensure that mobility hubs continue to meet the evolving demands of the community.

Several challenges to mobility hub implementation have emerged, such as securing funding and addressing modal conflicts that arise when multiple modes of transportation share road space. Some pilots were delayed or had to be reevaluated due to reliance on a future transit improvement that did not come to fruition (e.g., development of Rapid Bus system in the case of Broward County), or other unexpected obstacles (e.g., construction in the mobility hub's surrounding area in Lisbon). Balancing existing transit systems with future improvements is crucial during the conceptualization and implementation stages. Mobility hubs are most impactful in areas which have pedestrian-friendly infrastructure, dedicated lanes for micromobility, and reliable transit services.

In sum, the analysis of the literature and the practice has demonstrated that mobility hubs have potential to be an effective tool to move toward a sustainable transportation network, improve transportation access, and enhance community spaces. The key lessons learned emphasize the importance of flexibility, community engagement, and iterative improvements. By incorporating these insights into future mobility hub initiatives, cities can create more inclusive, connected, and sustainable transportation networks that meet the needs of their communities.

2 Developing a Multi-criteria Mobility Hub Site Selection Tool

The findings from the literature and case studies in Chapter 1 underscore the need for a systematic approach to site selection that incorporates both quantitative data and focuses on multiple community goals. Building on the insights and lessons learned, this chapter introduces the development of a Mobility Hub Site Selection Tool. This tool is designed to facilitate the identification of suitable locations for mobility hubs, ensuring they align with local needs and objectives. This tool aims to enhance the effectiveness of mobility hub planning and implementation across diverse contexts.

2.1 Introduction

While many cities and transit agencies have planned to develop mobility hubs as part of their transportation improvement programs, there is not yet an established methodology for selecting candidate sites for mobility hub development. In collaboration with City of Gainesville Regional Transit System and FDOT, as well as stakeholders from FDOT District 2 and District 4, our research team sought to address this important planning need by developing a Mobility Hub Site Selection Tool. The tool primarily uses publicly available datasets such as transit data U.S. Census, and street network for mobility hub identification, which ensures the generalizability of the proposed approach.

2.2 Methodology

The planning of mobility hubs requires careful consideration of factors such as land use patterns, accessibility, infrastructure availability and socio-economic factors. While it is widely recognized that mobility hubs are most effective when located at or near transit stops with high ridership activity, few studies have considered the location and quantity of transit stops as primary criteria for determining the placement of mobility hubs. Furthermore, there is a limited number of studies that target the first mile/last mile gaps and enhance transit connectivity. Additionally, mobility hubs can be built at various scales such the neighborhood, district, and regional levels. However, existing methods often overlook the typology of mobility hubs and instead focus only on one level. To address such research gaps, we have proposed a multicriteria decision framework for quantitatively analyzing the suitability of transit stops for siting mobility hub.
The objectives of mobility hubs include the following:

1. Integrate transit with alternative modes to facilitate multimodal trips.
2. Enhance first-/last-mile connectivity and facilitate transfers.
3. Prioritize disadvantaged populations.

2.2.1 Analytical Framework Design

A visual representation of the analytical framework for identifying mobility hub is shown in Figure 28.

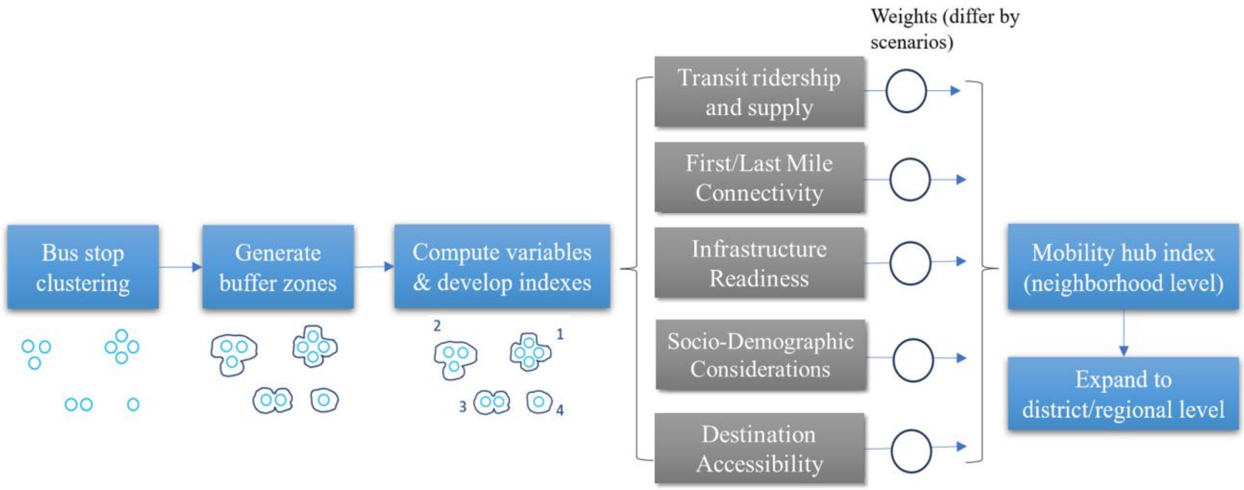


Figure 28: GIS-based Multi-criteria Analytical Framework for Mobility Hub Identification

The analytical framework involves the following steps:

1. **Cluster transit stops**: Mobility hubs should be anchored by high-frequency transit, and so we consider transit stops to be potential sites for mobility hubs.
2. **Determine criteria and weights**: Based on a literature review and discussions with stakeholders, we identify five criteria for sitting mobility hubs: transit ridership and supply; first/last mile connectivity; infrastructure readiness; socio-demographic considerations; destination accessibility. Each of the five criteria is made up of several indicators (sub-criteria), whose weighted sum results in a composite score (one score for each criterion). The five scores are further weighted (the weights will differ by scenario or planning priority) and summed to construct a final mobility hub index.
3. **Compute neighborhood-level hub index**: Based on the results from Steps 1 and 2, we calculate the index value for the neighborhood-level hub by assuming a potential catchment area of a mile.
4. **Identify a network of mobility hubs**: We apply the following steps to first identify neighborhood-level mobility hubs: 1) select the site with the highest index value as the first hub; 2) exclude all potential hubs within 1.5-mile of the selected hubs from considerations; 3) repeat steps 2 and 3 until the service area of the mobility hubs reach 75% of transit coverage areas or the total number of hubs reach N. Repeat Step 3 and compute the district- and regional-level hub indexes (assuming a catchment area of 3 miles and 5 miles, respectively) for the selected neighborhood hubs.
5. **Generate results under different scenarios**: Cities and transit agencies often need to carefully evaluate competing priorities when planning for mobility hubs. To aid the prioritization of infrastructure investments based on different priority schemes, our tool allows one to adjust the weights used for constructing the mobility hub index and hence generate potentially different results for each scenario.

2.2.2 Novelty of the Proposed Approach

Our tool is innovative in the following aspects:

1. Unlike previous approaches that commonly use an area unit (e.g., a block group) for identifying candidate mobility hubs, we used transit stops as the unit of analysis. The focus on transit stops ensures that the research results can be readily applied to guide infrastructure investment decisions, which can promote research implementation.
2. Different levels of mobility hubs can vary in size, have different facilities and amenities, and serve different functions. However, the existing mobility hub identification methods do not distinguish hub typology. Our tool addresses this deficiency by classifying mobility hubs into three levels (regional, district, and neighborhood) and identifying them in a sequential fashion.
3. An important function of mobility hubs is to enhance first-mile/last-mile transit connectivity. In our tool, we have developed a novel approach to quantify first-mile/last-mile transit service gaps.

2.3 Data

As mentioned, we consider five criteria in deciding the mobility hubs. Each criterion has several sub criteria, which involve different considerations. The criteria and their associated variables and are summarized in
Table 15.

Table 15: List of criteria and sub criteria in deciding mobility hubs

Criteria	**Transit Ridership and Supply**	**FM/LM Connectivity**	**Infrastructure Readiness**	**Socio-Demographic Considerations**	**Destination Accessibility**
Sub criteria	Ridership Service frequency	Bicycle trips FM/LM (microtransit, escooter) trips FM/LM gap score	Intersection density Bike lanes Sidewalks	Household without vehicle Black population People living in rental units Poverty Disabilities	Destination accessibility via auto/transit Walk score
Source	RTS City	City ACS LODES	Smart location OSM	ACS LODES	Smart location database Walkscore API

The tool primarily utilizes data from the Gainesville Regional Transit System (RTS)[2], the local transit service in Gainesville, Florida. Information on bus routes and stops was sourced from the General Transit Feed Specification (GTFS) dataset, which includes transit schedules and geographic details. Ridership data, including passenger counts and the number of onboard wheelchairs and bicycles at stops, were provided by Gainesville RTS.

On FM/LM connectivity, data were collected on FM/LM trips and gap scores. FM/LM trips encompass microtransit services from Gainesville RTS and shared micromobility trips from three vendors (Bird, Spin, and Veo). The origins and destinations of these trips were obtained from the vendors, assuming that trips within 50 feet of transit stops are FM/LM connections, a common method in existing literature. The FM/LM gap score was calculated using data from the American

[2] http://go-rts.com/rts-data/

Community Survey (ACS) and the LEHD Origin-Destination Employment Statistics (LODES), focusing on block-level population and employment data.

Supporting infrastructure for mobility hubs was assessed through intersection density and road infrastructure for pedestrians and cyclists. Intersection density data were sourced from the Smart Location Database, which measures location efficiency and multi-modal facility accessibility. Road infrastructure information, including bike lanes and sidewalks, was obtained from OpenStreetMap (OSM). Additionally, household characteristics were analyzed using ACS data to ensure accessibility for disadvantaged and transit-dependent populations. Accessibility to destinations was measured using the Smart Location Database[3], and walkability around bus stops was evaluated using Walk Score data from the Walkscore API[4].

2.4 Analytical Steps

2.4.1 Definition of Spatial Unit

The variables were preprocessed and aggregated at the spatial unit of analysis, which is the 1-mile buffer zone from groups of adjacent transit stops. We believe that 1 mile is an appropriate size for identifying a neighborhood-level mobility hub. We applied DBSCAN clustering algorithm to group adjacent transit stops in proximity into clusters based on a specified search distance. Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is a base algorithm for density-based clustering. As Figure 29 shows, it can identify clusters of different shapes and sizes from a large amount of data which contains noise and outliers. The algorithm contains two parameters[5]:

1. The minimum number of points clustered together for a region to be considered dense.
2. The distance measure to locate the points in the neighborhood of a point.

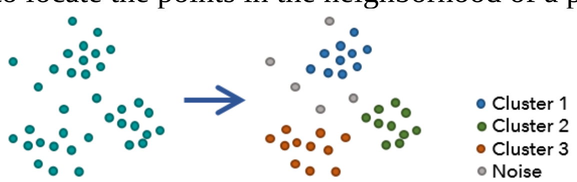


Figure 29: DBSCAN clustering algorithm

Figure 30 shows the workflow of implementing the algorithm in ArcGIS Pro. We set the search distance to 100 meters and the maximum bus stop number of each cluster to 10. This generated a total of 628 grouped clusters among 1,081 stops. We then created 1 mile buffer zone around each stop as spatial unit in our analysis. Figure 31 shows the generated spatial units.

[3] https://www.epa.gov/smartgrowth/smart-location-mapping
[4] https://www.walkscore.com/professional/api.php
[5] https://www.kdnuggets.com/2020/04/dbscan-clustering-algorithm-machine-learning.html

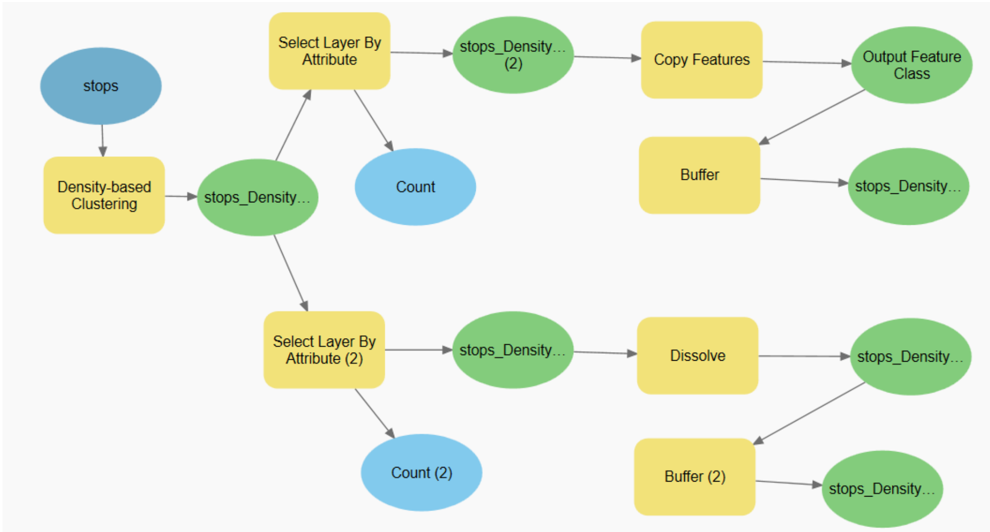
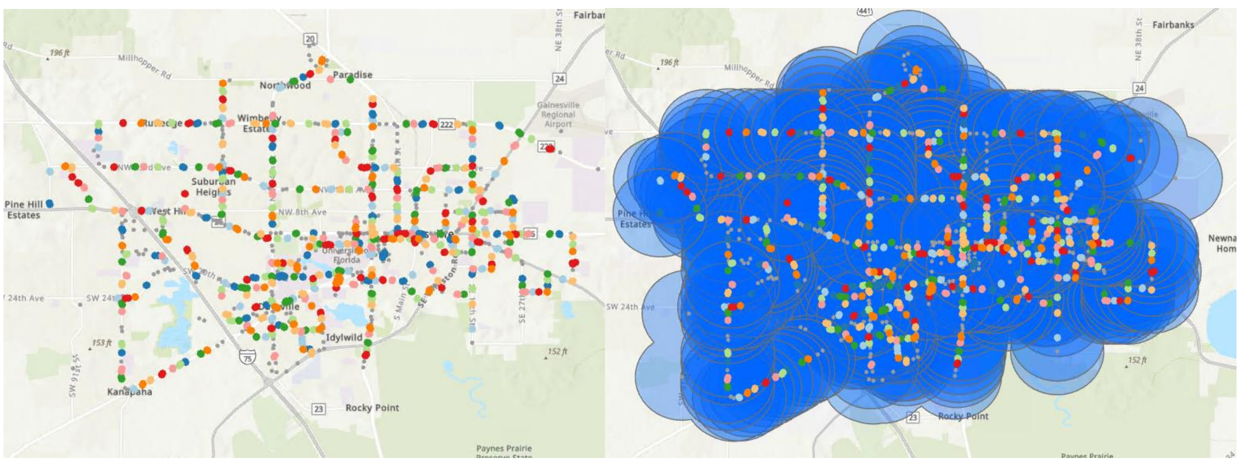


Figure 30: Workflow for generating spatial units in ArcGIS Module Builder



(a). grouped and isolated transit stops (b). 1-mile buffer zones around the stop clusters

Figure 31: Generation of spatial analytical units

2.4.2 Multi-criteria Considered in Planning Mobility Hubs

In the proposed tool, we assess five criteria that are key considerations in identifying a mobility hub. Subsequently, we combine these five criteria with varying weights to create six scenarios reflecting different planning priorities, ultimately yielding six sets of results. Each of the five criteria has its own set of sub-criteria and weights, which are detailed below.

Criterion 1: Transit Ridership and Supply

The first criterion, transit ridership and supply, consists of two sub criteria: ridership and service frequency. These variables are all stop-level and need to be aggregated to the spatial unit. Then they are scaled to 0-100 and weighted sum are calculated to derive the index score. Table 16 shows the transit ridership and supply criterion with its associated sub criteria, variables, and weights. Figure 32 shows the bus stop level calculation results.

Table 16: Transit ridership and supply (Criterion 1) variables and weights

Criterion	Sub-criteria	Variables	Weights
Transit ridership and supply	Ridership	Passenger count	0.4
		Number of wheelchair passenger boardings	0.1
	Service frequency	Number of unique bus routes	0.1
		Number of bus stops	0.1
		Total number of buses passing by the stop	0.3

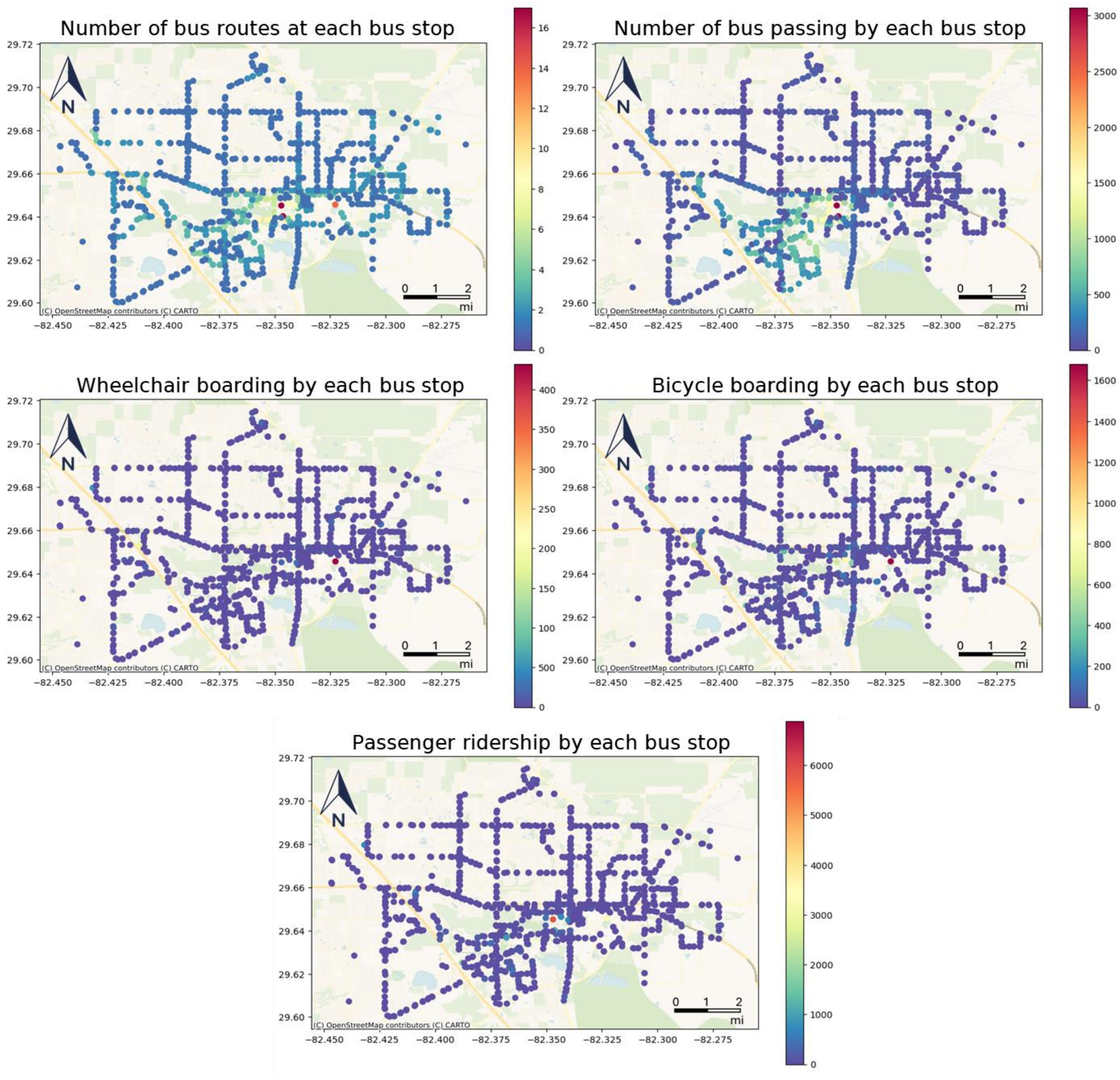


Figure 32: Variables related to transit ridership and supply

Criterion 2: First/Last Mile Connectivity
FM/LM problems refer to the gap between transit stops and travelers' origin or destination. Micromobility can solve the FM/LM problems by enhancing the connectivity to transit stops.

The FM/LM connectivity criterion consists of two sub criteria: one is the existing FM/LM trips that indicate the current demand for FM/LM connectivity at a transit stop (or a stop cluster), and the other is FM/LM gap that captures potential demand for FM/LM trips if better connection options are provided. The idea here is as follows: if more FM/LM trips are observed around some bus stops, building mobility hubs at them would serve more current travelers with FM/LM access needs; also, if a greater FM/LM gap is observed at some bus stops, there is a great need for building mobility hubs. Table 17 shows the FM/LM connectivity criterion with its associated sub criteria, variables, and weights.

Table 17: FM/LM connectivity (Criterion #2) variables, and weights

Criterion	Sub-criteria	Variables	Weights
FM/LM Connectivity	Existing FM/LM trips	Number of bicycle boardings at stops	0.15
		Number of FM/LM micromobility trips at stop	0.15
		Number of FM/LM microtransit trips at stop	0.15
	FM/LM gap	FMLM gap score	0.55

We first calculated the census block level FM/LM gap score. This score is evaluated based on the distance between the centroid of each census block and the nearest bus stops, weighted by the number of jobs/the total population of the block. This involves the following steps:

1. Calculate the number of jobs plus the total population of each block centroid.
2. Find the distance to the nearest bus stop for each block centroid. Recode the distance into the following values: <0.25 mile: 0; 0.25-0.5 mile: 1; 0.5-0.75 mile: 2; 0.75-1 mile: 3.
3. Calculate the FM/LM gap score at centroid level by multiplying the number of jobs plus residents and nearest distance.
4. Aggregate the total values of centroid-level FM/LM gap score to the spatial unit.

Figure 33 illustrates the workflow for computing the FM/LM gap score in Module Builder, and Figure 34 shows the block level calculation results.

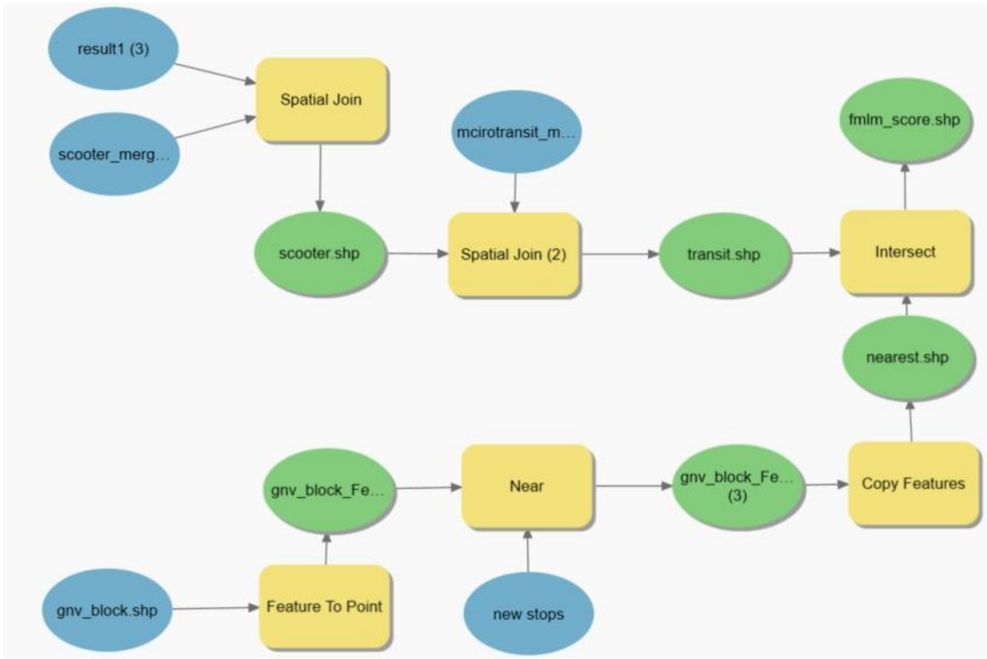


Figure 33: Workflow for generating the FM/LM gap score in Module Builder

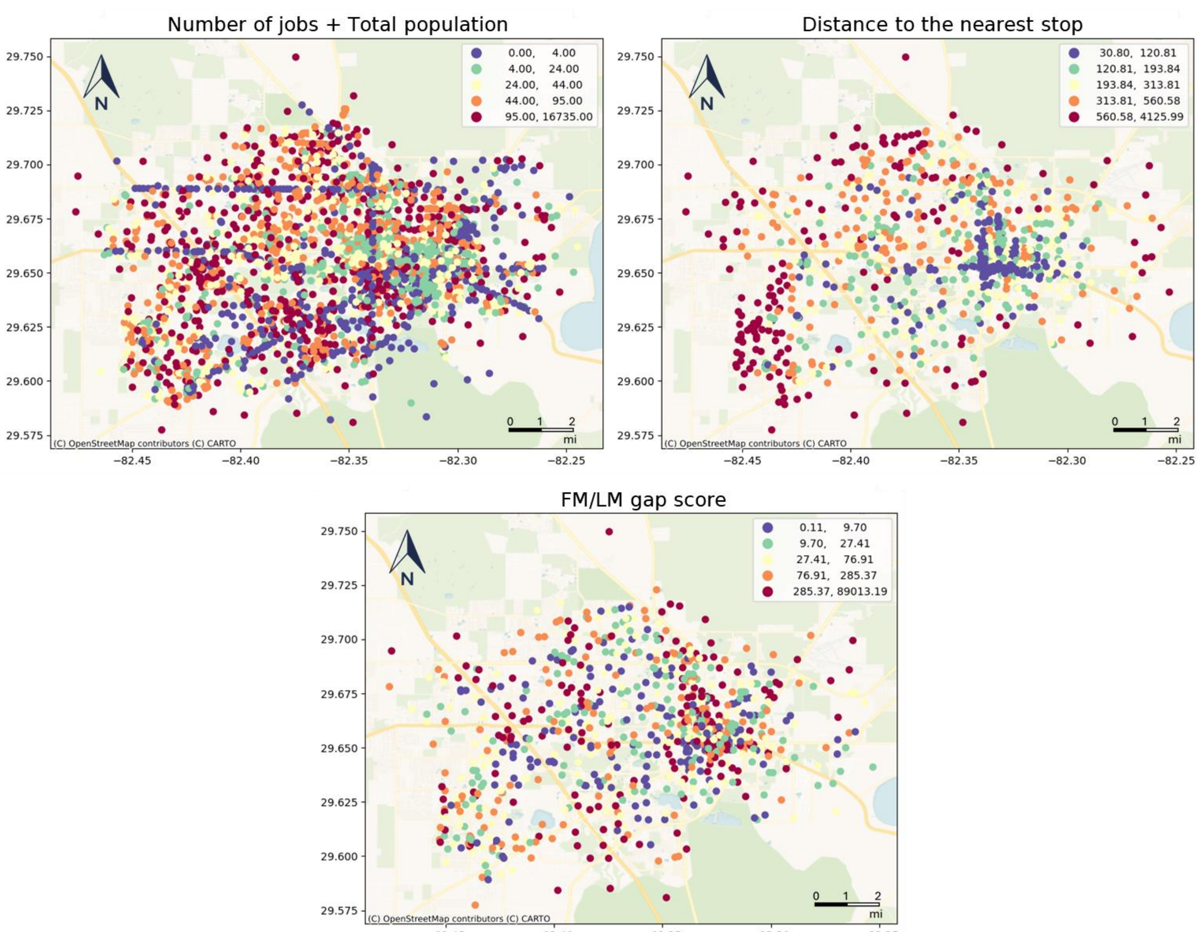


Figure 34: Variables related to FM/LM connectivity

Additionally, we measured the existing FM/LM trips with three variables, number of micro-transit trips (either its origin or destination) happening within 100 feet of a bus stops, number of shared micromobility trips (either its origin or destination) happening within 100 feet of a bus stops, and the number of bicycle boarding at each transit stop (or stop cluster). Figure 35 shows the calculation results of the three variables.

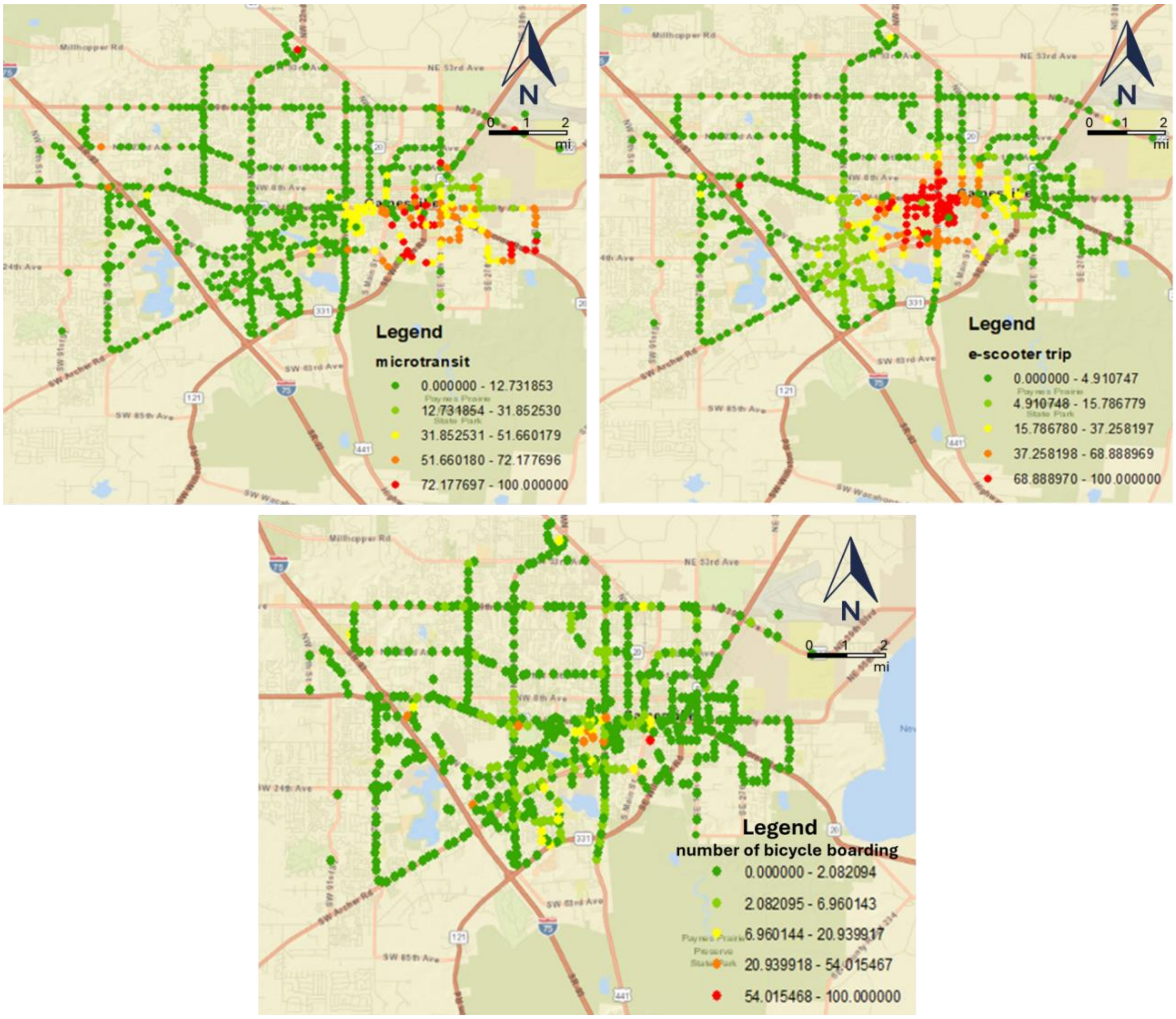


Figure 35: Variables related to FM/LM Connectivity

Criterion 3: Infrastructure Readiness

The infrastructure index score is measured by three dimensions:

1. Sidewalk: the ratio between sidewalk length and overall road network length within the spatial unit.
2. Bike lane: the ratio between bike lane length and overall road network length within the spatial unit.
3. The intersection density at which multi-modal facilities or pedestrian-oriented facilities met.

Table 18 shows the infrastructure criterion with its associated sub criteria, variables, and weights.

Table 18: Infrastructure readiness (Criterion #3) variables and weights

Criterion	Sub-criteria	Variables	Weights
Infrastructure Readiness	Intersection density	Multi-Modal Intersection Density	0.16
		Pedestrian-Oriented	0.16
	Bike lanes	Intersection Density	0.16
		bike lane length/street segment length	0.16
	Sidewalks	sidewalk lane length	0.16
		sidewalk lane length/street segment length	0.16

The original data are clipped and assigned to the spatial unit with the workflow in Figure 36 shows the calculation results of the related variables.

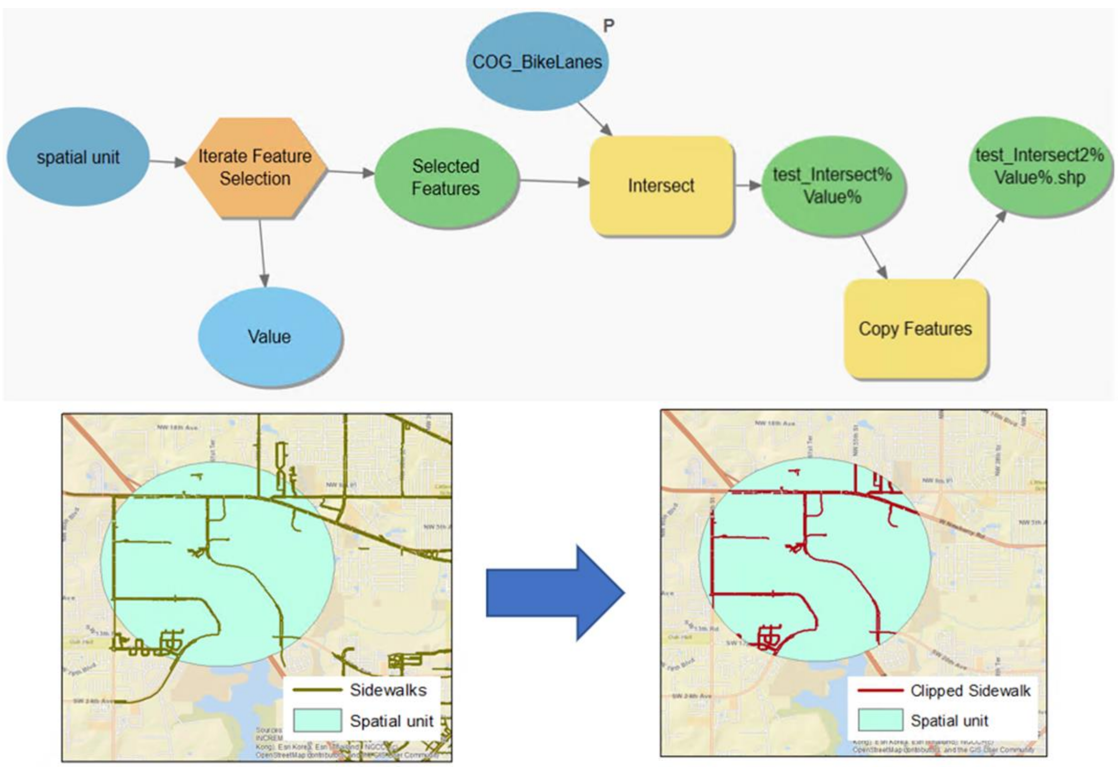


Figure 36: Steps of clipping and assigning infrastructure to spatial units

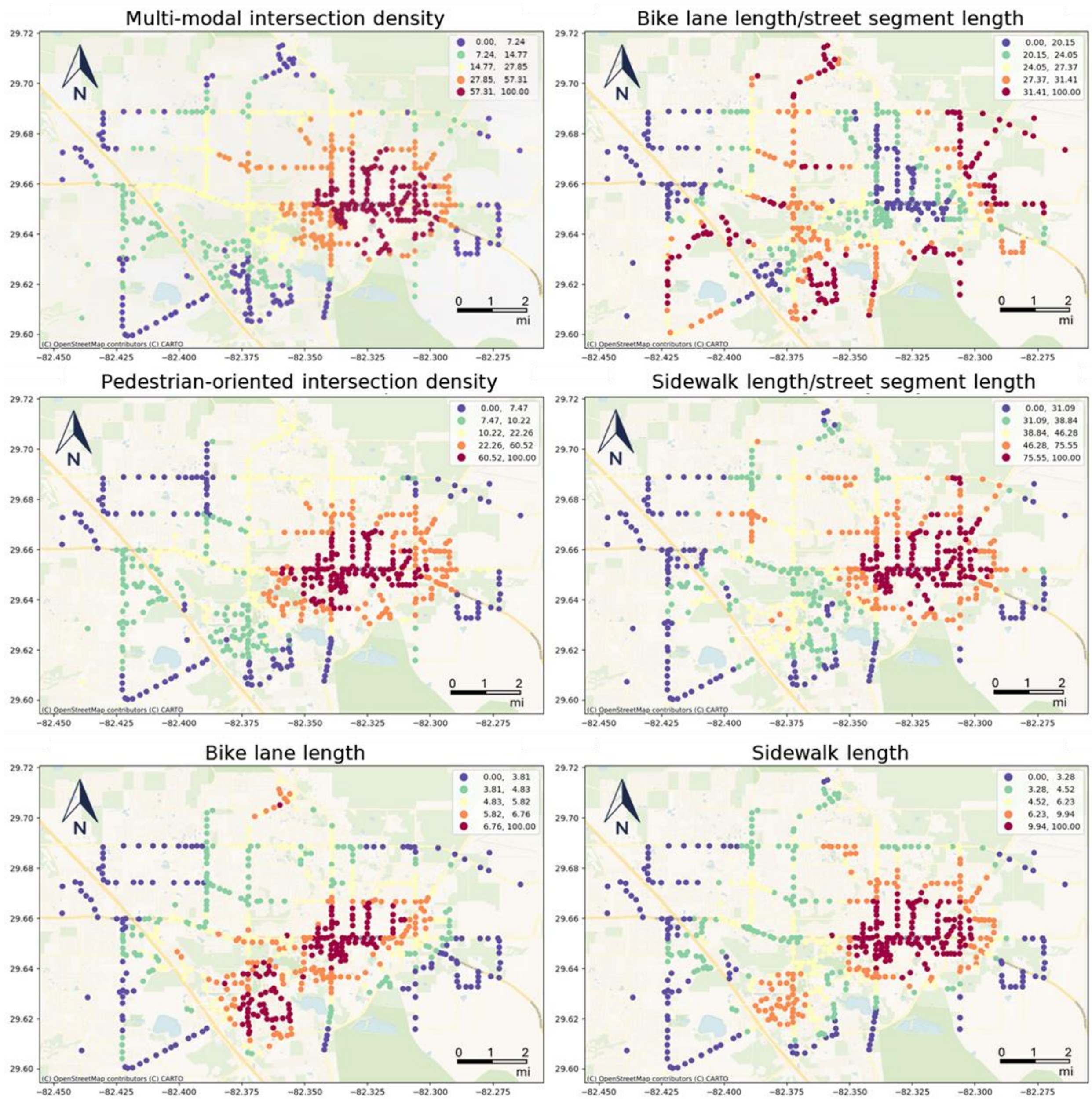


Figure 37: Variables related to infrastructure readiness

Criterion 4: Socio-Demographic Considerations

We obtained data from the ACS survey at census block group level. To aggregate the socio-demographic factors to the spatial units, we selected the census block groups intersected with the spatial unit and then calculated the indicators. Table 19 shows the socio-demographic criterion with its associated sub criteria, variables, and weights. Figure 38 shows the calculation results of the five related variables.

Table 19: Socio-demographic considerations (Criterion #4) variables and weights

Criterion	Sub-criteria	Variable	Weights
Socio-demographic considerations	Household without vehicle	Percentage (%)	0.2
	Black population		0.2
	People living in rental units		0.2
	Poverty		0.2
	Disabilities		0.2

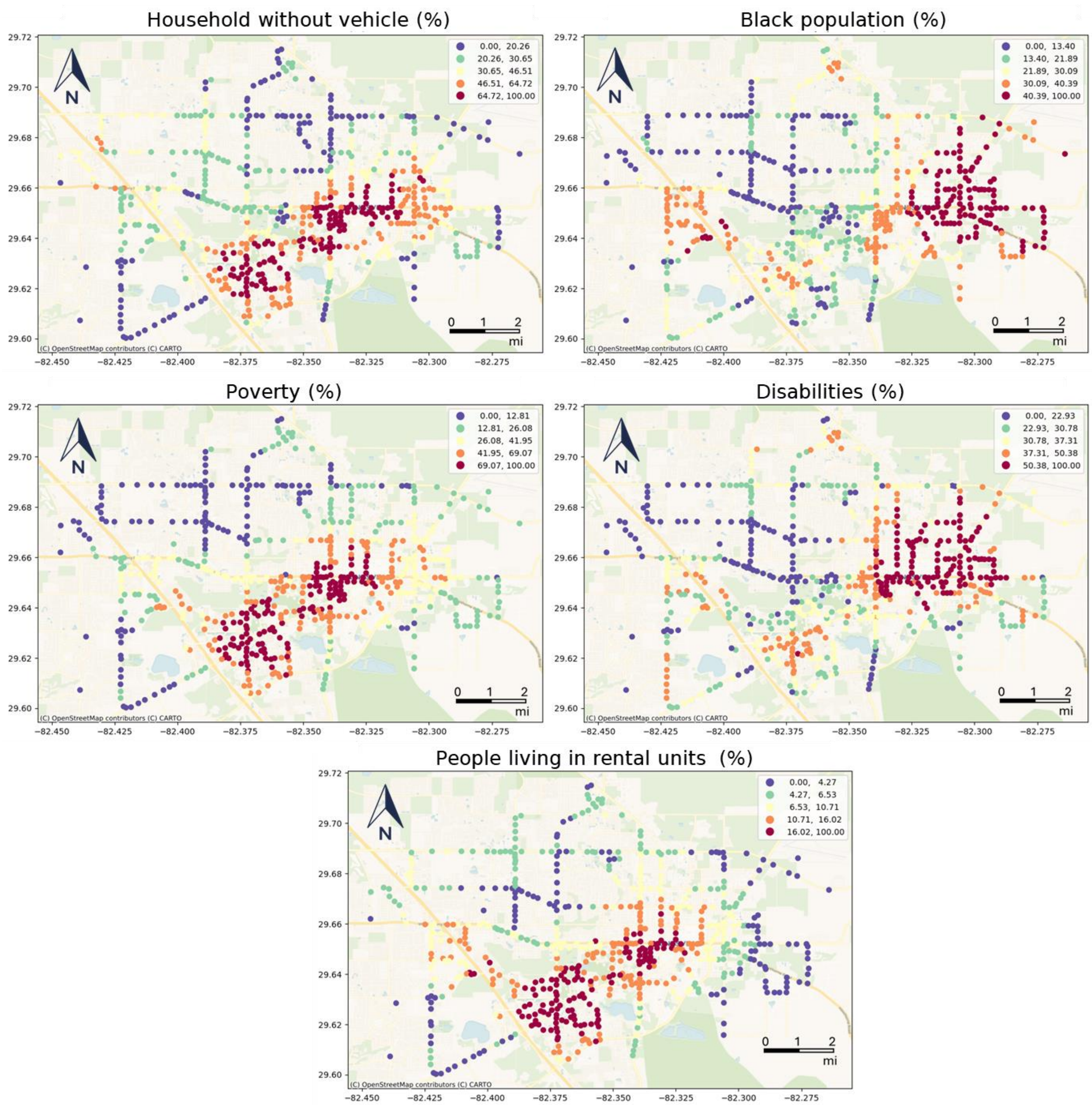


Figure 38: Criterion socio-demographic considerations, visualization of its sub criteria

Criterion 5: Destination Accessibility

The accessibility to destinations is measured by the following two aspects: the destination accessibility via auto or transit and the walkability score. Table 20 shows accessibility criterion with its associated sub criteria, variables, and weights. Figure 39 shows the calculation results of the related variables.

Table 20: Destination accessibility (Criterion #5) variables and weights

Criterion	Sub-criteria	Variable	Weights
Destination Accessibility	Destination accessibility via auto	Jobs within 45 minutes auto travel time	0.25
	Destination accessibility via transit	Jobs within 45-minute transit commute	0.25
	Walkability score	Walkscore API, 0-100	0.5

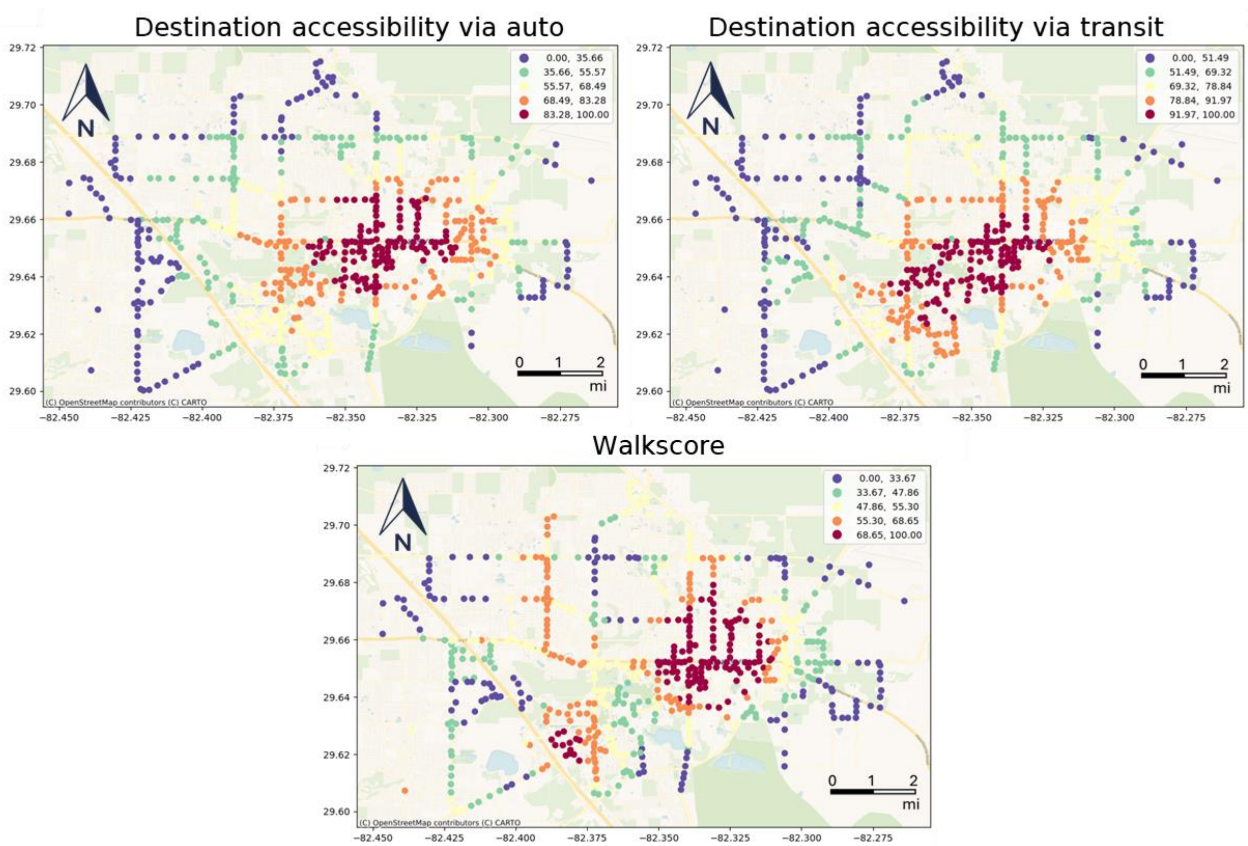


Figure 39: Variables related to destination accessibility

2.4.3 Selection of Mobility Hubs: Scenarios and Searching Algorithm

Mobility Hub Index Calculation in Six Scenarios

The mobility hub index is the weighted sum of index score of each criterion. We first formulate six planning scenarios that prioritize the five criteria different. Each scenario assigns different weights to the five criteria, resulting in a unique mobility hub index for that scenario. For one scenario (equal weighting), we assign the same weights (20%) for each criterion; for other scenarios, we emphasize each criterion by assigning it a 50% weight, while others remained 12.5%. The weighting schemes for the six planning scenarios are displayed in Table 21.

Table 21: Weights assigned to each criterion under six planning scenarios.

Criteria \ Scenarios	**Prioritizing Disadvantaged Populations *(“Socio-demographic”)***	**Enhancing Transit *(“Transit”)***	**Leveraging Existing Infra-structure *(“Infrastructure”)***	**Enhancing FM/LM Connectivity *(“FMLM”)***	**Enhancing Accessibility *(“Accessibility”)***	**Equal Weights *(“Equal Weights”)***
Transit Ridership and Supply	0.125	0.5	0.125	0.125	0.125	0.2
First/last Mile Connectivity	0.125	0.125	0.125	0.125	0.5	0.2
Destination Accessibility	0.125	0.125	0.125	0.5	0.125	0.2
Infrastructure Readiness	0.125	0.125	0.5	0.125	0.125	0.2
Socio-demographic Considerations	0.5	0.125	0.125	0.125	0.125	0.2

Searching Algorithm for Selecting Mobility Hubs

We then identify the mobility hubs based on the mobility hub index. To identify multiple mobility hubs from the spatial units, we implemented an algorithm to choose from the spatial unit following four steps:

1. Select the existing (or planned) mobility hubs.
2. Exclude all potential hubs within 1.5 mile of the selected hubs from considerations.
3. Select the hub with the highest mobility hub index as the next hub.
4. Repeat steps 2 and 3 until the service coverage is >60% or the total number of hubs reaches the pre-set value (which is set to be 12 for Gainesville).

Figure 40 and Figure 41 provide a demonstration of how the algorithm decides the mobility hubs stage by stage. First, there are three hubs planned to be sited in Gainesville (Figure 40): Butler Plaza Transit Center; Eastside hub; and a downtown hub. These are considered at the initial stage of siting the mobility hubs. Then, the algorithm selects the other mobility hubs one by one (Figure 41). The final output is a list of potential mobility hubs.

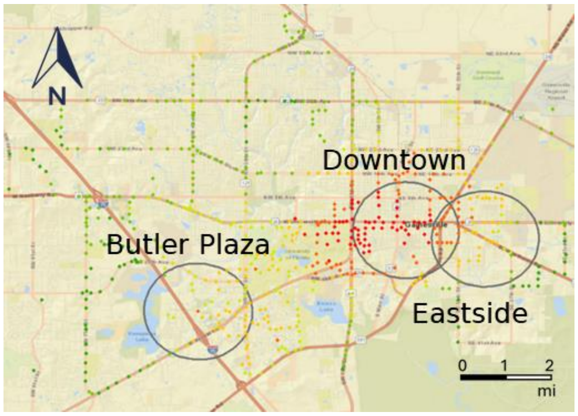


Figure 40: Three mobility hubs under development in Gainesville

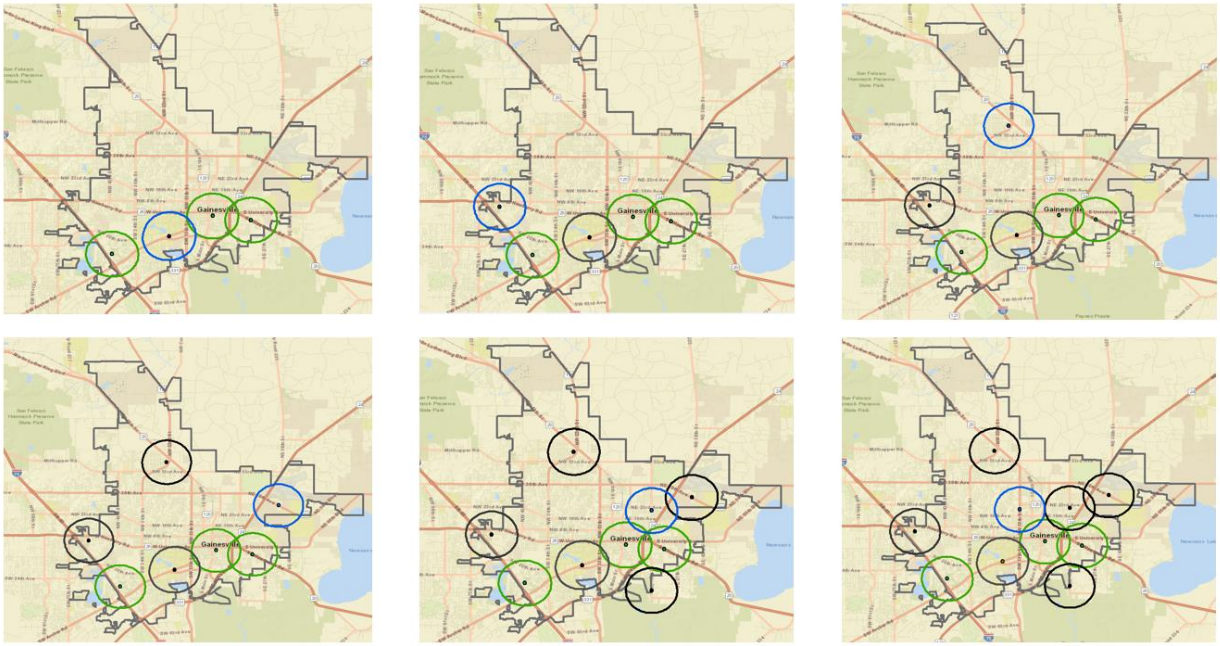


Figure 41: Demonstration of the mobility hub selection algorithm

2.4.4 Identification of District Hubs and Regional Hubs

In previous steps, we have obtained the locations of 12 potential mobility hubs under six planning scenarios. Next, we determine the scale of each mobility hub: neighborhood level, district level, or regional level. Table 8 compared the characteristics of the three different levels of mobility hubs. Neighborhood-level mobility hubs typically serve short-distance FM/LM connections made by walking and short-distance cycling, and district-level mobility hubs can *additionally* serve medium-distance connections made by cycling, microtransit, or ridesharing; besides having the functions of neighborhood-level and district-level hubs, regional-level hubs can even be appealing for personal car users (e.g., park and ride). Therefore, we can consider all 12 potential mobility hubs as neighborhood-level hubs first and then identify district- and regional-level hubs from them. The identification of district- and regional-level hubs can follow the same procedure discussed in 2.4.3 Selection of Mobility Hubs: Scenarios and Searching Algorithm but requires the analyst to first calculate district- and regional- hub indexes. This can be achieved by adjusting buffer zone size when calculating the FM/LM gap score and road infrastructure readiness score; also, the weights assigned to each accessibility variable (destination accessibility via transit/auto and walk score) need to be adjusted. We have provided some recommended values in Table 22.

Table 22: Characteristics of mobility hubs at different scales

Aspect/Level	Neighborhood	District	Regional
Mode to mobility hub	Walk/bike	Walk/bike, microtransit, rideshare	Walk/bike, microtransit, rideshare, car
Range	15-20 min walking: 1 mile	10-15 min biking: 3 miles	5-10 min driving: 5 miles
Weights of the sub criteria in the	Destination accessibility via auto: 0	Destination accessibility via auto: 0.2	Destination accessibility via auto: 0.33

Destination Accessibility criterion	Destination accessibility via transit: 0.25 Walk score: 0.75	Destination accessibility via transit: 0.3 Walk score: 0.5	Destination accessibility via transit: 0.33 Walk score: 0.33

Specifically, the identification of district- or regional-level mobility hubs has the following steps:

1. Identify 12 neighborhood-level mobility hubs.
2. For these hubs, revise the calculation of block-level FMLM gap score as follows:
    a. Calculate the number of jobs plus the total population of each block centroid.
    b. Find the distance to the nearest bus stop for each block centroid. Recode the distance into the following values: <0.75 mile: 0; 0.75-1.5 mile: 1; 1.5-0.2.25 mile: 2; 2.25 – 3 mile: 3.
    c. Calculate the FMLM gap score at centroid level by multiplying the number of jobs plus residents and nearest distance.
    d. Aggregate the total values of centroid-level FMLM gap score to the spatial unit of 3-mile buffer instead of 1.5-mile buffer when deciding the neighborhood-level mobility hubs.
3. Recalculate the multi-modal intersection density using 3-mile buffer zone.
4. Adjust the weights of sub criteria about accessibility as table 3: 20% for destination accessibility via auto, 30% for destination accessibility via transit and 50% for walk score.
5. Recalculate the mobility hub suitability index score with the revised FMLM connectivity score, infrastructure readiness and destination accessibility score following the weights of Table 22.
6. Identify the top 4 highest scores as District-level mobility hubs.
7. For the 4 District hubs, assign all the sub criteria regarding accessibility with equal weights.
8. Recalculate the mobility hub suitability index score with the revised accessibility score following the weights of Table 7.
9. Identify the top score as Regional-level mobility hub.

Following these steps, we first identify 4 district-level mobility hubs from the 12 neighborhood-level hubs and then identify 1 regional-level mobility hub from the 4 selected district-level hubs. In other words, we have identified 8 neighborhood-level mobility hubs, 3 district-level hubs and one regional hub in Gainesville.

2.5 Mobility Hubs Identified in Each Scenario

2.5.1 Scenario 1: Equal Weights

By assigning each criterion with the same weights, we calculate the mobility hub index in Figure 42. We can observe that east Gainesville and downtown have the highest score.

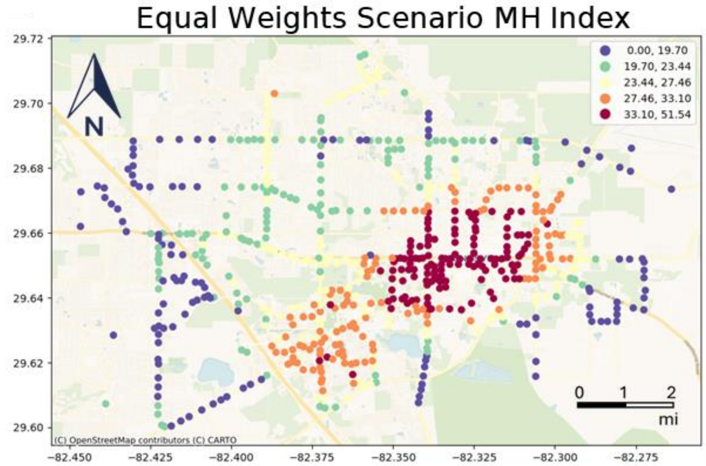


Figure 42: Mobility hub index under the "equal weights" scenario

Figure 43 shows the siting of mobility hubs when weighting each criterion equally. The regional hub is sited at Shands Hospital, while three district-level mobility hubs are sited at North Walmart, GNV airport and Oaks Mall.

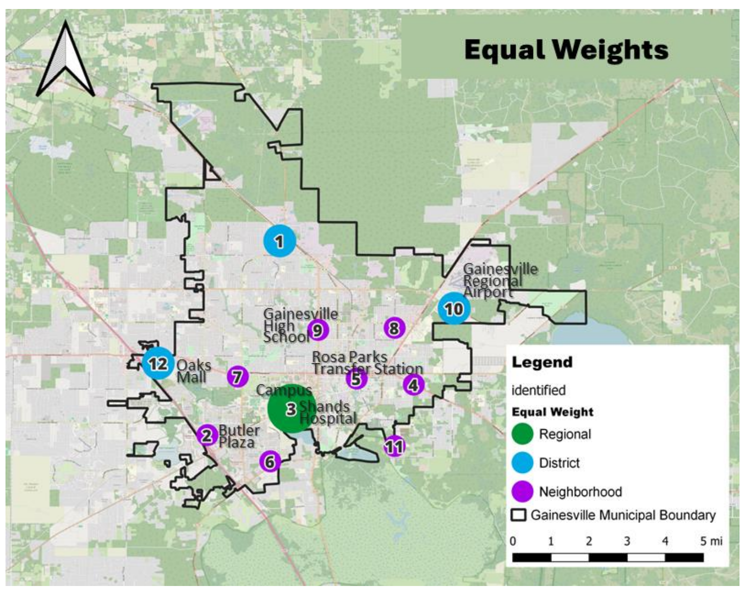


Figure 43: Identified mobility hub locations under the "equal weights" scenario

2.5.2 Scenario 2: Enhancing Transit

With the objective of enhancing transit supply, we assign a greater weight on the transit ridership and supply criterion. Figure 44 shows the calculated mobility hub index score of this scenario. We can observe UF campus has the most abundant transit supply and ridership, where many bus stops cluster and the passenger ridership was the highest. In contrast, north and east Gainesville has the lowest transit supply and ridership.

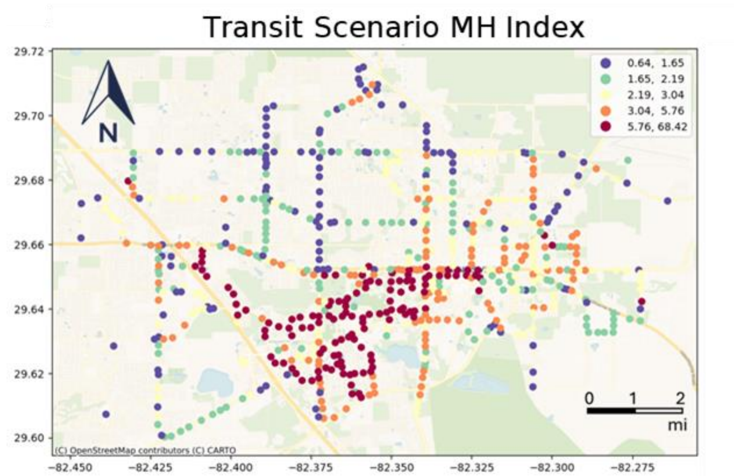


Figure 44: Mobility hub index score under the “enhancing transit” scenario

We also identify the mobility hubs at different scales as Figure 45 shows. The regional level mobility hub was sited around Rosa Park Transfer hub, while three district level mobility hubs are sited at Polos, North Walmart and Buttler Plaza. Neighborhood-level mobility hubs are sited at downtown, GNV airport, Oak Mall, etc.

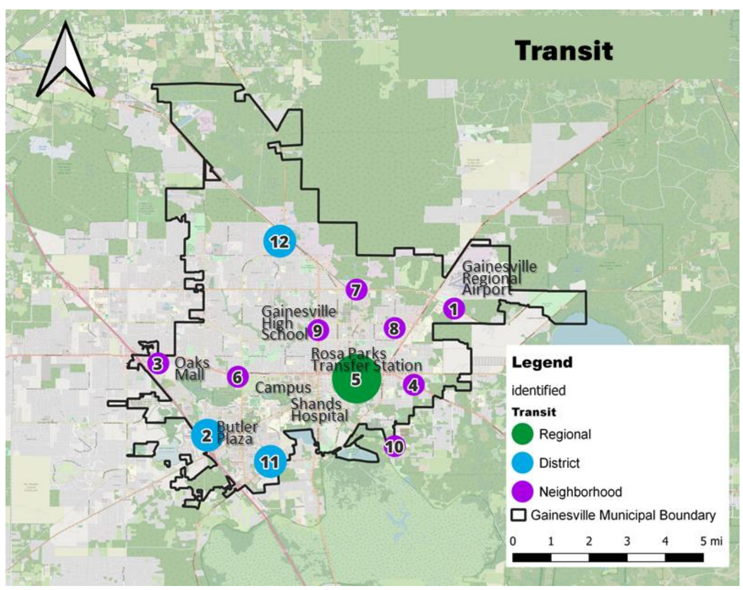


Figure 45: Identified mobility hub locations under the “enhancing transit” scenario

2.5.3 Scenario 3: Enhancing FM/LM Connectivity

This scenario prioritizes FM/LM connectivity, which is decided by the micromobility trips and the block-level FM/LM gap score. Figure 46 shows the calculated mobility hub index of this scenario. We can notice that Southwestern and North Gainesville has the most serious FM/LM gap problem, where lots of people need to access transit but there are few bus stop clusters. On the contrary, UF campus and the east Gainesville have abundant transit supply and a less serious FM/LM problem.

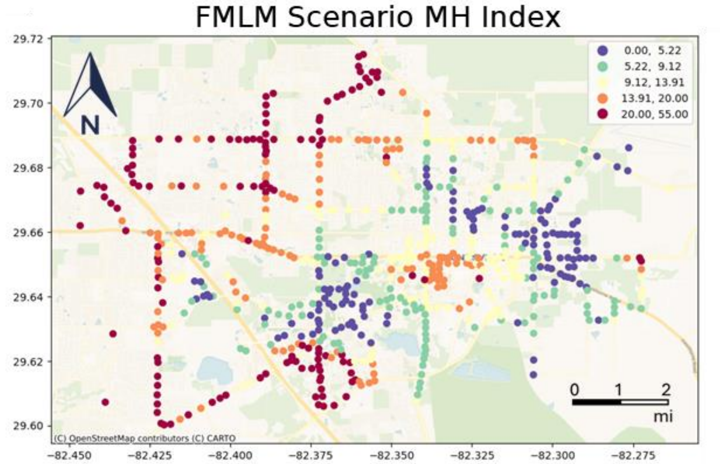


Figure 46: Mobility hub index under the "enhancing FM/LM connectivity" scenario

With an emphasis on enhancing FM/LM connectivity, we identify the mobility hubs as Figure 47 shows. The regional hub was sited at Shands Hospital, while three district hubs were decided at Oak Mall, Rosa Park and downtown. Neighborhood-level mobility hubs are decided at North Gainesville, GNV airport, Butler Plaza, etc.

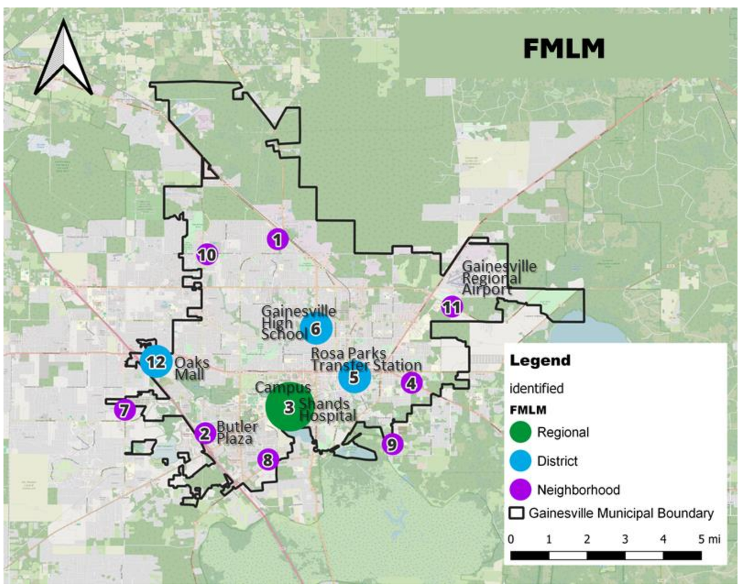


Figure 47: Identified mobility hub locations under the "enhancing FM/LM connectivity" scenario

2.5.4 Scenario 4: Leveraging Existing Infrastructure

This scenario prioritizes infrastructure readiness, which is decided by intersection density (multimodal and pedestrian), sidewalk and bicycle road length.
shows the calculated mobility hub index score of this scenario. East Gainesville has the highest score, with more pedestrian and cyclist infrastructure being provided, while the edge area of Gainesville has less road infrastructure.

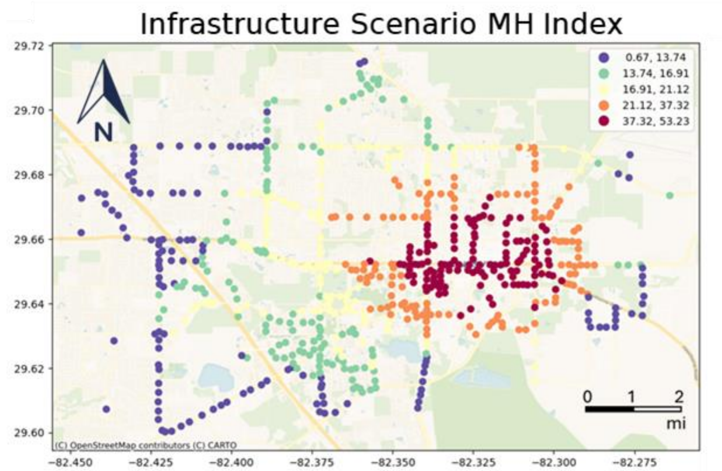


Figure 48: Mobility hub index under the "leveraging existing infrastructure" scenario

Aiming at leveraging the road infrastructure, we identify the mobility hubs as Figure 49 shows. The regional hub was sited at Shands Hospital, while three district hubs were decided at Oak Mall, Rosa Park and downtown. Neighborhood-level mobility hubs are decided at North and east Gainesville, Buttler Plaza etc.

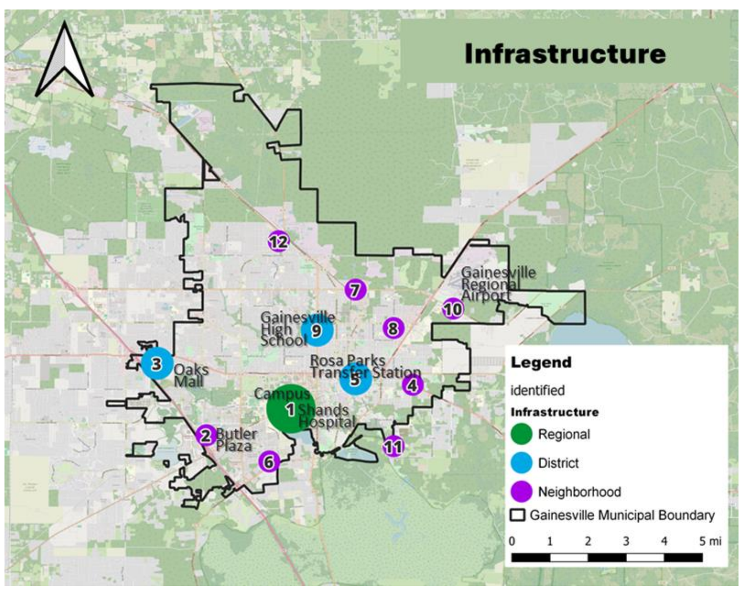


Figure 49: Identified mobility hub locations under the "leveraging existing infrastructure" scenario

2.5.5 Scenario 5: Prioritizing Disadvantaged Populations

This scenario prioritizes disadvantaged populations and takes household characteristics into consideration. Figure 50 shows the calculated mobility hub index score of this scenario. According to the figure, east and southwest Gainesville have the highest score of socio-demographic considerations, suggesting more disadvantageous groups living there.

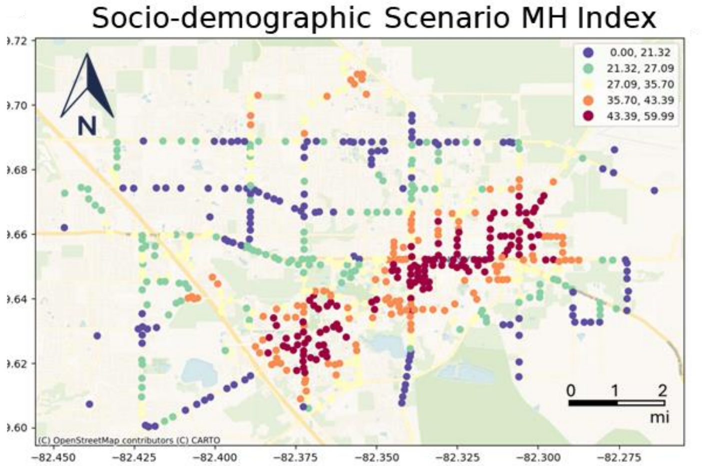


Figure 50: Mobility hub index under the "prioritizing disadvantaged populations" scenario

With objective of prioritizing disadvantaged populations, we identify the mobility hubs as Figure 51 shows. The regional hub was still sited at Shands Hospital, while three district-level mobility hubs are sited in North Walmart, GNV airport and east Gainesville.

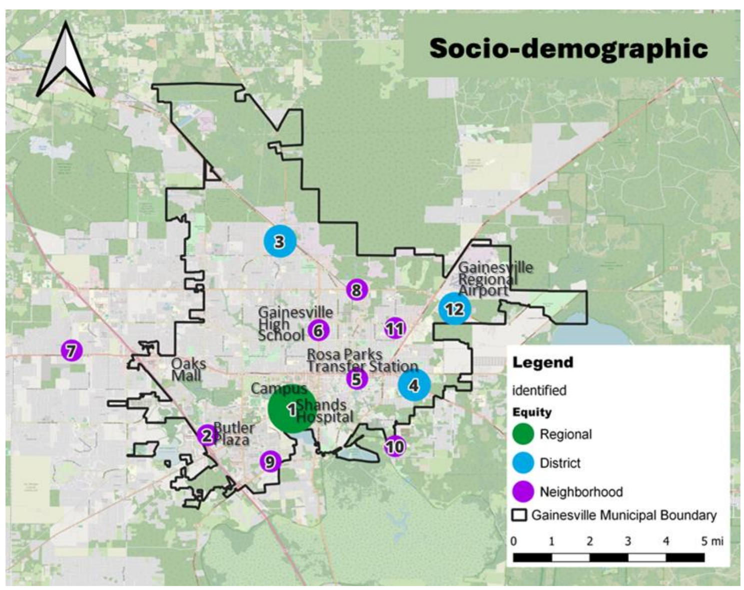


Figure 51: Identified mobility hub locations under the "prioritizing disadvantaged populations" scenario

2.5.6 Scenario 6: Enhancing Accessibility

This scenario prioritizes destination accessibility, which is measured by walkability score and destination accessibility via transit/auto.

shows the calculated mobility hub index score of this scenario. Downtown and east Gainesville has the highest score, while southwest, north Gainesville and GNV airport surroundings have the least accessibility score.

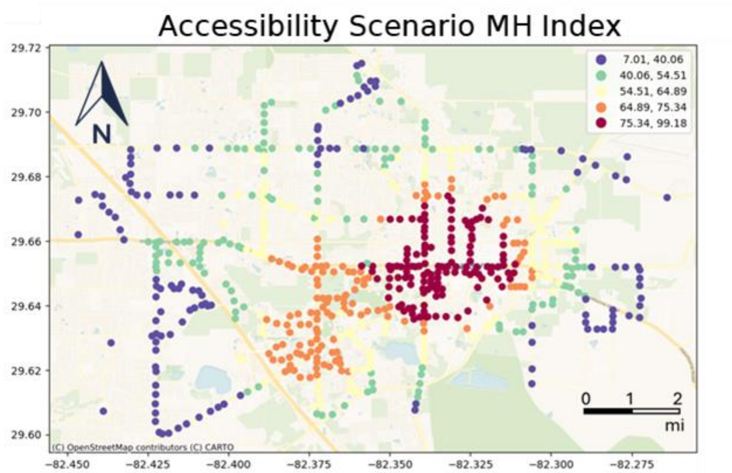


Figure 52: Mobility hub index under the “enhancing accessibility” scenario

With objective of promoting enhancing accessibility, we identify the mobility hubs as Figure 53 shows. The regional hub was still sited at Shands Hospital, while three district-level mobility hubs are sited at North Walmart, GNV airport and Oaks Mall.

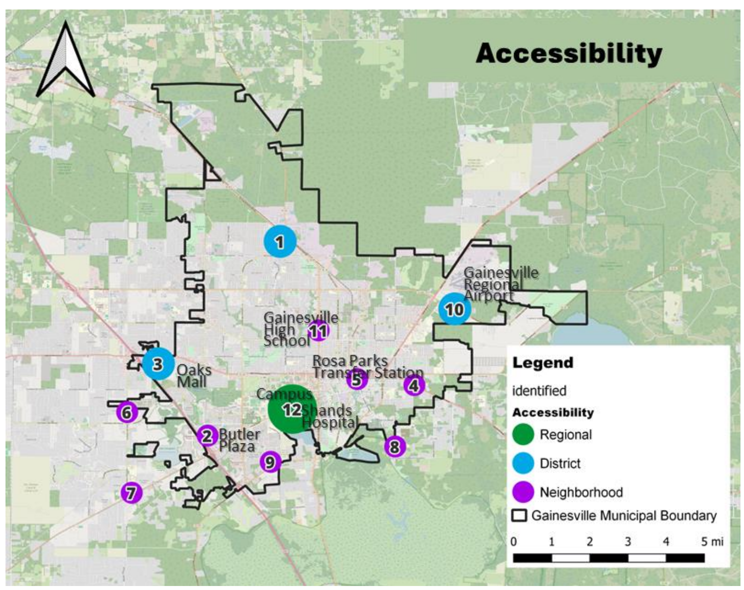


Figure 53: Identified mobility hub locations under the “enhancing accessibility” scenario

2.6 Summary of Quantitative Data Analysis

The objectives of mobility hubs involve increasing transit use, enhancing first-/last-mile connectivity, and prioritizing disadvantaged populations. Motivated by these goals, we have developed a GIS-based analytical framework for identifying the most suitable locations for mobility hubs within the context of Gainesville, Florida. The proposed methodology is designed to evaluate and prioritize potential hub locations at different scales by assigning scores and weights to a variety of criteria. These criteria encompass essential factors such as transit ridership and supply, first/last mile connectivity, infrastructure readiness, socio-demographic considerations, destination accessibility. By integrating these criteria into a comprehensive evaluation process, this research aims to provide valuable insights and data-driven recommendations that will guide the strategic placement of mobility hubs in Gainesville, ultimately fostering a more efficient, equitable, and accessible urban transportation system.

The results demonstrate that the mobility hub concept and the proposed GIS-based analytical framework can address a variety of scenarios in planning the mobility hubs. Given six different objectives, we identified 8 neighborhood-level mobility hubs (which reaches about 40% service coverage), 3 district-level hubs and one regional-level hub in Gainesville. Most of neighborhood-level hubs are in southwest and east Gainesville. District-level hubs should be built at Oak Mall, north Gainesville and GNV airport, which has the highest FMLM gap. Butler Plaza and downtown Gainesville are also potential sites for district-level hubs, which scores higher in terms of prioritizing transportation disadvantaged populations and in relation transit supply. Shands Hospital is most suitable for siting the regional-level mobility hub, where ridership and accessibility were the highest. In general, this outcome seems plausible. We expected that mobility hubs should be built at stops with high accessibility, ridership, sufficient infrastructure, and transit supply.

3 Survey of Gainesville Residents on Travel Behavior and Multimodal Infrastructure

Survey Findings Summary

Building on the results from Chapter 2 in which we use a GIS-based multi-criteria approach to identify potential mobility hub locations, we surveyed a diverse group of individuals to understand considerations for hub locations from local travelers' perspectives. The survey focused on understanding their current travel behavior, opinions towards multimodal travel, perceived barriers towards using transit, and the potential impact of mobility hubs on their travel patterns. We also used maps, and interactive maps components, to seek residents' feedback on where mobility hubs should be planned and what features should be programmed for the hubs.

The total number of valid responses collected exceeded 500. Most respondents (68%) are full- or part-time students, and between 19-30 years old (70%). The results indicate a demand for transit and multimodal travel among Gainesville residents, alongside perceived barriers and inconveniences. Respondents reported that more frequent services, shorter waiting time, and shorter transit travel times would make them use transit more often.

These findings highlight the potential of mobility hubs in promoting and facilitating transit usage, multimodal travel, and shared mobility. Respondents generally welcome the idea of mobility hubs and believe that they would enhance transit services. In terms of design and location, the survey identifies parking spaces, bike racks, and pick-up/drop-off zones as key transportation amenities desired by users. Respondents also value other features such as safety, comfortable climate control facilities, and access to information. Regarding potential mobility hub locations, the survey respondents have indicated preferences for hubs in the Western and Southern parts of the City of Gainesville, as well as near UF's and Sante Fe College's campus locations. In addition, feedback from respondents regarding proposed mobility hubs have noted the importance of considerations for wheelchair and crosswalk access, emergency services, support for the homeless population, and accommodations for nighttime usage. These insights provide valuable guidance for the design and implementation of mobility hubs in Gainesville and highlight the potential of mobility hubs in promoting and facilitating transit usage, multimodal travel, and shared mobility.

3.1 Survey Design and Distribution

3.1.1 Background

Mobility Hub, Multimodal Travel and Community Input

It is important to understand the current and potential users of an MH to best tailor each hub to their needs. Several studies have explored how potential users will harness the supportive services available at MHs, typically employing surveys and occasionally using focus groups. User-centric topics that have been investigated in the literature include mode choice intentions, traveler profiles, and interest in applications of novel transportation solutions at mobility hubs.

Little is known about the preferences of MH users as the concept of MH is relatively new. Furthermore, user satisfaction with multimodal transfer centers has been widely studied, but future work could incorporate the novel aspects of MHs (e.g., new mobility options) into user satisfaction surveys. Additionally, research on user preferences and needs regarding the location of MHs remains limited. Studies on user preferences have been largely conducted in Europe, failing to cover user preferences in non-European and non-urban settings. There is very limited knowledge about potential MH users in Florida. There is currently no academic research addressing MH users in Florida; however, some organizations (e.g., Miami Dade Transportation Planning Organization) have conducted surveys with their user base as part of local MH studies.

To address these research gaps and explore how Gainesville residents value the proposed MH locations, we designed and distributed a survey to understand potential users' travel behavior and preferences regarding MHs. The remainder of this chapter will detail the survey objectives, methods, and results.

3.1.2 Research Objective and Survey Design

Planning for mobility hubs requires a clear understanding of travelers' preferences and behavioral patterns related to transit and shared mobility integration. Hence, in collaboration with the project managers and the stakeholder group, the research team developed survey questions to understand to what extent the last-mile problem impedes transit use, whether and how people use shared mobility options to connect with transit, and opportunities and obstacles for combined transit and shared micromobility use as an alternative to car trips. Survey respondents were also asked about their views on where mobility hubs should be planned and what features should be programmed for the hubs.

Primary goals of the survey were to answer the following questions:

1. To what extent can mobility hubs promote multimodal travel and transit use?
    a. What factors shape mode choice?
    b. What barriers prevent individuals from using transit and multimodal travel?
    c. Can mobility hubs address these barriers and promote access and multimodal travel?
    d. To what extent can mobility hubs promote access among disadvantaged populations?
    e. To what extent can mobility hubs promote more sustainable travel behavior among drivers, especially carshare users and EV users?
2. What factors should be considered when determining the features and locations for prospective mobility hubs in Gainesville?
    a. Where do respondents want mobility hubs to be implemented?
    b. How do these desired locations compare to the locations that respondents are currently using to transfer between modes?
    c. How do they compare with candidate locations identified through the geospatial approach?
    d. What features and amenities of mobility hubs are most important to users?

3.1.3 Survey Distribution Methods

We developed a web-based survey devised to gather insights into participants' travel behavior, attitudes toward travel, and their opinions regarding a series of proposed mobility hubs. The survey was crafted using webpages hosted on Qualtrics, featuring interactive map components powered by JavaScript. To ensure diverse participation, we employed various recruitment strategies, including distributing survey links via flyers and workshops, in-bus monitors, and promoting them on the Gainesville Regional Transit System (RTS) webpage and the RTS app (see Figure 54).

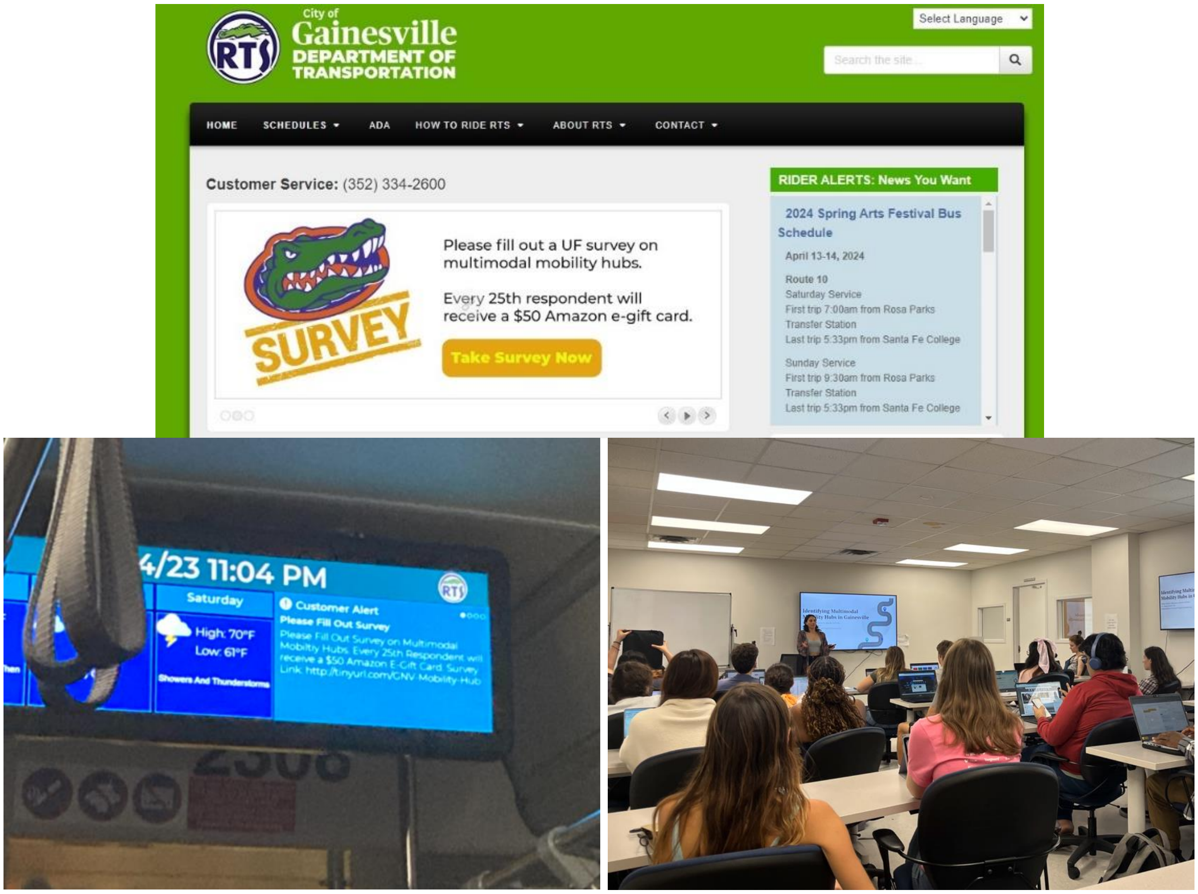


Figure 54: Survey Distribution Methods

3.2 Survey Results

3.2.1 Number of Responses

Initial Data Collected
Our data collection efforts yielded a total of 1,210 responses from participants who accessed the survey through the web, supplemented by an additional 34 responses obtained from off-line workshops. However, upon closer examination of the data, it became apparent that the dataset exhibited issues such as AI-generated- or duplicated responses.

Manual Screening
To ensure the quality and validity of our dataset, we implemented a manual screening process conducted by two research assistants. Each response was individually assessed and categorized into three groups: valid, potential valid, or invalid. Criteria considered during the screening process included response quality scores provided by Qualtrics, as well as examination of fields such as email addresses, geographical locations, responses to open-ended questions, and response time duration. The exclusion and inclusion criteria included:

- UF email addresses were considered indicative of non-bot respondents, although response validity was further assessed through examination of open-ended comments.

- Duplicate responses to open-ended questions from different emails were flagged as bot responses and marked as invalid. Duplicate responses from the same email were retained as potential duplicates for further evaluation.
- Responses to open-ended questions that were deemed unrelated to the survey topic, such as mentions of airline exchange hubs or international trade, were classified as invalid.
- Responses to open-ended questions that had clear personal opinions or experiences were considered indicative of non-bot respondents.
- Responses with a duration of less than 2 minutes or many unanswered questions were considered invalid.
- We utilized the bot.detector() tool, developed by Prims, J., Motyl, M. (2018), to assist in identifying bot responses and survey-farmers. This tool analyzed spatial-temporal patterns, duplicate responses, and bot-like comments. It assigns a score to each response. The tool's GitHub page is: https://github.com/SICLab/detecting-bots. Responses with high scores from bot.detector() and/or Qualtrics were manually reviewed.
- Additionally, the responses obtained from offline workshops were of higher quality, so they were either considered valid or potential valid.

Cross Validation

After the initial screening, each response to the survey was marked as valid, invalid or potentially valid ("potential") by the two research assistants. Then, a cross-validation process was carried out to final label the results into the binary classification of valid or non-valid. This procedure was implemented to ensure consistency and accuracy in our data analysis.

We consider the combination of valid-valid and valid-potential as valid; the combination of valid-invalid, potential-potential, invalid-potential and invalid-invalid as invalid.

After the cross-validation process, 529 responses were deemed valid, comprising of 497 responses from the web survey and 32 from workshops, and 713 were identified as invalid. Only the valid responses were included in the subsequent analysis and interpretation.

3.2.2 Socio-demographic Profile of the Survey Respondents

Overview of the Survey Sample

The majority of the survey respondents (68%) are full- or part-time students, and 70% of the sample is between the ages of 19-30 years old. Very few respondents (about 10%) were older than 50 or younger than 19. 50% and 46% of the respondents identify as male and female, respectively, with the remaining 4% identifying as non-binary/third gender. A small portion of the respondents reported having a disability that can affect mobility: 3% reported traveling in a wheelchair or mobility-scooter, 4% reported being incapable of riding a bike or scooter, and 3% reported being incapable of walking for five or more minutes. 88% of respondents reported having none of these disabilities. The sociodemographic characteristics of respondents are summarized in Table 23.

Table 23: Socio-Demographic Profile of the Survey Sample

Demographic Characteristic	Percent
Age	
0-18	5
19-30	70
31-40	14
41-50	7

Demographic Characteristic	Percent
51-65	4
65+	<2
Gender	
Female	46
Male	50
Non-binary / third gender	4
Student	
Full-time student	61
Part-time student	7
Not a student	31
Highest Education Level	
Some high school	<2
High school graduate	12
Some college	39
Bachelor's degree	29
Post-graduate degree	18
Vocational or technical training	<2
Disability	
Travel in a wheelchair/mobility-scooter	3
Incapable of riding a bike/e-scooter	4
Incapable of walking more than 5 minutes	3
Difficulty going outside the home	<2
None of the above	88
Race or Ethnicity	
White or Caucasian	54
Asian	18
Black of African-American	12
Hispanic or Latino	12
American Indian or Alaskan Native	<2
Native Hawaiian or Pacific Islander	<2
Other	3

Characteristics of Student Respondents

Of the 68% of respondents who are part-time or full-time students, 43% do not have a personal vehicle (including cars and moped scooters) and 57% have an annual expenditure of less than $20,000 per year. The vehicle ownership and annual expenditure of students are displayed in Table 24.

Table 24: Vehicle Ownership & Annual Expenditure of Student Respondents

Demographic Characteristic	Percent
Vehicle Ownership	
Personal car (for use in Gainesville)	34
Moped scooter (for use in Gainesville)	23
None	43
Annual Living Expenditure	
Less than $10,000	26
$10,000-$19,999	31
$20,000-$29,999	20
$30,000-$39,999	17
$40,000-$49,999	3
$50,000-$74,999	3
$75,000 or more	<2

Characteristics of Non-student Respondents
Of the 31% of respondents who are not students, one-quarter have no vehicle in their household and half have one vehicle. The largest share of respondents is currently employed (77%), with 15% employed part-time and 62% employed full-time. The unemployment rate is 12%. Just under half of respondents (49%) annual household income is less than $50,000; and 22% have an annual income of greater than $100,000. The vehicle ownership, employment status, and annual household income of non-students are displayed in Table 25.

Table 25: Vehicle Ownership, Employment Status, and Annual Income of Non-student Respondents

Demographic Characteristic	Percent
Number of Vehicles in Household	
0	34
1	23
2	43
3 or more	0
Employment Status	
Not currently employed	12
Employed part-time	15
Employed full-time	62
Self-employed	5
Homemaker	<2
Unpaid volunteer or intern	<2
Retired	4
Annual Household Income	
Less than $25,000	26
$25,000-$49,999	23
$50,000-$74,999	15
$75,000-$99,999	12
$100,000-$124,999	16
$125,000-$149,999	6
$150,000 or more	<2

3.3 Travel Behavior and Preferences of Gainesville Travelers

3.3.1 Travel Behavior and Attitudes

The first section of the survey asks respondents to describe their current travel behavior such as travel modes and their respective frequency of use. Figure 55 displays the frequency to which respondents utilize different modes of transportation.

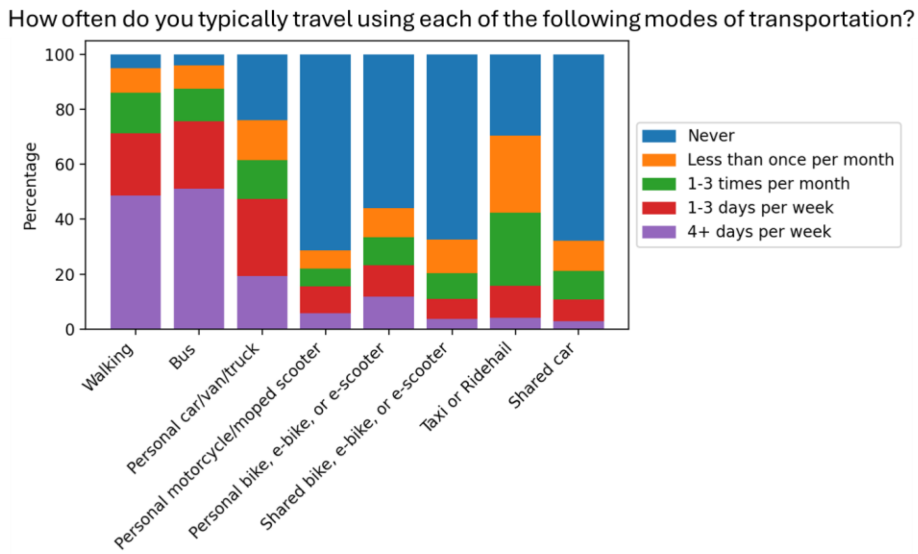


Figure 55: Frequency Distribution Regarding the Use of Different Travel Modes

Walking and taking the bus were the most common modes of transportation; roughly 70% of respondents walk or take the bus at least 1-3 days per week, with over 40% walking or taking the bus 4+ days per week. Less than 10% of respondents indicated that they never walk or take the bus. On the other hand, over half of respondents never used a shared car, a shared bike/e-bike/e-scooter, a personal bike/e-bike/e-scooter, or a personal motorcycle/moped to get around. The low usage rates of shared car or shared micromobility could be contributed to their costs, or because these modes are not located in convenient locations. A small portion of respondents use shared car, taxi/ridehailing, or shared bike/e-bike/e-scooter 4 or more days per week. About half of the respondents occasionally use taxi or ridehailing to get around.

43% of students and 34% of non-student respondents indicated that they did not have access to a personal vehicle (Table 24). However, only about 25% of respondents indicated that they never use a personal vehicle to get around (Figure 55), potentially meaning that even those without cars occasionally rely on a friend or family member's vehicle to get around. About 50% of respondents use a personal car at least 1-3 times per week. This means that about 25% of respondents who have access to a vehicle use it only occasionally (less than once per week). This could be due to their vehicle trips being primarily for specific purposes, such as grocery shopping or occasional travel, as well as the influence of UF campus parking regulations.

The survey also asked about respondents' attitudes regarding different modes of transportation and the availability/adequacy of transportation infrastructure. The responses to a series of attitudinal statements are displayed in Figure 56.

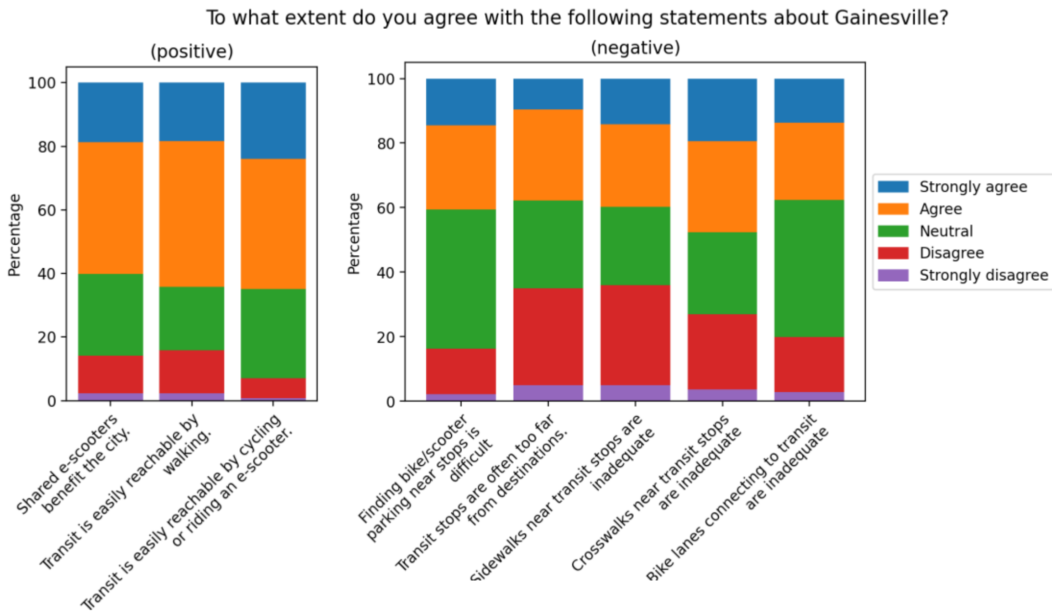


Figure 56: Responses to Attitudinal Statements on Various Travel Modes and Transportation Infrastructure

When asked whether they agree with the statement "Shared e-scooters benefit the city," about 60% of respondents agreed or strongly agreed with the statement. However, only about 40% of respondents use e-scooters to get around, possibly meaning that even those who do not use e-scooters see value in having them in Gainesville. About 60% of respondents agreed or strongly agreed that transit is easily reachable by walking, cycling, or riding an e-scooter. However, about half of respondents agreed or strongly agreed that crosswalks near transit stops are inadequate, and 40% felt that sidewalks near transit stops are inadequate. Most respondents indicated being neutral about difficulty finding bike/e-scooter parking at transit stops or the inadequacy of bike lanes connecting to transit stops.

3.3.2 Transit Usage and Perceived Barriers

Mobility hubs can play a crucial role in enhancing the transit ridership experience. Therefore, the second set of questions focused on respondents' usage of transit, along with their considerations, and perceived barriers.

Figure 57 and Figure 58 show the frequency respondents *consider* using transit and how much they *actually* use transit. Almost all respondents *consider* using transit sometimes, frequently, or always. However, 70% of respondents reported that they sometimes, frequently, or always take a different mode after considering transit, indicating that there are barriers to taking transit. In most cases, the distance to the nearest transit stop is an important factor in deciding whether to use transit; only 15% of respondents stated that they do not use transit for other reasons. 31% of respondents stated that distance is almost always an important factor in the decision to take transit.

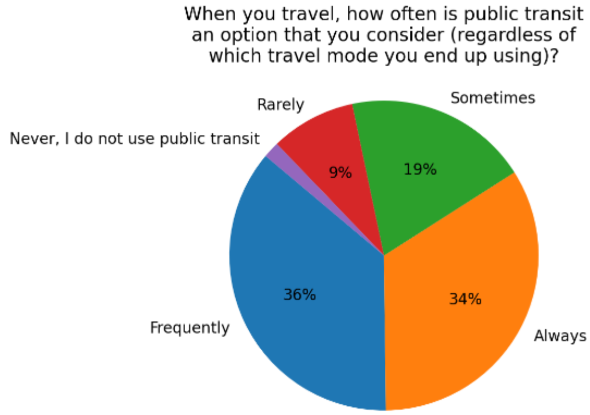


Figure 57: Frequency of Considering Using Transit for Travel

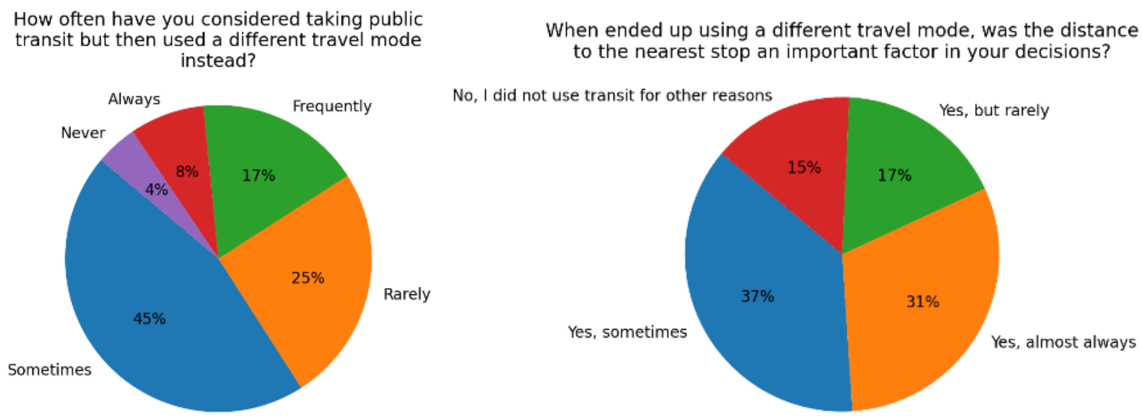


Figure 58: Responses to Questions about Considering Transit but Using a Different Mode

About three-quarters of respondents (*Strongly agree* or *Agree*) indicated that they try to take transit whenever possible (Figure 60). However, previous questions revealed that many respondents end up taking other modes after considering transit. When asked what improvements would make transit a more attractive mode, the three most frequently selected options were more frequent service, more off-peak service, and shorter waiting times. Over half of respondents agreed that taking transit takes too much time (Figure 60). This indicates that poor transit availability and reliability may be a more significant barrier than inconveniently located stops or lack of amenities at stops. Few respondents thought that more mobility options at transit stops should be a priority. This suggests that improving transit supply may be more urgent than increasing the availability of other modes. Alternatively, travelers could be underestimating the value of additional modes at mobility hubs because most respondents walk to transit stops.

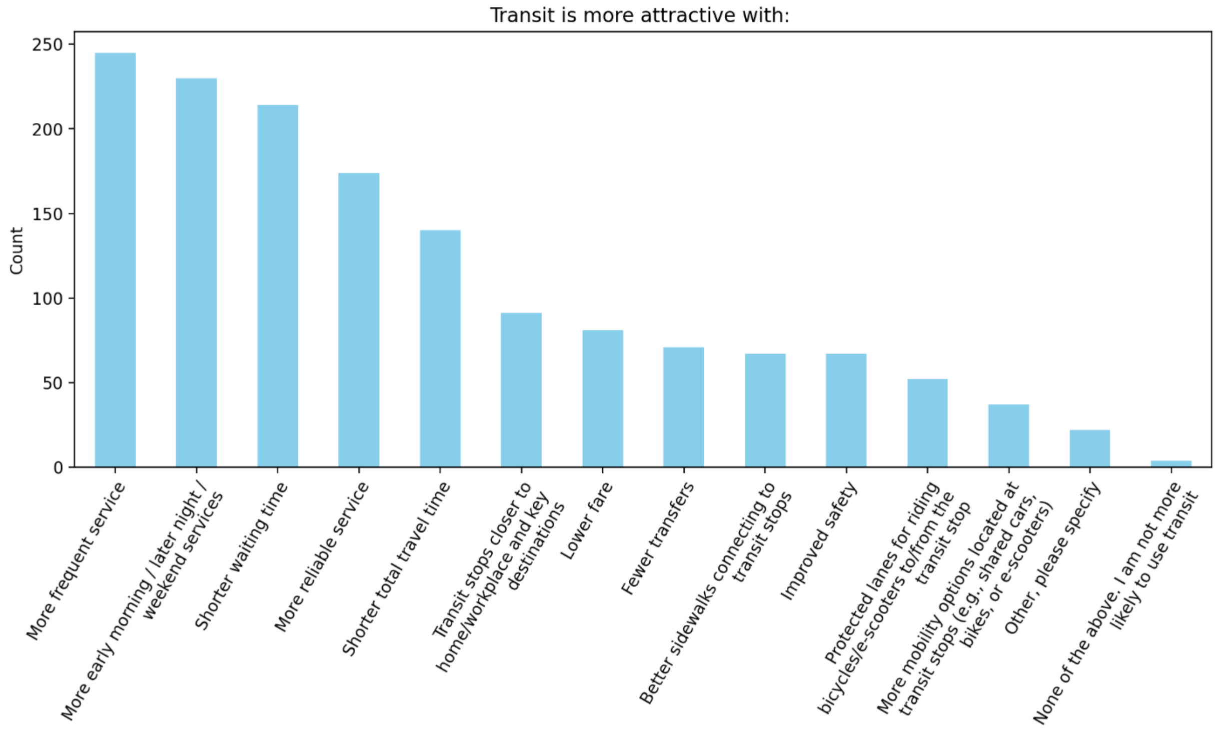


Figure 59: Improvements that Would Make Transit a More Attractive Option

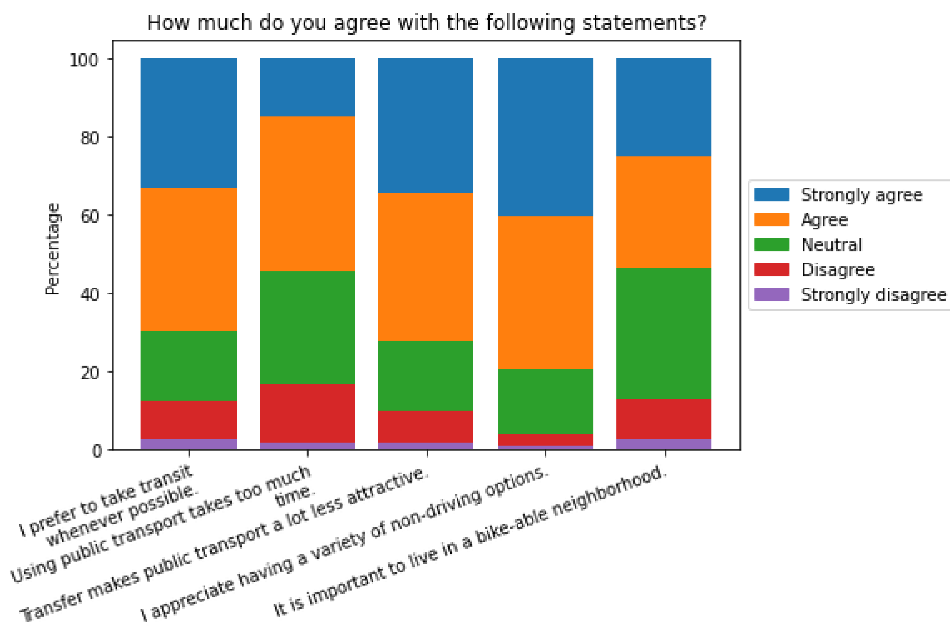


Figure 60: Responses to Attitudinal Statements Regarding Sustainable Transportation

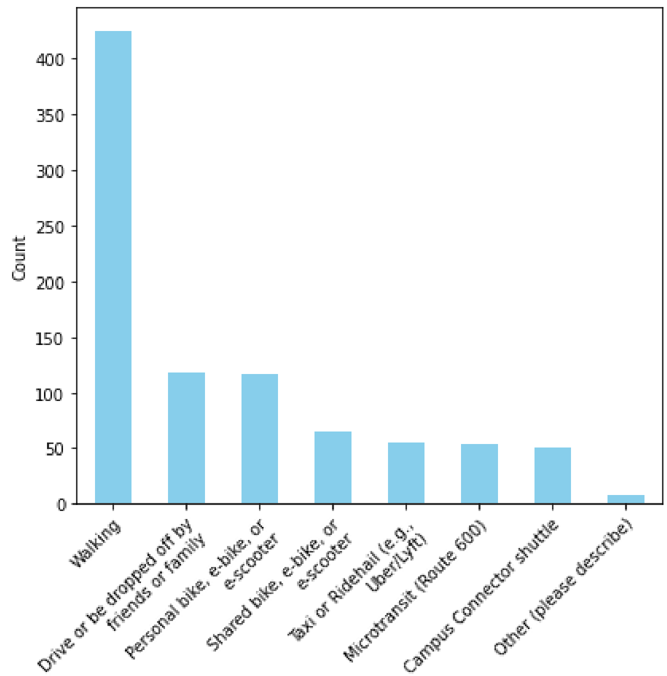


Figure 61: Frequency Distribution of Access/Egress Modes to Transit Stops

3.3.3 Multimodal Travel Behavior

The survey further asked how often respondents combine modes to take a multimodal trip and how they rate the convenience of different mode combinations.

Respondents were asked about combining certain modes only if they indicated that they used that mode in a previous question (i.e., if a respondent said that they "never" use a shared car, they were not asked about any mode combinations including a shared car). The frequency that respondents combine different modes, and the convenience of these combinations are displayed in Figure 63. Each bar reveals the option selection distribution within each respondent group of that mode combination. We can see that "Bus + personal bike/e-scooter" and "Personal car + personal bike/e-scooter" are the top two popular modal combinations. If we compare the bars in the frequency figure, we notice that nearly 50% of the respondents of all seven groups engage in multi-modal travel every week. However, a similar percentage perceive this mode of travel as neutral or inconvenient. This underscores the potential significance of mobility hubs in addressing these challenges.

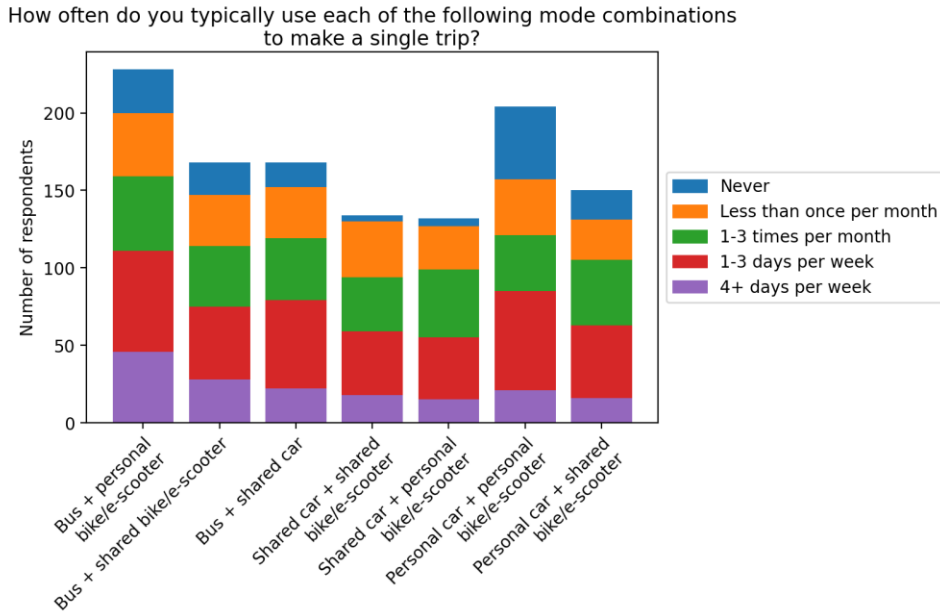


Figure 62: Usage Frequency of Combining Various Travel Modes

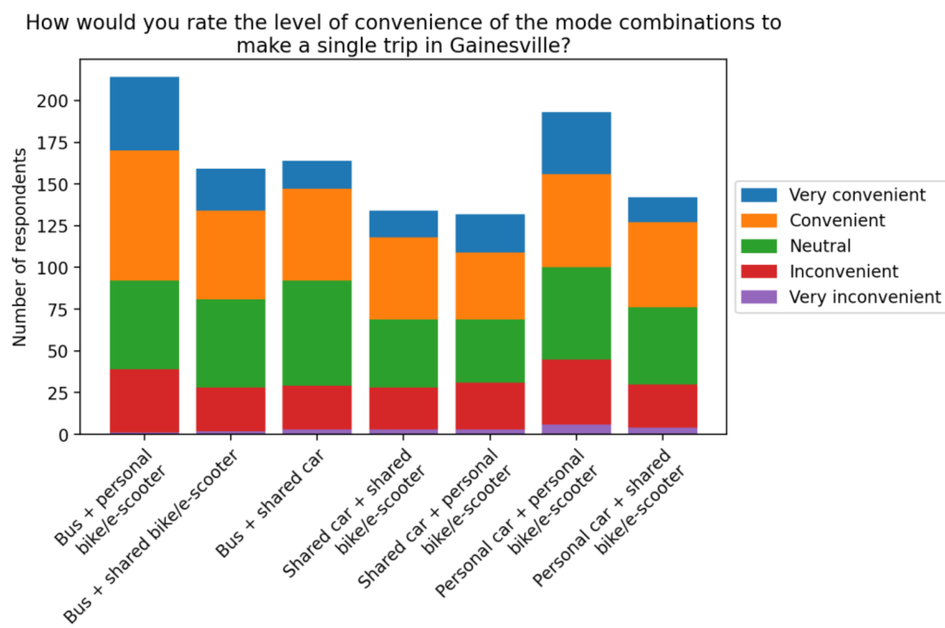


Figure 63: Convenience of Combining Various Travel Modes

3.4 Attitudes Towards Mobility Hubs

In the second section of the survey, respondents were asked to provide feedback about Mobility Hubs (MHs). The survey included a short description of MHs, along with a 30 second video (https://www.youtube.com/watch?v=Fm9jbg7K5vs&t=32s), to allow respondents to familiarize themselves with the concept.

3.4.1 Use of Mobility Hubs

The first set of questions in this section is about the general sentiments regarding MHs. About three-quarters of respondents indicated that they would use MHs if they became available in Gainesville, and about two-thirds indicated that the availability of MHs would make transit a more attractive option (Figure 64).

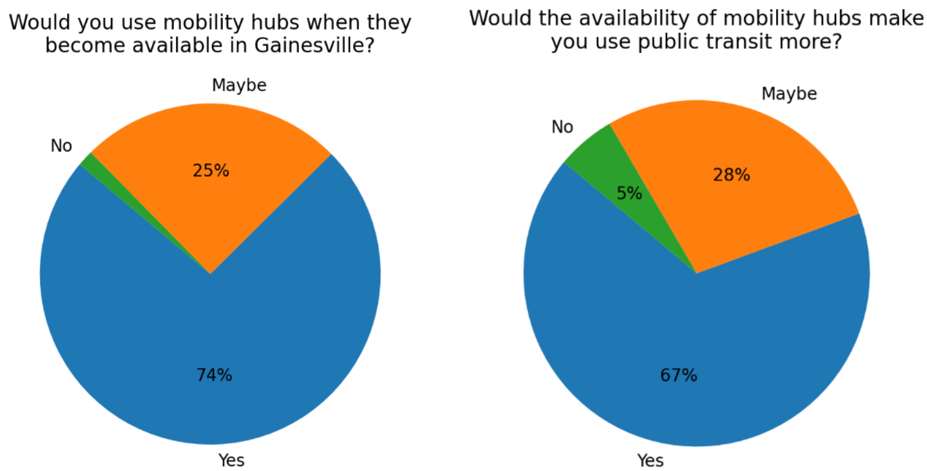


Figure 64: Use of Mobility Hubs and Potential of Mobility Hubs to Enhance Transit

3.4.2 Desired Mobility Hub Features and Amenities

MHs have a variety of features that make multimodal travel more attractive. Respondents were asked about both transportation-related features (e.g., bike/e-scooter racks, parking for shared cars) and additional amenities (e.g., landscaping and public art, charging stations). Figure 66 display the responses to questions about MH features and amenities.

As shown in Figure 65, parking spaces for personal cars were the transportation-related feature selected as important or very important by the greatest portion of respondents (almost 60%). This may indicate that respondents want to drive to MHs to access other modes; in this case, MHs would resemble park-and-rides with additional features. Bike/e-scooter racks and ridehailing pick-up/drop-off zones were selected as important or very important by roughly half of the respondents. Roughly 40% indicated that parking for shared mobility and charging stations for electric vehicles were important or very important.

As shown in Figure 66, in general, the non-transportation amenities were regarded as important or very important by a greater portion of respondents than the transportation-related amenities. About 80% of respondents felt that safety features, comfortable waiting areas, and information were important or very important. Slightly fewer (about 70%) felt that nearby services and charging options were important or very important. Landscaping and public art were regarded as important or very important by the least, about half of the respondents.

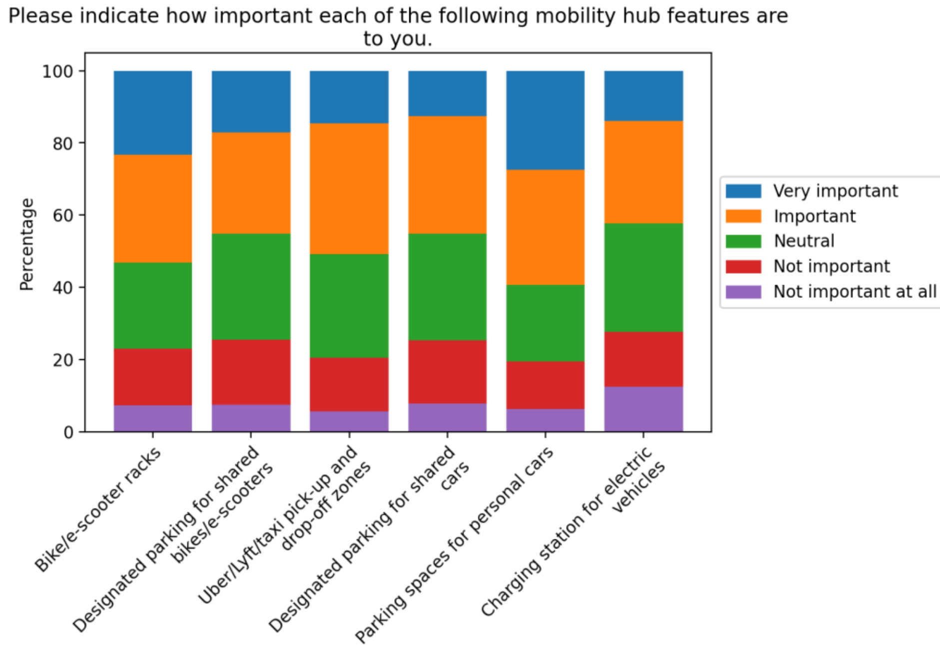


Figure 65: Importance of Different Transportation-related Features of Mobility Hubs

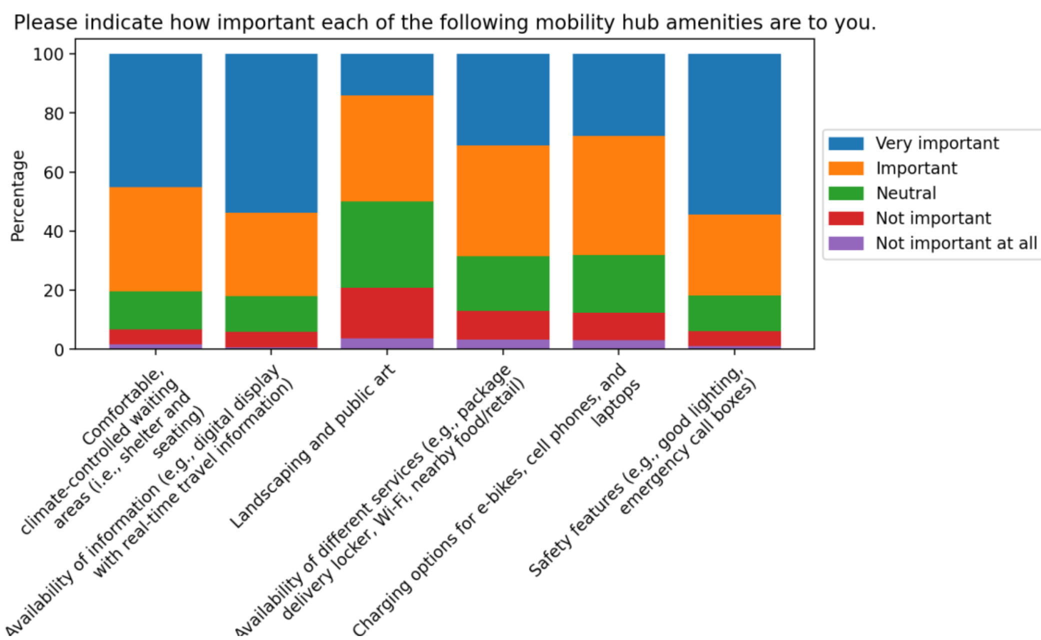


Figure 66: Importance of Various Non-transportation Features of Mobility Hubs

Respondents were also asked to what extent various measures would incentivize MH use. Figure 67 contains the results for these questions. About 70% of respondents indicated that they agreed or strongly agreed that better pedestrian or cyclist infrastructure around the MH. They also indicated that having a single interface to plan, book, and pay for multiple modes of transportation would make them more likely to use the MH. This could be indicative as to why "parking for private cars" scored highest in the question related to transportation features of MH. For example, if the cycling/walking infrastructure to get to the hub is poor, or the distance is too far, people would more likely say that they want to have parking options available at the hub. Slightly fewer (about 60%) agreed or strongly agreed that discounted fare for combining modes and a wide variety of shared mobility options would make them more likely to use the MH.

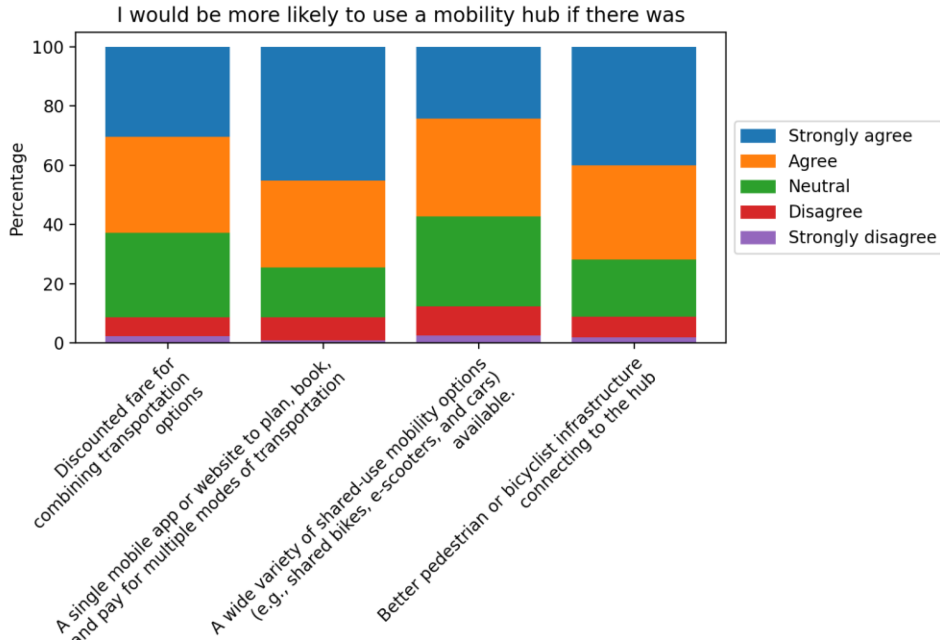


Figure 67: Effectiveness of potential incentives for promoting MH use

3.4.3 Prioritization Criteria for Selecting Mobility Hub Locations

As mentioned in Section 2.4 Analytical Steps, a variety of prioritization criteria were considered when identifying the most appropriate locations for MHs in Gainesville. These criteria fell into five categories: transit ridership and supply, first/last mile connectivity, infrastructure readiness, socio-demographic considerations, destination accessibility. Respondents were asked to select which two criteria they felt were most important for selecting MHs (including an option for equal weight). The responses are displayed in Figure 68. Overall, most respondents felt that accessibility to key destinations and transit ridership are the most important criteria for identifying MHs.

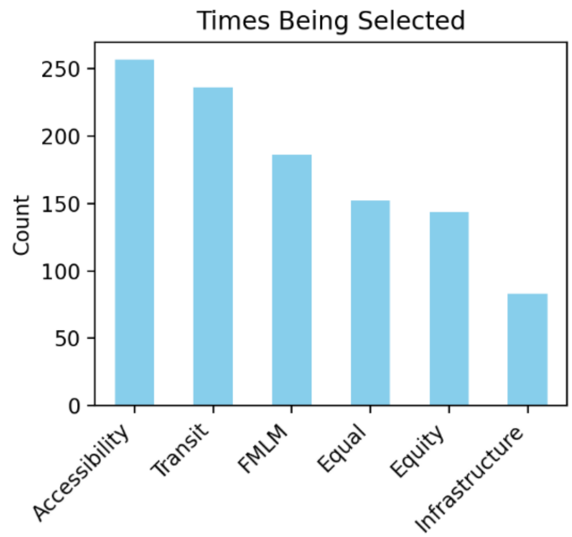


Figure 68: Frequency of each prioritization criteria being selected

3.5 Assessment of Mobility Hub Locations

To facilitate the assessment of potential mobility hub locations among respondents, we incorporated both traditional maps, and maps with interactive features using JavaScript, in our survey. For these questions, users can view, click, and edit the maps.

3.5.1 Desired Locations of Mobility Hubs

Users were first prompted to select any location on the map where they envision mobility hubs. The map in the survey is displayed centered around Gainesville.

> *Imagine that you could build a mobility hub anywhere in Gainesville. Click on the map to indicate the locations that you feel make the most sense for developing a mobility hub. Please select up to three locations.*

Figure 69 shows the MH locations that survey respondents selected and the corresponding heatmap. The majority of selections were center within three big clusters inside the municipal boundary: (1) UF campus and downtown, (2) Butler Plaza, and (3) Oaks mall. We can also notice some small clusters at Sante Fe College, the interchange by NW 13th St and NW 22nd St and the Gainesville airport.

This distribution aligns with popular trip generation and distribution points in the city. Overall, the distribution of these clusters highlights the diverse mobility needs and preferences of Gainesville residents, underscoring the importance of strategically locating mobility hubs to enhance accessibility and connectivity across the city.

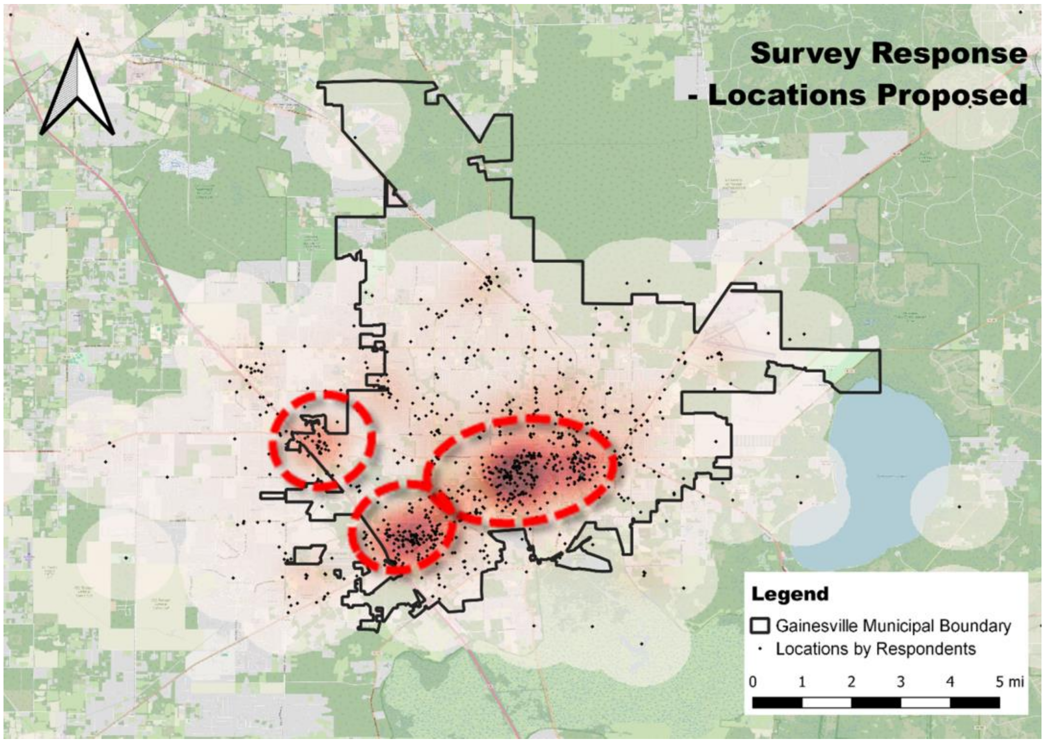


Figure 69: Mobility Hub Locations Proposed by Respondents

3.5.2 Assessment of Identified Mobility Hub Locations for Each Planning Scenario

General Acceptance of the Proposed Hubs

To seek feedback from respondents regarding the mobility hub locations identified from the GIS-based approach, we asked them whether they would use any of the mobility hubs identified in the map for each planning scenario. We calculated the percentage of respondents answering "yes" for each scenario. The results are shown in Table 26.

Table 26: Percentage of Respondents Indicating They Would Use the Mobility Hubs Identified in Each Scenario

Scenario	Number of respondents	% of respondents answering "yes"
Enhancing Transit, "Transit"	196	83%
Enhancing FM/LM Connectivity, "FMLM"	167	90%
Leveraging Existing Infrastructure, "Transit"	78	94%
Prioritizing Disadvantaged Populations, "Transit"	129	90%
Enhancing Accessibility, "Transit"	229	89%
Equal Weights, "Transit"	136	89%
Overall	935	88%

Overall, a large majority of respondents (88%) indicated that they would use at least one of the mobility hubs identified in each scenario. Interestingly, while the "infrastructure" criteria was the least selected option among respondents, the mobility hubs identified in its corresponding planning scenario had the highest percentage of respondents (94%) intending to use them.

Scenario Comparisons and Synthesis of Results

Through display logic, the survey further asked the respondents to evaluate the mobility hub locations identified from the two criteria they have chosen. That is, each respondent was asked to indicate two out of six sets of mobility hub locations, each corresponding to a planning scenario. We asked two sets of questions with two interactive maps.

1. First, we asked them which specific hub(s) they would like to use. With this question, we can identify the reasonable/popular hubs. ("*Click on the red pins to select up to 3 mobility hubs that you would be most likely to use*")
2. Secondly, we asked them which hub they dislike. In this question, respondents can click and/or drag the hubs they dislike and state their reasons. ("*Click on the hubs that you feel are inconvenient or undesirable locations. For each selected hub, if you believe there is a more suitable location nearby, drag the yellow pin to move it to that position.*")

The second question aimed to gather respondents' feedback on proposed mobility hub locations. If respondents simply selected a mobility hub without moving it, it implied that they found the location desirable, with no specific suggestions for improvement. Alternatively, if a respondent clicked on a mobility hub and moved it, it suggests that the original location is considered inconvenient and undesirable.

We present the results of the two sets of questions of each planning scenario. Each scenario is organized by presenting two maps and two tables. The detailed maps and tables are presented as appendixes in the **Appendix** section.

- Map 1 - shows the number of times each hub was selected by respondents due to intended use. Shown in *Appendix 1: Popular Mobility Hub Locations*
- Map 2 - shows the number of times a hub was moved due to "dislikeness" and the suggested movements. Shown in *Appendix 2: Suggested Movements Proposed by Respondents*
- Table 1 - shows the reasons respondents gave for selecting but not moving certain disliked hubs. Shown in *Appendix 3: Comments by Respondents Regards Unpopular Mobility Hub Locations*
- Table 2 - shows the reasons respondents gave for moving hub locations. Shown in *Appendix 3: Comments by Respondents Regards Unpopular Mobility Hub Locations*

Here, in this section, we synthesize the findings with a comparison of results across scenarios. To keep the numbers consistent and facilitate discussion, we use the below numbering of the 17 proposed hubs.

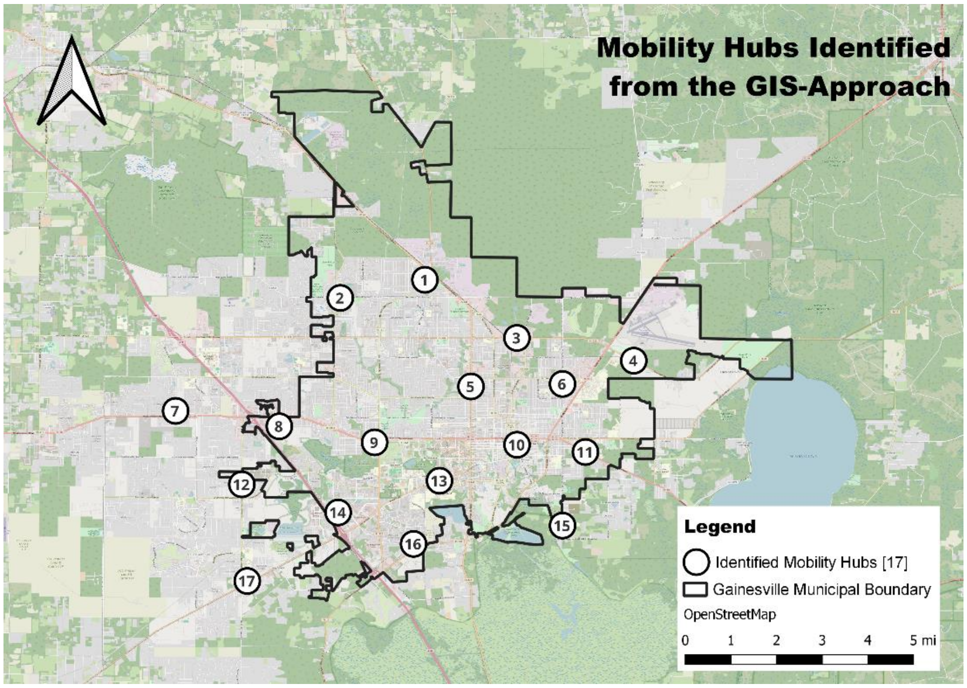


Figure 70: All 17 potential mobility hub sites identified from the GIS approach

- *Popular mobility hub locations*

Upon comparing the first sets of maps for the six scenarios, we notice both similarities and disparities. Hubs located in the west and south of the city exhibit higher levels of popularity. Notably, locations near downtown, the UF campus, and Butler Plaza emerge as hotspots across all scenarios.

However, while the two hotspots remain consistent across scenarios, we observe variations in the distribution of hub preferences. In some scenarios, respondent selections are more evenly dispersed among the proposed hubs, while other scenarios exhibit a more clustered distribution, with a concentration of selections on specific hubs. This trend is particularly pronounced in the top three scenarios: Accessibility, Transit, and FMLM. A notable comparison can be drawn between the Accessibility and Transit scenarios. In the former, respondents predominantly favor hubs MH#1, 13, and 6, with minimal interest in other locations. Conversely, in the Transit scenario, the distribution is more even, with approximately 50 selections recorded for six out of the proposed hubs.

- *Disliked mobility hub locations*

Mobility hubs disliked by respondents are predominantly located in the east and north areas. Dislikes are more evenly dispersed in scenarios such as Accessibility, Equal Weight, and FMLM. Cross-analyzing the six maps reveals that hubs in the NW 13th St and NW 22nd St vicinity (MH#1) are generally unpopular among respondents, especially in the Transit and Socio-demographic scenarios. Similarly, opinions regarding hubs around GNV airport are uniform, with respondents expressing disfavor in the Socio-demographic and FMLM scenarios. Additionally, hubs in the southeast side of the city (MH#11) and Northman Street-Northeast 39th avenue (MH#3) are also unpopular in the "Infrastructure" scenario.

➢ *Proposed changes to mobility hub locations*

For the hubs that were moved by respondents, we notice distinct movements patterns. Firstly, we observe two movement patterns across scenarios. One pattern involves dragging hubs towards the UF campus, observed in the Infrastructure and Transit scenarios. The other pattern entails moving hubs towards a more evenly distributed arrangement, as seen in the Equal weight, Socio-demographic, and FMLM scenarios. The Accessibility scenario falls somewhere between these two patterns. This divergence aligns with the objectives of each scenario. For instance, FMLM, Equal weight, and Socio-demographic aim to attract a broader community, hence the preference for a more even distribution. Conversely, the Transit scenario focuses on improving transit experiences, with students being significant transit riders, thus the inclination towards the campus area for hubs.

3.5.3 Open-ended comments

Finally, we asked respondents to share their thoughts on mobility hubs by answering an open-ended question: *Do you have more comments regarding the locations?*

From the collected responses, we generated a word cloud shown in Figure 71. This visualization offers valuable insights into the community's perceptions and priorities regarding mobility hubs. Notably, we observe recurring themes aligned with the six criteria we previously outlined. Additionally, some novel concepts have emerged, such as wheelchair and crosswalk access, emergency services, support for the homeless population, and considerations for nighttime usage. These diverse inputs provide valuable guidance for the design and implementation of mobility hubs, ensuring they meet the varied needs of our community.

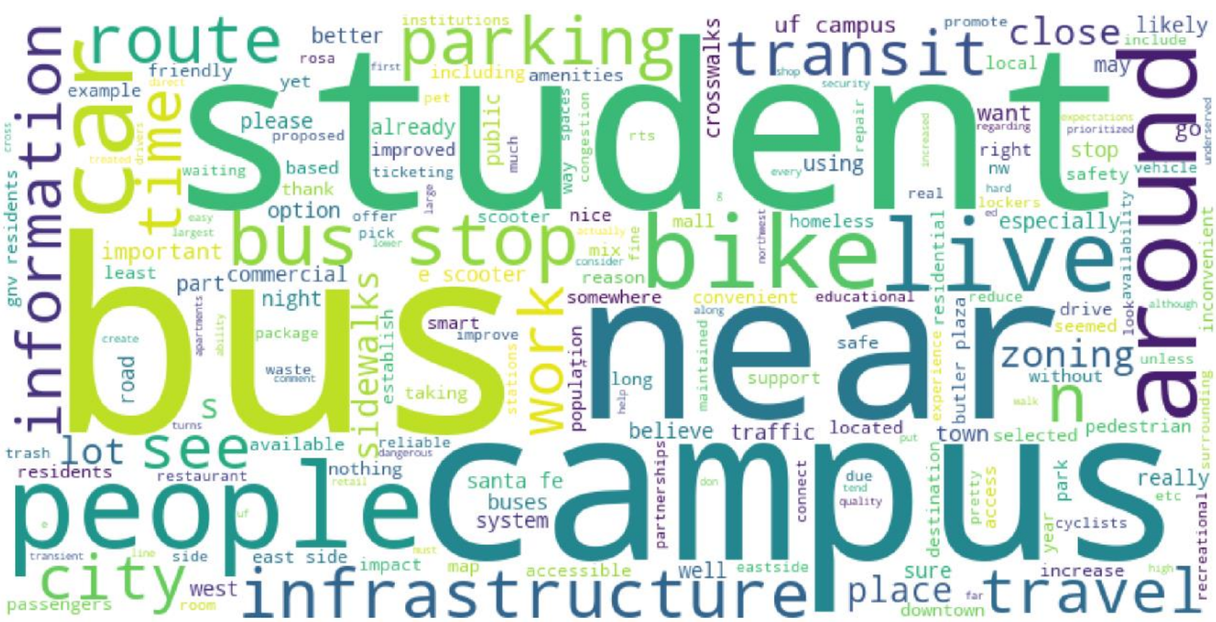


Figure 71: Word Cloud from the Open-Ended Question

3.6 Conclusion

The survey findings shed light on various aspects of mobility behavior and preferences, offering valuable insights into the potential impact of mobility hubs on promoting multimodal travel and addressing transportation barriers. The main findings are as follows:

- Travel patterns and preferences differed among residents. Walking and taking the bus are the most common ways to get around, roughly 70% of respondents walk or take the bus at least 1-3 days per week. About 50% of respondents use a personal car at least 1-3 times per week, while 25% of respondents who have access to a vehicle only use it occasionally.
- Almost all respondents consider taking transit when making their mode choice selections but often opt other modes. Over 70% reported using a different mode despite considering transit. Effective improvements that could enhance transit include more frequent service and shorter waiting times.
- Our analysis of multi-modal combinations revealed that the most common pairings include “bus & e-scooter/bike” and “car & e-scooter/bike”, highlighting the importance for mobility hubs to facilitate diverse transportation options, streamlined transfers and opportunities for mixing modes.
- A significant percentage of respondents expressed willingness to use mobility hubs, with 74% indicating "yes." Desired transportation infrastructure at mobility hubs primarily includes parking spaces for personal cars, while non-transportation amenities such as comfortable waiting areas, safety features, and information displays were also deemed important.
- Results from interactive mapping exercises show preferences for hubs in the Western and Southern parts of the city, as well as near campus locations. Respondents demonstrated a tendency to redistribute hubs more evenly and towards campus areas. High population and ridership locations emerged as priority concerns in respondents' comments.
- Feedback from respondents regarding proposed mobility hubs revealed the importance of considering wheelchair and crosswalk access, emergency services, support for the homeless population, and accommodations for nighttime usage.

These insights provide valuable guidance for the design and implementation of mobility hubs in Gainesville. Overall, the survey results indicate that mobility hubs hold promise in overcoming existing barriers to transit use, particularly through the provision of key amenities such as designated parking for bikes and cars, climate-controlled shelters, and integrated digital displays. Additionally, respondents express a preference for mobility hubs located in areas that align with their travel patterns and offer convenient access to different transportation modes. Moreover, the survey underscores the importance of factors such as incentives, infrastructure, and user education in shaping mobility choices and promoting sustainable travel behavior. The socio-demographic profile of respondents further highlights the diverse needs and preferences within the community, emphasizing the importance of targeted strategies to address specific mobility challenges and promote inclusive transportation solutions.

In sum, the survey findings confirm that mobility hubs have the potential to play a significant role in enhancing access, promoting multimodal travel, and fostering sustainable transportation practices, with implications for urban planning, infrastructure development, and policy formulation in Gainesville and beyond.

4 Recommendations for Mobility Hub Development in Gainesville

4.1 Introduction

With the ever-evolving landscape of urban transportation, the development of mobility hubs (MHs) has emerged as a strategic approach to enhance connectivity, improve accessibility, and promote sustainable modes of travel in the City of Gainesville. In this chapter, we follow the steps shown in Figure 72 to provide recommendations for mobility hub planning and implementation in Gainesville, Florida. The recommendations are developed by drawing insights from a GIS-based analysis (Chapter 2), a survey conducted to understand Gainesville residents' travel behavior, modal preferences, and opinions toward mobility hubs (Chapter 3), as well as engaging with key stakeholders such as the Gainesville Department of Transportation and Gainesville Regional Transit System. Through objective data-driven analysis, coupled with community and stakeholder engagement, our aim is to provide valuable guidance for developing a resilient network of mobility hubs tailored to the specific needs of Gainesville.

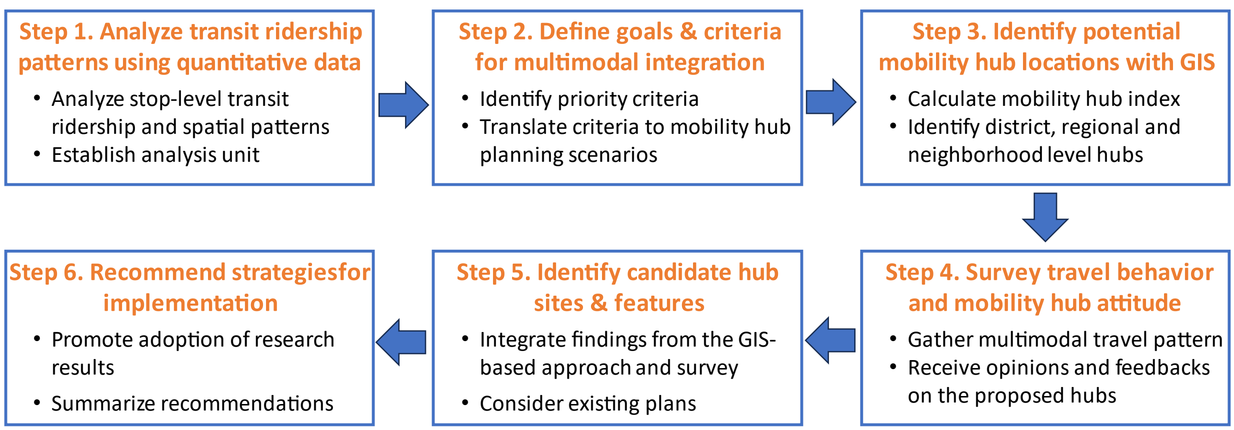


Figure 72: Steps for mobility hub planning and development

4.2 Suggestions and Recommendations

4.2.1 Synthesizing results from the GIS-based approach and the survey

Through the GIS-based approach, we have identified a total of 17 candidate mobility hub sites. We continue with numbering in

. Table 27 summarizes the results regarding mobility hub selection and preferences derived from the GIS-based approach and survey responses. The table includes the mobility hub ID (MH#), the nearest bus stop to each hub, the number of times each hub was identified as a neighborhood, district, or regional hub across the six planning scenarios by the GIS-based approach. It also includes the number of times survey respondents indicated that they would be likely to use the hub, and the average distance each hub was moved.

Table 27: Summary results from the GIS-based approach and survey

MH #	Nearest bus stop	Number of times being identified as a hub across planning scenarios			Survey responses		
		Neigh-borhood	District	Regional	Freq. selected as a desirable site	Freq. being moved	Avg. moved dist. (mi)
1	North Walmart Supercenter	2	4	0	105	26	2.14
2	NW 31st Terrace @ Nearside NW 53rd Ave	1	0	0	14	10	2.19
3	Southeast Car Agency	3	0	0	35	9	1.78
4	Alachua County Jail	3	3	0	98	8	1.91
5	Gainesville High School	4	2	0	236	46	1.43
6	NE 15th St @ NE 20th Place	4	0	0	40	15	1.20
7	Westside Baptist Church	1	0	0	17	5	1.89
8	Oaks Mall @ NW 62nd St	1	4	0	249	10	2.67
9	The Wynwood Apartments	2	0	0	105	18	1.76
10	Rosa Park Downtown Station	3	2	1	422	41	0.93
11	SE Hawthorne Rd @ SE 21st St Eastbound	5	1	0	70	12	1.42
12	Sunrise Subdivision	2	0	0	26	16	1.77
13	Shands Hospital	0	0	5	374	57	1.16
14	Butler Plaza Transfer Station	5	1	0	424	20	1.15
15	Prairie Elementary School	6	0	0	86	50	1.96
16	Westbound SW 40th Place @ NW 26th Terrace	5	1	0	170	54	1.37
17	Publix @ Tower Square on SW 75th Street	1	0	0	14	5	1.89

4.2.2 Recommendation on mobility hub locations

From Table 27 we obtain valuable insights that can guide recommendations for mobility hub locations in Gainesville:

- High-potential Locations: Potential hub locations such as the North Walmart Supercenter, Oaks Mall @ NW 62nd St, and Rosa Park Downtown Station are recognized by both the

GIS-based analysis and survey responses, indicating their importance and potential suitability as mobility hubs.

- Strategic Locations for Enhancing Accessibility/Connectivity: Hubs located near major transit stops or transportation nodes, such as Gainesville High School and Butler Plaza Transfer Station, demonstrate strategic accessibility and connectivity within the city's transportation network. Prioritizing such locations can enhance the effectiveness and usability of mobility hubs, as they are also highly valued by the survey respondents.
- Regional Considerations: It's crucial to recognize certain hubs with regional significance that can profoundly impact overall transportation networks. For instance, despite being the 3rd most popular among respondents, hubs like the Shands Hospital hold potential as vital regional hubs owing to their strategic location and accessibility.
- Movements Suggested by Respondents: Analyzing average hub movement frequency and distances from respondents provides valuable community insights. The trend of relocation is towards the UF campus or dispersion for citywide coverage. Hubs with shorter move distances may require minimal adjustment to align with community preferences, presenting promising options for mobility hub development. However, we should also acknowledge potential biases in respondent movements, which may skew results towards personal convenience rather than broader community needs.

Note that there is also a notable discrepancy between the GIS-based results and the survey results. While the GIS approach identifies hubs across the city, the survey results indicate a general preference among respondents for hubs to be located at dense areas and not at remote areas. This may be because of the overrepresentation of survey respondents living in central and dense areas. However, the transportation system is charged with the coverage goal, which means a mobility hub network that can serve broader geographic area is often more desirable than a network that only serve high-demand areas. This sentiment is echoed by the study participants, as some respondents noted that certain areas are already adequately served. The city can potentially reconcile this by developing region- or district-level hubs in populated areas and expanding neighborhood-level hubs to less dense areas.

Based on the results obtained from both the data-driven GIS analysis and the community feedback from the survey, we make the following final recommendations regarding the designation of mobility hubs at different levels:

- *Regional-level Hubs*
  At the regional level, mobility hubs play a crucial role in facilitating seamless transportation connections across broader geographic regions. Shands Hospital (#13) stands out as an ideal candidate for a regional-level hub, given its strategic location and emphasis on efficient transit integration.
- *District-level Hubs*
  District-level mobility hubs serve as central points for transportation within specific urban districts, catering to the needs of localized populations and travel demands. Butler Plaza Transfer Station (#14), Rosa Park Transfer Station (#10) and Oaks Mall (#8) are appropriate for district-level hubs. They are notably favored in community surveys and the GIS approach. This underscores the importance of prioritizing efficient transit access at key transportation nodes to enhance overall mobility and connectivity within the region.
- *Neighborhood-level Hubs*

Neighborhood-level mobility hubs are designed to meet the transportation needs of specific communities, offering localized services and amenities. Gainesville High School (#5), Westbound SW 40th Place @ NW 26th Terrace (#16 close to SW student apartment area), North Walmart Supercenter (#1), Alachua County Jail (#4, close to the Gainesville Regional Airport) and the Wynwood Apartments (#9, close to West University Ave @ SW 34th St) exhibit considerable potential as district hub candidates. These locations show a relatively high frequency of selection across multiple scenarios and are situated in areas that cater to significant local traffic.
Additionally, NW 31st Terrace @ Nearside NW 53rd Ave (#2), Southeast Car Agency (#3), NE 15th St @ NE 20th Place (#6), Westside Baptist Church (#7), SE Hawthorne Rd @ SE 21st St Eastbound (#11), Sunrise Subdivision (#12), Prairie Elementary School (#15), and Publix @ Tower Square on SW 75th Street (#17) are recommended as neighborhood-level hubs.

It is important to note that the final designation of hubs should also consider factors such as land availability, cost-effectiveness, environmental impact, and infrastructure compatibility. Additionally, further engagement of relevant stakeholders and community members may be necessary to refine these recommendations and ensure their alignment with community needs.

4.2.3 Development of mobility hub features

Based on the survey results, we have identified key mobility hub features as desired by respondents:

- Prioritize parking spaces for personal cars, as nearly 60% of respondents consider them important. This suggests a strong interest for park-and-ride services.
- Include bike/e-scooter racks and ride-hailing pick-up/drop-off zones, as roughly half of respondents find them important for multimodal connectivity.
- Integrate parking for shared mobility and charging stations for electric vehicles to support sustainable transportation options, a need indicated by about 40% of respondents. Many respondents stressed the importance of providing charging options for e-bikes.
- About 80% of the respondents suggest the need for providing non-transportation amenities, such as safety features, comfortable waiting areas, and access to information. They emphasized the importance of charging options for cell phones and laptops, as well as the availability of different services (e.g., package delivery locker, Wi-Fi, nearby food/retail etc.). The finding of respondents valuing non-transportation related amenities over transportation related amenities is consistent with a recent Boston survey.[6]
- About 70% of respondents noted that mobility hub use can be incentivized by improving pedestrian/cyclist infrastructure around hubs and providing a single interface for planning, booking, and paying for multiple transportation modes.

By implementing these mobility hub features, the city can create mobility hubs that are accessible, sustainable, and tailored to the needs and preferences of its residents.

[6] https://www.youtube.com/watch?v=qc8KHH-ZsVw&t=2939s

4.3 Implementation of Research Results

This product has produced an analytical tool for mobility hub planning and development that can be used across U.S. cities. In addition, the project team has assisted the City of Gainesville in the creation of a Mobility Hub Development Plan. Based on these results, the city staff and the research team have been actively collaborating to apply for funding opportunities to implement/demonstrate mobility hubs at strategic locations. In April 2024, the City of Gainesville were awarded $189,820 from the U.S. Department of Energy (DOE)'s Energy Efficiency and Conservation Block Grant (EECBG) Program.[7] This grant will allow the city to plan and install climate-controlled bus shelters at some of its locations, prioritizing the mobility hub locations as identified in this study. These shelters will help promote the use of travel modes alternative to cars, improve multimodal travel experience, enhance overall transportation energy efficiency, and contribute to the creation of a more environmentally friendly and resilient community.

[7] https://www.gainesvillefl.gov/News-articles/Gainesville-receives-federal-award-to-fund-local-energy-efficiency-upgrades

5 Recommendations for Mobility Hubs in West Palm Beach

To ensure that the mobility hub identification tool developed from this project can be widely applied by Florida cities and beyond, we applied it to another Florida city (e.g., West Palm Beach). Specifically, we replicated the steps described in Chapter 2, 3, and 4 to identify mobility hubs in West Palm Beach. A key focus of said task was to examine if the proposed tool and data gathering/analysis procedure can be transferable to a context different from Gainesville. Through objective data-driven analysis, as well as community and stakeholder engagement, we provide valuable guidance for developing a suitable network of mobility hubs tailored to the specific needs of the City of West Palm Beach, with consideration of broader regional needs throughout Palm Beach County.

5.1 Background of Palm Beach County

The US Census estimate the population of Palm Beach County to be 1.52 million and the population of the City of West Plam Beach to be 120,932 as of July 1, 2022[8]. Palm Beach County is located in southeastern Florida ranging roughly from the Atlantic Ocean on the east to the Everglades and Lake Okeechobee on the west. The population is concentrated on the eastern third of the county around the I-95 and Tri-Rail corridors; most of the west of the county is agricultural or preservation lands. There are some small, predominantly minority communities in western Palm Beach County near Lake Okeechobee, collectively known at "The Glades."

There are two transit services operating in Palm Beach County. PalmTran (https://www.palmtran.org/) is the public-sector transit agency running buses and paratransit. Tri-Rail (https://www.tri-rail.com/) is a north-south commuter rail corridor with six stations in Palm Beach County (one in West Palm Beach) operated by the South Florida Regional Transportation Authority. Notably, Tri-Rail connects commuters in Palm Beach County to destinations in Broward County and Miami-Dade to the south. In addition to transit, Brightline (https://www.gobrightline.com/) is a private-sector company running a high-speed intercity rail line that connects Miami to Orlando, with two stops in Palm Beach County, one in West Palm Beach and the other in Boca Raton.

5.2 Review of Existing Plans

We review the following plans concerning transit or transportation in the City of West Palm Beach or Palm Beach County:

- Vision 2050, The Long Range Transportation Plan from the Palm Beach Transportation Planning Agency (2024)
- The Palm Beach Transportation Planning Authority Strategic Plan (2024)
- The Palm Beach Transportation Planning Authority Transportation Improvement Plan (TIP) (2024)
- The Palm Tran Transit Development Plan FY 2023 Update (2022)
- The Downtown Intermodal Coordination Summary Report (2023)

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[8] https://www.census.gov/quickfacts/palmbeachcountyflorida
https://www.census.gov/quickfacts/fact/table/westpalmbeachcityflorida,palmbeachcountyflorida/PST045222

- The US-1 Multimodal Corridor Study “Coffee Book” (2018)
- The Downtown West Palm Beach Mobility Study (2018)
- The Downtown Mobility Plan, adopted by the City of West Palm Beach (2018)

Although multiple plans focus on increased multimodal development in and around the City of West Palm Beach, few plans mention the concept of Mobility Hubs or discuss bus stop station amenities in detail. Increased multimodal development is mentioned in Vision 2050, The PBTPA Strategic Plan, the Transit Improvement Plan, the US-1 Coffee Book, and the Palm Tran Transit Development Plan. The concept of multimodal integration is well supported throughout these planning documents.

Several plans envision enhanced bus service in the planning area. Enhanced transit corridors are proposed for Okeechobee, Military, and US-1 in the Vision 2050 Plan. In addition, the Vision 2050 Plan identifies Transit Hubs at the following locations: The Palm Beach International Airport, the West Palm Beach Tri-Rail Station, the West Palm Beach BrightLine station at Quadrille Boulevard and Clematis, and Congress and Palm Beach Lakes, near the Tanger Outlets. The Palm Tran Transit Development Plan clearly calls out the West Palm Beach Intermodal Center as its regional transit hub, located at the West Palm Beach Tri-Rail station. Other major transfer stations are located throughout Palm Beach County, outside of the West Palm Beach area.

Improved shared mobility or micromobility options are also mentioned in several plans, especially the more local plans, such as the West Palm Beach Downtown Mobility Plan, the Downtown Intermodal Coordination Summary Report, and the US-1 Corridor Coffee Book. Interestingly, the Okeechobee Boulevard Multimodal Corridor study does not discuss micromobility or shared bikes as a consideration.

Improvements to bus stops or station areas are discussed in several plans, though this is rarely an area of existing plan focus. The US-1 Corridor Coffee Book discusses the importance of protection from weather, seating, real-time travel information, and wayfinding. A graphic of desired station amenities is provided. The Palm Tran Transit Development Plan includes funding for bus stops improvements and improved bus shelters. Increasing the number of bus stops with a shelter and/or seating is an explicit goal. The West Palm Beach Downtown Mobility Plan calls for real-time information at bus stops. The Okeechobee Multimodal Corridor study also calls for bus stop improvements, including bicycle racks, shelter from weather, trash cans, and seating.

Several plans also include a discussion of expanded or improved park-and-ride facilities. The Palm Tran Transit Development Plan calls for new park-and-ride facilities and a park-and-ride evaluation study of existing facilities. One of the existing park-and-ride facilities is the proposed mobility hub location at Congress and Palm Beach Lakes. The Okeechobee Boulevard Corridor study also recommends additional park-and-ride facilities at key locations.

Finally, the Downtown West Palm Beach Mobility Plan explicitly calls for the establishment of a new Mobility Hub at the “Tent Site” downtown, located at the crossroads of Okeechobee Boulevard and Dixie Highway. This Mobility Hub is called to serve regional bus routes, local trolley, bike share, and car share services.

5.3 Methodology

5.3.1 The adapted approach

In order to identify mobility hubs for West Palm Beach, we ran analyses at both the county-wide level for all of Palm Beach County and within just the City of West Palm Beach. After reviewing a series of alternative options, we identified five (5) mobility hubs within the City of West Palm Beach as preliminary recommendations for the purposes of survey feedback.

Figure 73: High-Level Overview of the Mobility Hub Analysis Identification Process

Figure 73 provides an overview of the proposed approach which includes the following 5 steps:

1. **Identify transit stop clusters** – Mobility hubs occur around transit stops. However, sometimes several transit stops are quite close together in space and could be considered part of a single mobility hub. Therefore, as our first step, we cluster transit stops that are proximate into groups, where any group may qualify as a mobility hub in future steps. In addition to transit bus stops, we also focused on two railway stations and created buffer zones as spatial units: Tri-rail and Brightline. These stations are located in downtown West Palm Beach and have high levels of passenger ridership.
2. **Generate buffer analysis areas** – To decide if a cluster should qualify as a mobility hub, we examined the transit operations, population, and built environment characteristics of the surrounding area. The size of the buffer area we examined depended upon the level of mobility hub we are considering – neighborhood, district, or regional.
3. **Calculate sub criteria for each hub** – We calculated five relevant sub-criteria for each hub: transit ridership and supply, first/last mile connectivity, infrastructure readiness, socio-demographic considerations, destination accessibility. The details of these calculations are described in section 2.4 Analytical Steps and are not repeated here.
4. **Weight sub-criteria into a single mobility hub score** – We weighted the five sub-criteria into a single mobility hub score for ranking mobility hub suitability. Higher-scoring clusters are the most suitable as mobility hubs. We considered a range of weighting schemes. Each weighting scheme corresponds to a different priority among the stakeholders who will ultimately decide where mobility hubs should be located.
5. **Recommend mobility hub locations** – We selected the highest-ranking locations based on the overall mobility hub score, but then excluded other nearby locations to avoid redundancy. After excluding nearby locations, we selected the next highest rank locations. In this way, we identified the most suitable locations with a fair amount of geographic diversity. Geographic diversity can also be altered by changing the weighting criteria.

As the City of West Palm Beach differs from Gainesville in several ways, we adapted our algorithm to account for said differences. First, the City of West Palm Beach has commuter rail, locally known as Tri-Rail. We included Tri-Rail stops and their ridership in the analysis alongside bus stops, but otherwise treated them in a similar fashion to bus stops. Second, as West Palm Beach is more urban with generally higher population densities, we allowed mobility hubs to be located closer together, with a minimum buffer of 1.2 miles instead of 1.5 miles for Neighborhood hubs as in Gainesville.

5.3.2 Data

Five types of data are required for the proposed mobility hub identification process:

- Transit ridership and supply
- First mile/last mile connectivity
- Infrastructure
- Sociodemographic
- Accessibility (ease of access to the hub by various modes)

Transit ridership and supply data

The bus routes and stops information are collected from the General Transit Feed Specification (GTFS) dataset, a public dataset for transit schedules and associated geographic information. Bus ridership data (including both boarding and alighting passenger counts) was provided by PalmTran for the year 2023. Tri-Rail ridership data was provided by the South Florida Regional Transportation Authority for the year 2023.

First-mile/last-mile connectivity data

First-mile/last-mile (FMLM) connectivity data concerns the current location of jobs and population and how proximate transit stops are for jobs and population. The base data sources for these calculations come from the American Community Survey (ACS) and LEHD Origin-Destination Employment Statistics (LODES). ACS is a survey conducted by the U.S. Census Bureau and includes detailed demographic, economic, social, and housing data. LODES provides employment and workplace characteristic data at the Census block level. To calculate the census block level FMLM gap, we require the latest block level population data from ACS and job data from LODES.

Infrastructure data

Mobility hubs must contain infrastructure for pedestrians and cyclists, which includes two aspects of data: intersection density and road infrastructure for pedestrians and cyclists. The intersection density data is collected from Smart Location Database[9], a nationwide geographic data resource for measuring location efficiency that includes neighborhood design, destination accessibility and transit service. From the Smart Location Database, we collected intersection density at which multi-modal facilities or pedestrian-oriented facilities met and where the number of legs was greater than 4. The road infrastructure data is collected from OpenStreetMap (OSM), which provides detailed information about road networks.

Sociodemographic data

For sociodemographic considerations, we take into account five variables regarding household characteristics such as age, income, disability status and vehicle ownership etc. This data is also collected from ACS at the Census block group level. For this analysis, we used data from the 2020 version of the ACS.

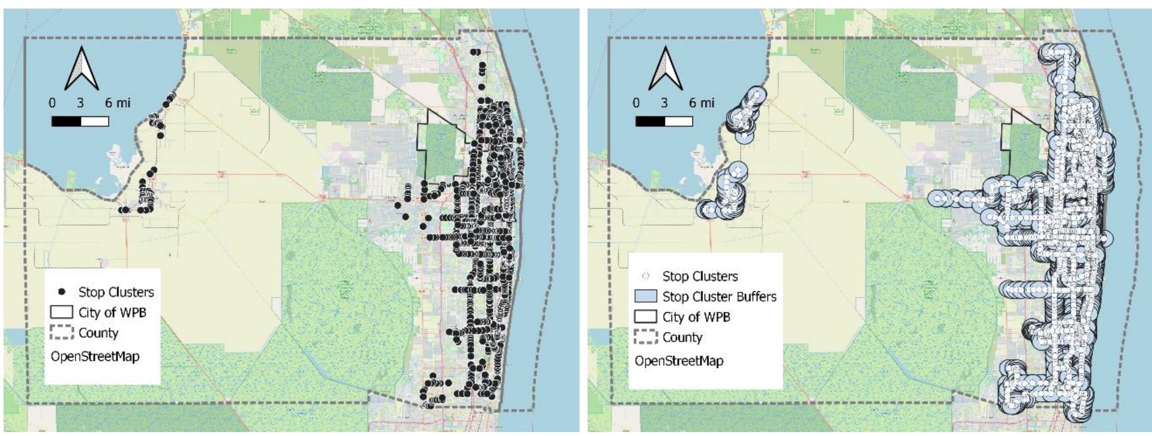
[9] https://www.epa.gov/smartgrowth/smart-location-mapping

Accessibility data
Mobility hubs aim at enhancing the accessibility to destinations. To measure the accessibility, we collected data regarding destination accessibility via auto or transit from Smart Location Database. To evaluate the walkability around bus stops as another measurement of accessibility, we also collected Walk Score for each transit stop cluster from WalkscoreAPI[10].

5.4 Analytical steps

5.4.1 Identification of Transit Stop Clusters

All Tri-Rail stops and the BrightLine stop were automatically identified as potential locations for mobility hubs and were buffered and entered into the analysis for next steps. Regarding bus stops, we again applied DBSCAN clustering algorithm. We set the search distance as 100 meters and the maximum bus stop number of each cluster as 10. This generated 1,897 grouped clusters among 2,981 stops. We then created 1 mile buffer zones around each cluster as the spatial unit in our analysis (see Figure 74). Note that there may be spatial overlap between the analysis areas for different transit stop clusters.



(a) Transit Stops 5 (b) 1-mile Buffer Zone Around Transit-Stop Clusters
Figure 74: Bus Stop and Clusters

5.4.2 Calculation of sub criteria scores

We calculated the following sub- criteria and criteria using the corresponding datasets (see Table 28).

Table 28: List of Criteria and Sub-criteria

Criteria	**Transit Ridership and Supply**	**FMLM Connectivity**	**Infrastructure Readiness**	**Socio-demographic Considerations**	**Destination Accessibility**

[10] https://www.walkscore.com/professional/api.php

Sub-criteria	Service frequency	FM/LM gap score	Intersection density; Bike lanes; Sidewalks	Household without vehicle; People living in rental units; People in Poverty; People with Disabilities etc.	Destination accessibility via auto; Destination accessibility via transit; walk score
Source	City	ACS, LEHD	Smart location; OSM	ACS	Smart location; Walkscore API

Table 29 below summarizes the descriptive statistics of the variables considered in the 5 sub-criteria.

Table 29: Description of Sub-criteria Variables

Criteria	**Sub-criteria**	**Variable**	**mean**	**median**	**max**	**min**
Transit Ridership & Supply	Ridership	Passenger count	773.06	190.33	145736.50	0.00
	Service frequency	Number of unique bus routes	1.80	2	23	1
		Number of bus stops in cluster	1.57	2.00	13.00	1.00
		Total number of buses passing the stop	95.37	75	1894	8
First-/last-mile Connectivity	FM/LM gap	FM/LM gap score	6391.33	5345.00	26917.00	69.00
Infrastructure Readiness	Intersection density	Multimodal intersection density	8.00	5.79	49.95	0.05
		Pedestrian-oriented intersection density	19.28	16.09	82.64	0.07
	Bike lanes	Bike lane length	0.04	0.03	0.32	0.00
		Ratio of bike lane length to road network length	0.03	0.02	0.21	0.00
	Sidewalks	Sidewalk length	0.59	0.62	0.98	0.00
		Ratio of sidewalk length to road network length	0.41	0.41	0.71	0.02
Socio-demographic Considerations	Socio-economic & demographic variables	% households without vehicles	7.77	7.15	30.07	0.42
		% Black residents	26.42	22.16	85.54	0.35
		% residents living in rental units	39.60	39.55	91.86	6.34
		% residents in poverty	14.60	13.22	46.47	2.66
		% residents with disabilities	5.08	4.97	19.55	0.86
Destination Accessibility	Accessibility via auto	Number of jobs within 45 minute travel time by automobile	69591.87	75225.52	103674.93	700.25
	Accessibility via transit	Number of jobs within 45 minute travel time by transit	13126.29	16835.40	111643.25	0.00
	Walkability	Walkscore	49.83	50	99	0

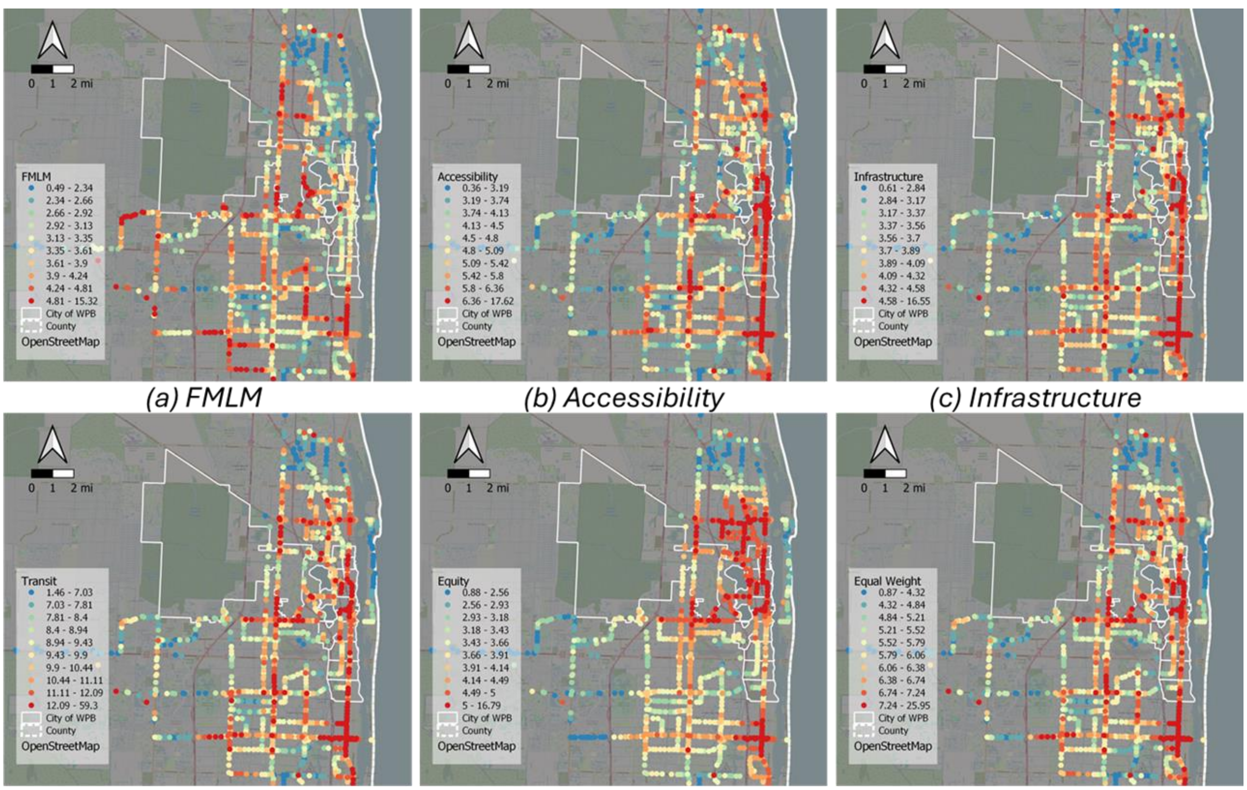
5.4.3 Weighting of Sub-criteria into an Overall Mobility Hub Index

The mobility hub index is the weighted sum of the index score of each criterion. We provide six different weighting schemes (see Table 30). Five weighting schemes weigh a single sub-criteria at

50% weight, with the other sub-criteria at 12.5% weight. The final weighting scheme weighs all sub-criteria equally (20% each). Figure 75 shows the mobility hub index results across the scenarios.

Table 30: Scenario Weight Comparison

Criteria (score)	Accessibility	Transit	Socio-demographic	Infrastructure	FMLM	Equal Weights
Transit Ridership and Supply Score	0.125	0.5	0.125	0.125	0.125	0.2
First/Last Mile Connectivity Score	0.125	0.125	0.125	0.125	0.5	0.2
Infrastructure Readiness Score	0.125	0.125	0.125	0.5	0.125	0.2
Socio-demographic Considerations Score	0.125	0.125	0.5	0.125	0.125	0.2
Destination Accessibility Score	0.5	0.125	0.125	0.125	0.125	0.2



(a) FMLM (b) Accessibility (c) Infrastructure

(d) Transit (e) Socio-demographic (f) Equal Weight

Figure 75: Mobility Hub Index City-Wide Maps of Six Scenario

5.4.4 Identification of Recommended Mobility Hub Locations

By weighting each criterion, we can compute the mobility hub index score of each spatial unit. To identify multiple mobility hubs from the spatial units, we implemented an algorithm to choose from the spatial unit following four steps:

1. Select the existing (or planned) mobility hubs.

2. Exclude all potential hubs within 1.5 mile of the selected hubs from considerations

3. Select the hub with the highest mobility hub index as the next hub

4. Repeat steps 2 and 3 until the service coverage is >60% or the total number of hubs reaches the predefined number.

5.5 West Palm Beach (WPB) Survey Analysis

5.5.1 WPB Survey Responses

The West Palm Beach team was concerned that the original survey was too long and would deter responses. Therefore, in consultation with the UF team, we reviewed the survey and reduced its length, making sure to keep the most critical questions for purposes of comparison. The net result was a reduction from 166 to 78 queries (if each response is considered a separate query). A significant portion of the reduction came by requiring respondents to respond to a single set of recommended mobility hub locations rather than two sets. In addition, certain mobility options that were available in Gainesville were not available in West Palm Beach, such as shared electric scooters. On the other hand, electric shuttles from Circuit were available in West Palm Beach at the time of the survey. Therefore, appropriate adjustments to the survey were made to correspond with available travel modes.

The survey was then pilot tested by the West Palm Beach team and a small group of local professionals. We made final revisions to the survey and launched it on March 22, 2024. We publicized the survey primarily through email and through our professional networks. A link to the survey was provided on the Center for Urban and Environmental Solutions home page (www.cues.fau.edu). Professional organizations that helped us publicize the survey include: the Treasure Coast Regional Council, the West Palm Beach Mobility Coalition, BrightLine, the South Florida Regional Transit Authority, the downtown West Palm Beach CRA, and Palm Beach County Transportation Planning Agency, and the City of West Palm Beach.

In addition, a team of students spent two days, March 29 (Friday) and March 30 (Saturday), disseminating postcards with links to the survey at four high-traffic transit station areas. Where possible, the students also conducted intercept surveys through portable tablets on site.

The survey was closed on May 15th, 2024, after a period of 85 days and multiple rounds of email publicity. At that time, 1,274 survey responses had been started. After reviewing surveys for quality, including Qualtrics scores for screening out bots and a visual inspection of survey responses, we deemed 500 responses from West Palm Beach to be of high quality and likely from human responders.

5.5.2 Sociodemographic Profile of the WPB Survey Respondents

Table 31 displays a demographic overview of respondents. The largest age segment is the group aged 18-30, which constitutes 43% of survey respondents. The age group between 31-40 is also overrepresented, constituting 28% of the sample but only 14.6% of the City of West Palm Beach population. Older ages are underrepresented, with those over 65 comprising just 9% of the sample but 19.5% of the West Palm Beach population. The gender balance is close to evenly split between men and women with less than 1% reporting non-binary status.

The educational attainment in our sample is higher than for the city as whole. College graduates constitute 41% of our sample but just 23.8% of the city's population. The next most common group is persons with a post-graduate degree, who comprise 19% of our sample but 14.4% of the population.

In comparison with the Gainesville sample, we have significantly fewer students, with just 18% of respondents identifying as either full or part time students, in comparison with 68% in Gainesville. While 92% of respondents reported no disability, 4% cannot bike, 3% cannot use an e-scooter, 3% cannot walk 5 minutes or more, and 2% use a wheelchair for mobility. This compares with 4.7% of West Palm Beach residents overall reporting an ambulatory difficulty.

Our sample is somewhat skewed racially. 68% of the sample is White (not biracial), in comparison to 43% of the West Palm Beach population. Only 18% of our survey sample were Black and 12% Hispanic or Latino, in comparison with 31.6% and 24.6% reported in the 2020 West Palm Beach census.

Table 31: Demographic Characteristic of West Palm Beach Survey Respondents

Demographic Characteristics	**Percent**
Age	
0-18	2%
18-30	43%
31-40	28%
41-50	7%
51-65	11%
66+	9%
Gender	
Female	51%
Male	48%
Non-Binary	0%
Student	
Not a student	82%
Full-time student	11%
Part-time student	7%
Highest Educational Level	
College Graduate	41%
Post-Graduate Degree	19%
Some college	18%
Vocational Training	10%
HS Graduate	10%
Some HS	1%
Disability	
None	92%
Cannot bike	4%
Cannot e-scooter	3%
Cannot walk 5 mins	3%
Wheelchair	2%
Difficulty outside home	1%
N.B.: Multiple categories allowed, so may sum to over 100%	

Race or Ethnicity	
White	68%
Black	18%
Hispanic/Latino	12%
Native American	4%
Asian	2%
Pacific Islander	2%
Other	0%
N.B.: Multiple categories allowed, so may sum to over 100%	

Table 32 presents the economic characteristics of West Palm Beach survey respondents. The respondents represent a wide range of household incomes, with 17% having household incomes below $50,000, 29% having incomes of $50,000-74,999, 21% having incomes of $75,000-99,999, and 33% with incomes over $100,000. This is skewed toward higher incomes than the typical transit rider. The median household income reported from the US Census for 2022 was $71,138.

Most of our survey sample is employed full-time (74%), with the next most common categories being employed part-time (9%) and retired (9%). The high proportion of employed full-time may reflect a commuting population.

Table 32: Economic Characteristics of West Palm Beach Survey Respondents

Economic Characteristics	Percent
Household Income	
Less than $25,000	5%
$25,000-49,999	12%
$50,000-74,999	29%
$75,000-99,999	21%
$100,000-124,999	16%
$125,000-149,999	6%
$150,000 or more	12%
Primary Occupation	
Employed full-time	74%
Employed part-time	9%
Retired	9%
Self-employed	5%
Not currently employed	2%
Homemaker	1%
Volunteer	0%

By far, most respondents own a car (82%) with 11% owning no motorized vehicle. The remaining survey participants own a motorcycle or motorbike as their primary personal vehicle (7%).

Among all respondents living in households, most own two vehicles, 26% of households own ja single vehicle and 4% own no vehicles (Table 33). Among multi-person households, 73% own a car.

Table 33: Vehicle Holdings of WPB Survey Respondents

Vehicle Holdings (multi-person households)	**Percent**
Owns a Car	73%
No Personal Vehicle	11%
Owns a Car & Motorcycle	9%
Owns a Motorcycle/Motorbike	7%
Number of Household Vehicles (all respondents)	
0	4%
1	26%
2	47%
3	12%
4 or more	10%

5.5.3 Current Travel Behavior and Concerns of WPB Respondents

As shown in Figure 76, traditional modes outpace shared mobility modes among our respondents. Personal car and walking are the most common modes, with about 65% driving at least once a week and 60% walking at least once a week. Buses are taken once a week by about 40% of respondents and trains by 25% of respondents. Shared bikes, shared cars, and taxis are all similar at close to 20% of respondents using these shared mobility modes once a week or more. Shared micromobility and shared cars are rarely used (less than once a year) among about 40-45% of the survey population; ride-hailing is used a bit more frequently.

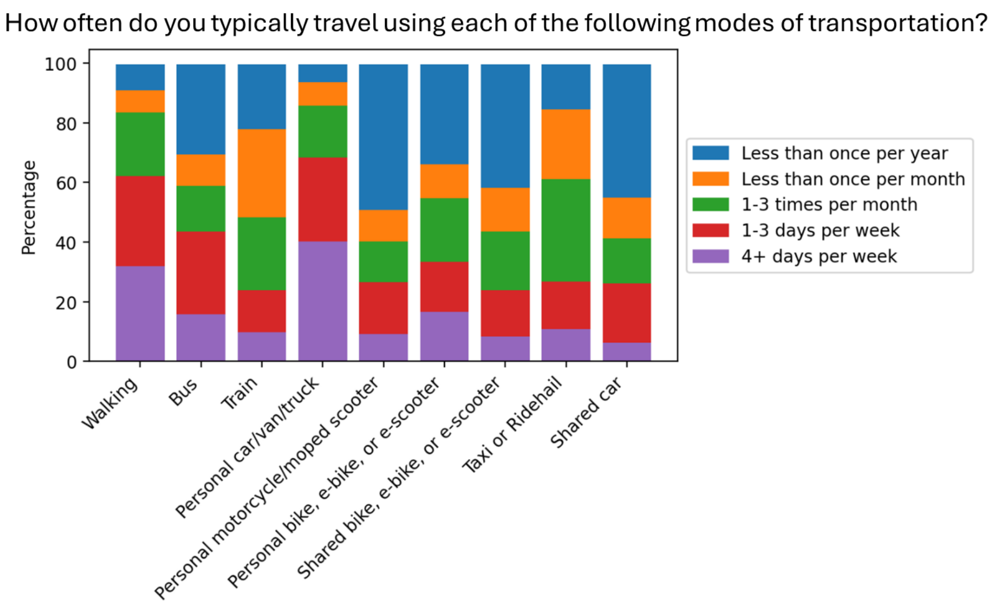


Figure 76: Current Modal Frequency for WPB Respondents

Regarding opinions about current WPB transportation system (see Figure 77), a majority of West Palm Beach survey respondents say that shared bicycles benefit the city (65%), that transit is easily reachable by walking (55%) and that transit is easily reachable by bike or e-scooter (60%). Only about 10% disagree with such statements, indicating an openness to reaching transit by nonmotorized means.

About 35-45% also find problems with multimodal travel connecting to transit. Similar numbers report that finding bike or scooter parking near transit stops are difficult; that transit stops are often too far from destinations, that sidewalks are inadequate near transit stops, that crosswalks are inadequate near transit stops, or that bike lanes do not connect to transit stops. The strongest disagreement among these statements concerns adequate sidewalks, suggesting that the concern around the level of sidewalks is a bit less than other concerns.

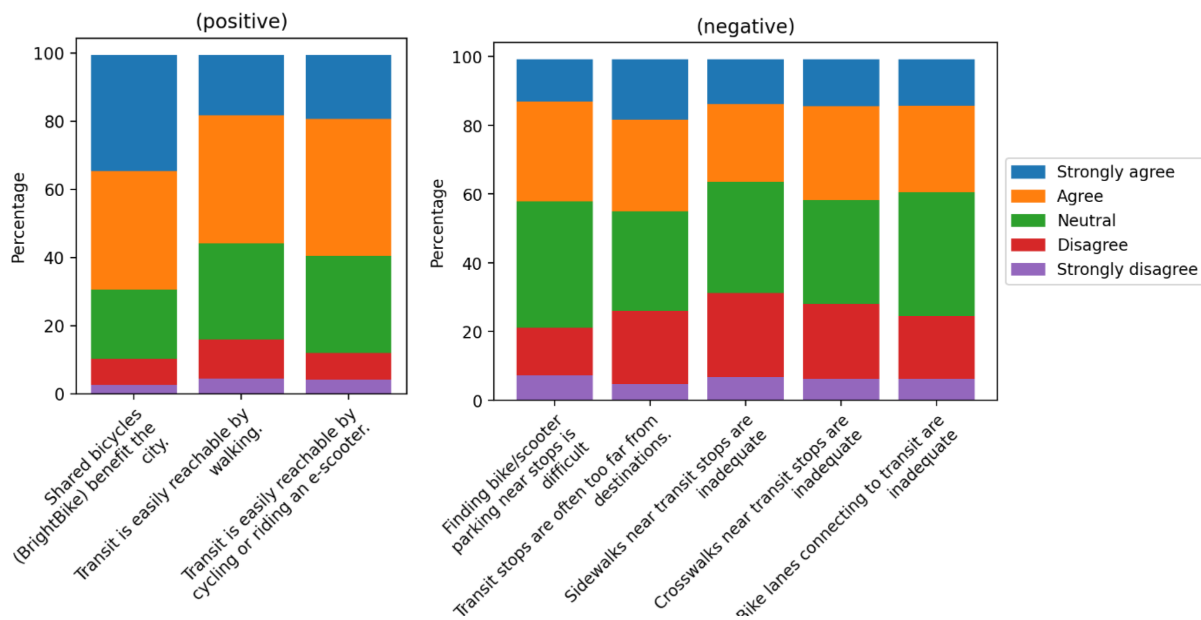


Figure 77: Opinions about Current WPB Transportation System

5.5.4 Attitude and Behavior about Transit for West Palm Beach Respondents

As shown in

, Most of the survey population regularly considers transit as an option. A total of 33% say they consider transit frequently or always, and an additional 42% consider it sometimes. Many switch to other modes after considering transit. 55% of responses say they consider transit and then switch to another mode, with 18% saying they switch frequently and 19% reporting they do so rarely. 26% of respondents report that the distance from the transit stop to the destination is an obstacle almost always, whereas 52% report that it is sometimes an obstacle. Moreover, 10% of the respondents report not using transit for reasons other than FMLM.

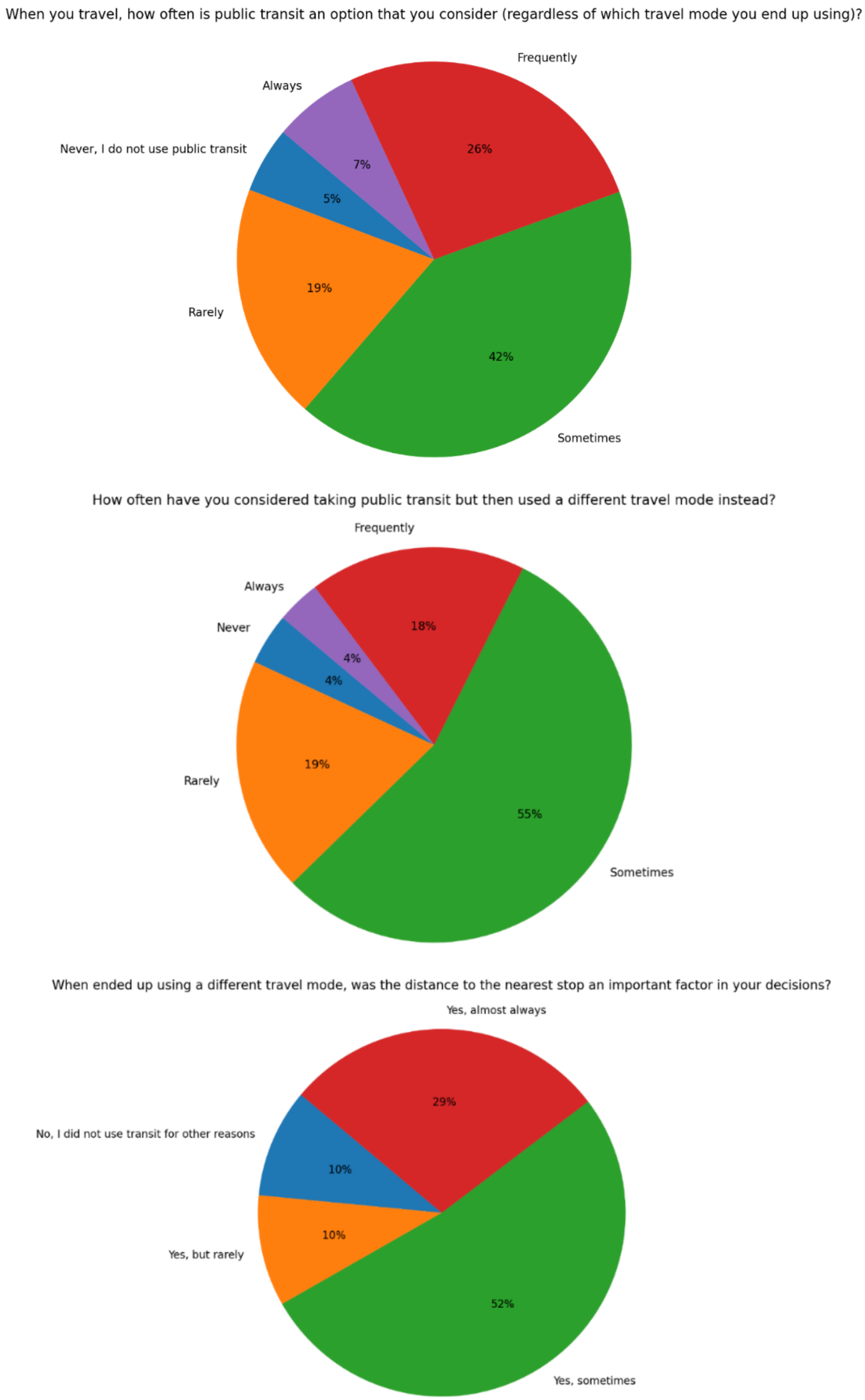


Figure 78: Transit Choice Factors for WPB Respondents

Many modes are currently used to access transit in West Palm Beach (see Figure 79). The most common access modes are walking and driving to the station, but ride-hailing, personal bike, shared bike, and microtransit shuttles (Circuit) are also mentioned for significant numbers.

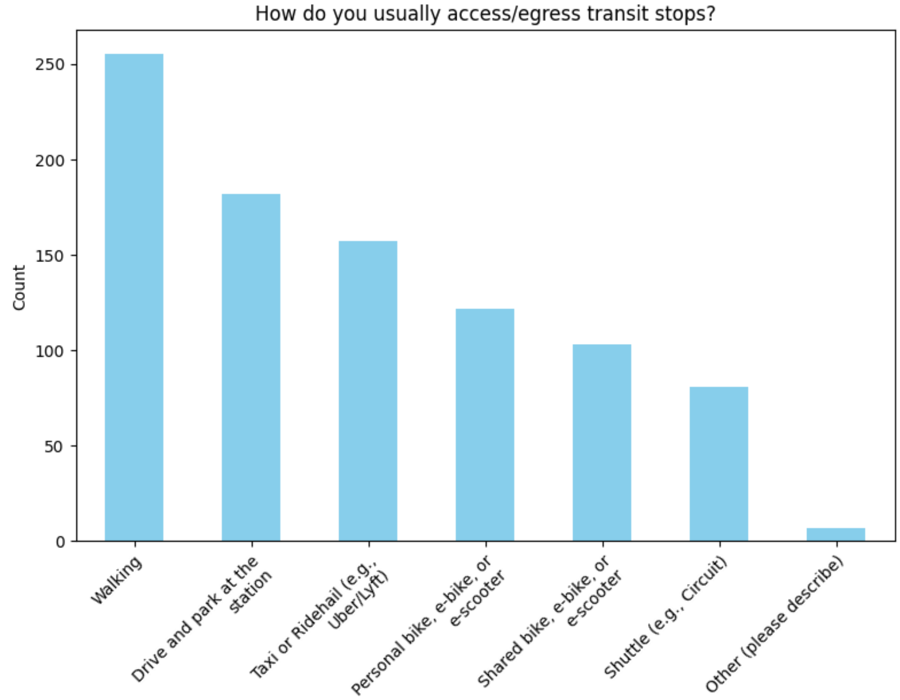


Figure 79: Access Modes for Transit for WPB Respondents

As shown in Figure 81, in terms of prospective improvements to transit, four of the top six responses concerned more frequent or more reliable service: More reliable service (#1), shorter waiting time (#3), shorter total travel time (#4) and more off-peak service (#6). The second most common answer was lower fares. Distance and multimodal concerns generally rated a bit lower, including transit stops closer to key destinations (#4) more mobility options at stops (#7) and better nonmotorized infrastructure (#10 & #11).

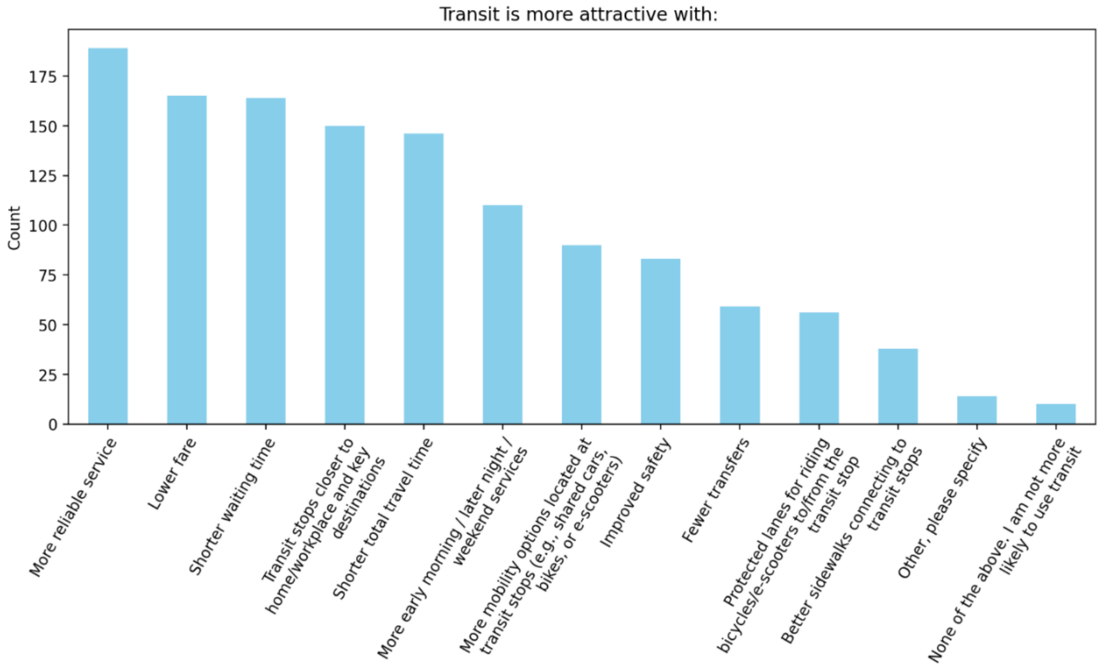


Figure 80: Desired Improvements to Transit for WPB Respondents

5.5.5 Multimodal Travel Behaviors in West Palm Beach

West Palm Beach respondents reported how frequently they engaged in certain kinds of multi-modal trips, as shown in Figure 82. The most common type of multimodal trip was personal car plus personal bike or scooter, in other words not making use of shared mobility services. About 30% of respondents (150 out of 500) reported using the following multimodal combinations at least once a week: train + personal bike or personal e-scooter, bus + personal bike or e-scooter, bus + shared bike, and personal car + shared bike. Therefore, our sample of informants report a significant usage of multimodal options, with slightly more reporting using personal bikes over shared bikes. If we include travelers who make use of multimodal options at least once a month, the percentage approaches 50% for many combinations (train + personal bike/scooter, train + shared bike, bus + personal bike/scooter, bus + shared bike, personal car + personal bike/scooter, personal car + shared bike).

The participants' description of the level of convenience of these multimodal options is fairly consistent across options. Approximately 50% rate all multimodal options as either "Convenient" or "Very Convenient," and only about 10% rate them as inconvenient or worse. This includes all six listed multimodal options: Train + personal bike/scooter, train + shared bike, bus + personal bike/scooter, bus + shared bike, personal car + personal bike/scooter, personal car + shared bike. Bus + shared bike scored slightly worse, with 46% rating this option as "Convenient" or "Very Convenient" and 11% rating it as "Inconvenient" or worse. Train + shared bike was by a small margin rated the most convenient option, with a total of 55% rating this option as "Convenient" or "Very Convenient."

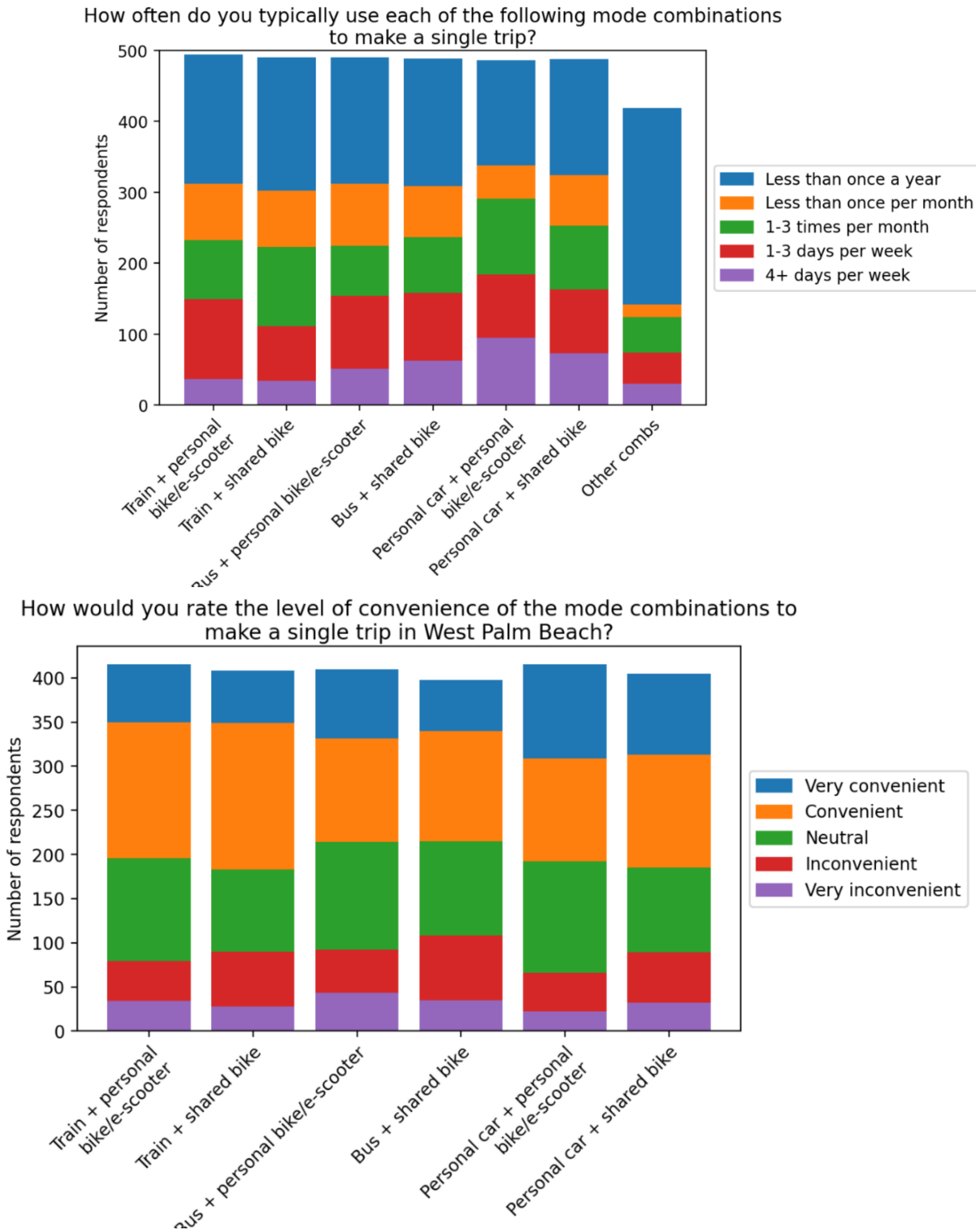


Figure 81: Multimodal Travel and Opinion among WPB Respondents

5.5.6 Attitudes Toward Mobility Hubs for WPB

As shown in Figure 82, respondents' attitudes towards the potential of mobility hubs to improve their travel experience is positive. About 80% responded affirmatively that they would use mobility hubs if they became available in West Palm Beach. This is notably higher than the current

50% who report multimodal behaviors. An additional 19% said that they might use new mobility hubs in West Palm Beach.

Likewise, by far most interviewees said that they would use transit more if mobility hubs were available, with 75% replying “Yes” and an additional 21% replying “Maybe.”

It should be said that the indefinite nature of the future Mobility Hub design may bias such responses, but nevertheless, our survey group seems positively inclined toward the potential of mobility hubs to improve the transit rider experience.

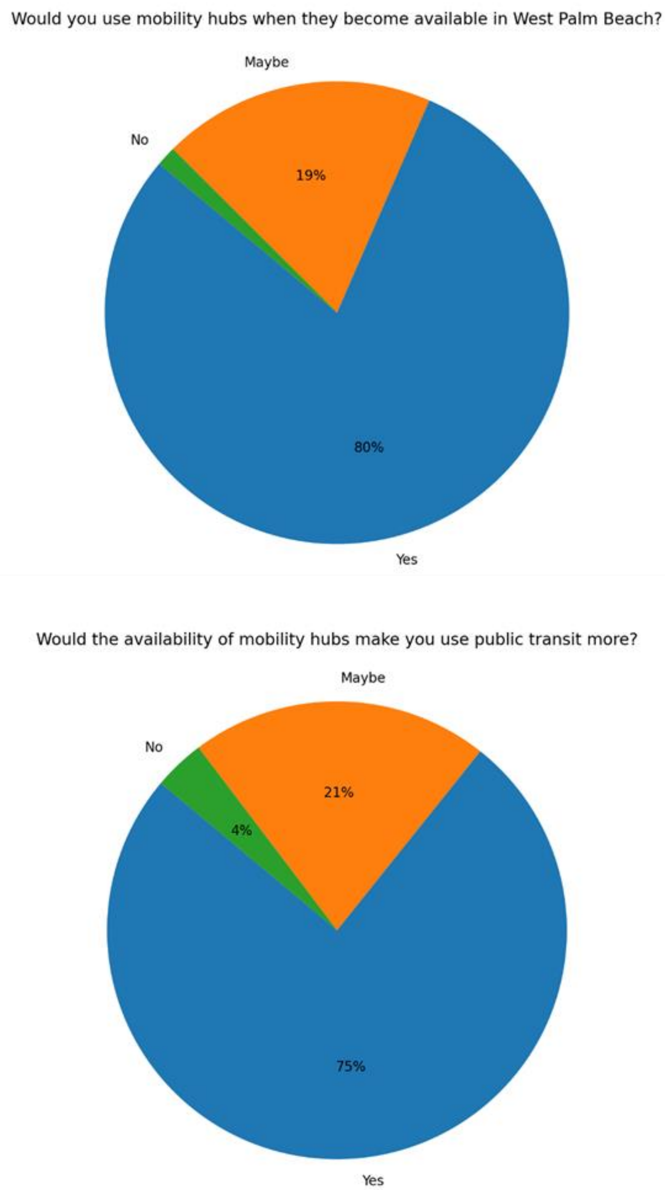
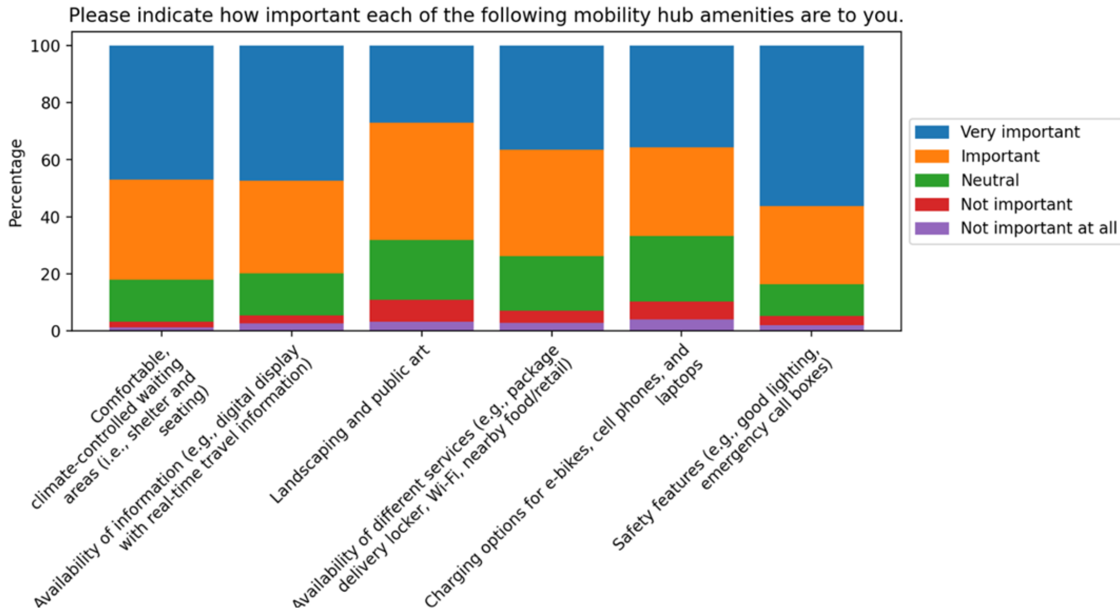


Figure 82: Support for Mobility Hubs in WPB



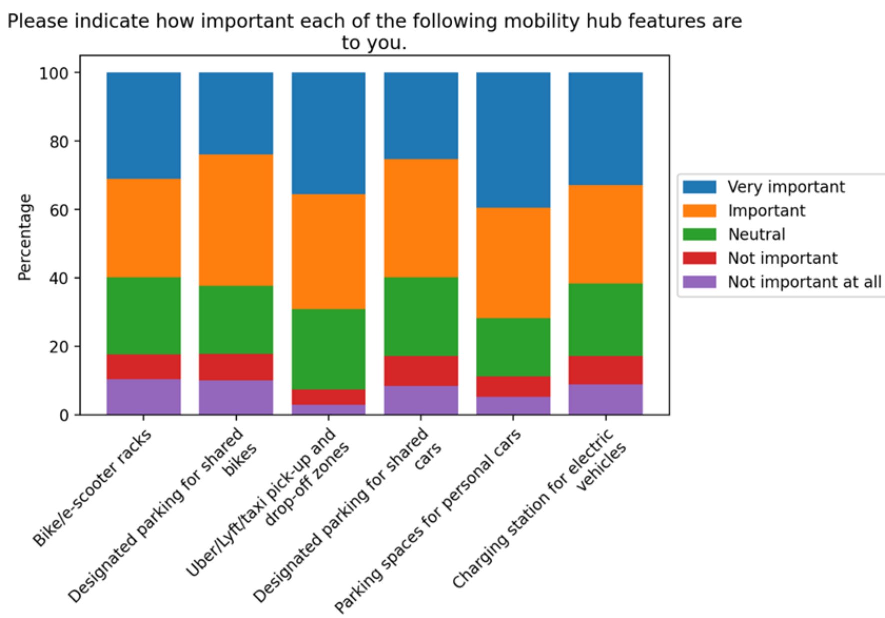


Figure 83: Desired Infrastructure and Amenities in WPB

As shown in Figure 82: Support for Mobility Hubs in WPB

, in terms of preferred infrastructure features and amenities, respondents had a broad interest, with a majority supporting most types of potential mobility hub features. 60% or more indicated bike/e-scooter racks, designated parking for shared bikes, ride-hailing/taxi pick up zones, parking for shared cars, parking for personal cars, and charging stations as important or very important infrastructure features. By slight margins, the most preferred infrastructure features were

pick-up zones for on-demand ride services and parking spaces for personal cars. This conforms with the fact that a significant access mode among respondents is drive-to-transit. Less than 20% deemed any of these infrastructure options unimportant.

At least 66% of respondents said that all six amenities were important or very important. Comfortable, climate-controlled waiting areas; real-time information, and safety features came in as the most popular options, rated as important or very important by over 80%. The least supported amenities were landscaping and public art, as well as charging options for e-bikes, cell phones, and laptops, but these two options were supported by at least 2/3 of responses.

5.5.7 Feedback on Mobility Hub Locations from West Palm Beach Respondents

The survey also provided respondents with an opportunity to respond in terms of preferred locations for Mobility Hubs. Survey participants both responded to the five (5) locations proposed by the algorithm and had an opportunity to propose their own locations.

Mobility Hub Siting Criteria

In terms of criteria for selecting mobility hub locations, the most commonly selected criteria were: Transit stops with the highest number of riders (27.5%), transit stops where riders can have access to the most destinations (24.7%), transit stops in underserved neighborhoods (18.1%), transit stops where transit riders need to travel longer distances to reach transit (15.3%), and transit stops with high-quality bicycle and pedestrian infrastructure (14.4%).

Feedback on Algorithm Locations

The survey presented participants with five locations within West Palm Beach identified through the data analysis as potential mobility hub locations (see Figure 85). These locations were:

1. Military and Hibiscus, just north of the commercial development at Military and Okeechobee Blvd
2. The West Palm Beach Tri-Rail Station
3. Congress and Palm Beach Lakes, near the Tanger Outlets
4. Dixie and 23rd Street, near the Northwood neighborhood
5. Dixie and Korn, near the Shops at Palm Coast Plaza

When asked which of the above mobility hubs they would be likely to use, 70% of participants chose the proposed mobility hub at West Palm Beach Tri-Rail station. By many measures, this stop already serves as a multimodal mobility hub, but additional improvements could be considered. For example, the Tri-Rail station could be improved by a climate-controlled waiting area; real-time bus information; places to get food or beverage while waiting; improved wayfinding; and charging facilities for phones and laptops. The next most popular mobility hubs were #3 Congress and Palm Beach Lakes (49%), #4 Dixie and 23rd (46%) and #5 Dixie and Korn (41%). Of least interest was the proposed hub #1 at Military and Hibiscus (26%). A total of 88% of participants reported that they would likely use one of the five proposed mobility hub locations.

When asked which locations were inconvenient, about 30% responded that each location was inconvenient for each of the five locations. The most inconvenient location was #5 at Dixie and Korn, rated as inconvenient by 34% of respondents. The least inconvenient location was location #3, Congress and Palm Beach Lakes, rated as inconvenient by 28% of respondents.

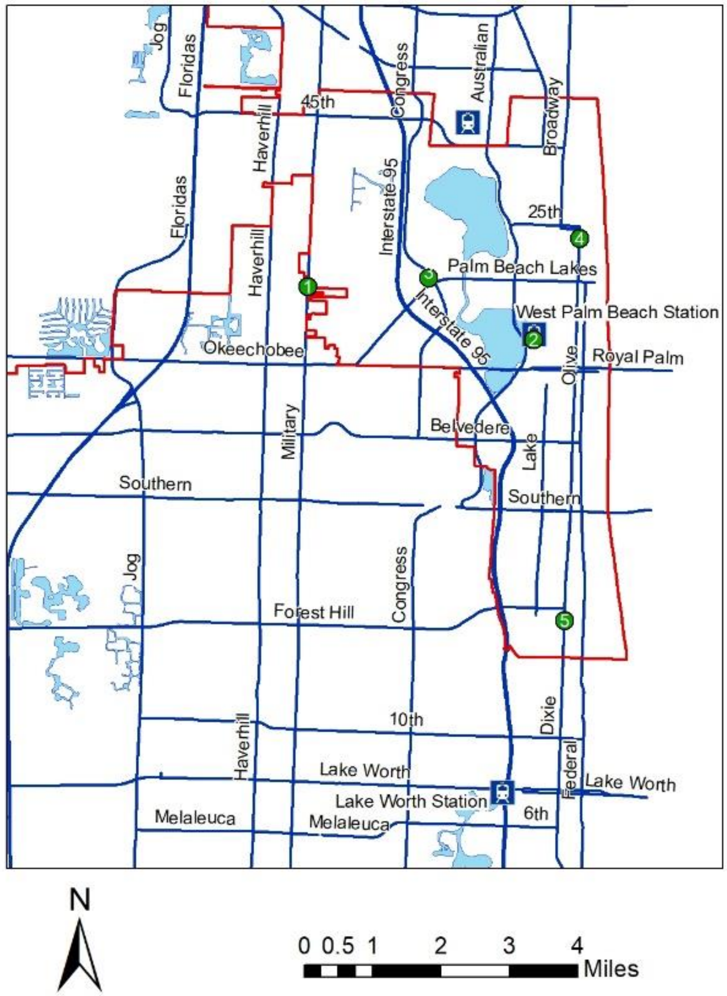


Figure 84: Five Recommended Mobility Hub Locations from GIS Analysis

Proposed Locations from Survey Participants

The largest concentration of proposed mobility hub locations was downtown West Palm Beach. This area included the proposed mobility hub at West Palm Beach Tri-Rail station but also proposed locations further east along Clematis Street and further north and south, bounded by Okeechobee Boulevard to the south and Palm Beach Lakes to the north. Because the proposed algorithm did not allow multiple mobility hubs within 1.2 miles of each other, the mobility hub at the Tri-Rail station precluded other downtown locations. Perhaps multiple mobility hub locations should be permitted to be nearby in downtown areas, an exception to the current algorithm's guidance.

The second largest concentration of proposed mobility hub locations was the Palm Beach International airport. This location was not identified by the algorithmic process, likely due to its limited transit service, low ridership levels, and that pedestrian infrastructure may be lacking. The airport is also unusually close to downtown for a major airport, making it a more promising location for transit service. Nevertheless, the airport already has ample parking, and micromobility modes may not offer much marginal benefit from the airport location, as few other destinations are within 1-2 miles.

Survey respondents also concurred with the proposal for a mobility hub in location #3 at Congress and Palm Beach Lakes. Smaller clusters of proposed locations could be found in the Town of Palm Beach, along the Okeechobee corridor as far west as its intersection with Military Trail, and along the Belvedere Road corridor (see Figure 85). The algorithm did not propose any mobility hub locations along the Belvedere Road corridor.

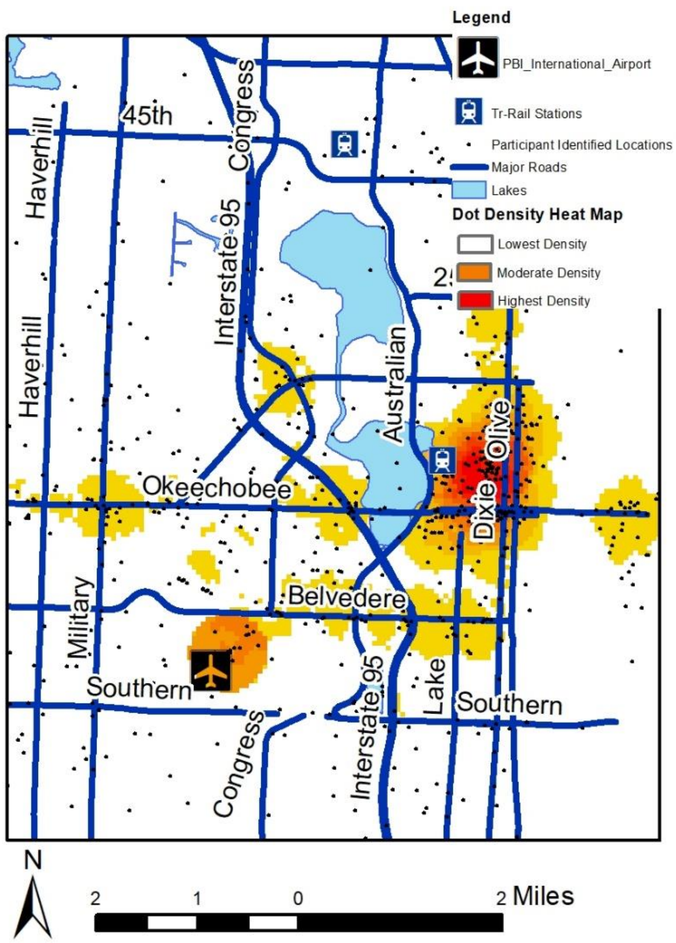


Figure 85: Heat Map of Suggested Mobility Hub Locations from Survey Respondents

The reasons respondents provided for moving proposed mobility hub locations varied. Many suggested locations that were more convenient for them personally. Many mentioned specific destinations that they would like to access, including the Palm Beach International Airport, Clematis Street, the beach, BrightLine, Rosemary Square, Lake Park, Westgate, and Royal Palm Estates. Some other issues that were mentioned include safety from traffic, general safety, population density and travel demand, and the ability to serve tourists.

5.5.8 West Palm Beach Survey Conclusions

The main findings from the West Palm Beach survey include:

- This convenience sample had more young adults, fewer older adults (65+), more educational attainment, and was more racially white than the City of West Palm Beach as a whole.
- In comparison with the Gainesville sample, there were many fewer students, with the vast majority of respondents working full time (74%).
- By far most respondents own a car (82%) with 11% owning no motorized vehicle.
- Among those living in households, most own two vehicles. However, 26% of households own just a single vehicle.
- The most common forms of shared mobility currently among the respondents are shared bikes, shared cars, and ride-hailing, each being used by about 20% of the population once a week or more.
- About 35-45% also find problems with multimodal travel connecting to transit. Similar numbers report that finding bike or scooter parking near transit stops is difficult.
- The most common access modes are walking and driving to the station, but ride-hailing, personal bike, shared bike, and microtransit shuttles (Circuit) were also mentioned.
- In terms of prospective improvements to transit, four of the top six responses concerned more frequent or more reliable service: More reliable service (#1), shorter waiting time (#3), shorter total travel time (#4) and more off-peak service (#6).
- Distance and multimodal access generally rated a bit lower, including transit stops closer to key destinations (#4) more mobility options at stops (#7) and better nonmotorized infrastructure (#10 & #11).
- About 30% of respondents (150 out of 500) reported using the following multimodal combinations at least once a week: train + personal bike or personal e-scooter, bus + personal bike or e-scooter, bus + shared bike, and personal car + shared bike.
- Approximately 50% rate all multimodal options as either “Convenient” or “Very Convenient,” and only about 10% rate them as inconvenient or worse. This includes all six listed multimodal options.
- About 80% responded affirmatively that they would use mobility hubs if they became available in West Palm Beach. This is notably higher than the current 50% who report multimodal behaviors.
- Likewise, by far most interviewees said that they would use transit more if mobility hubs were available, with 75% replying “Yes” and an additional 21% replying “Maybe.”
- In terms of preferred infrastructure features, respondents had a broad interest, with the majority supporting most types of potential mobility hub features. 60% or more of respondents replied that they would deem bike/e-scooter racks, designated parking for shared bikes, ride-hailing/taxi pick up zones, parking for shared cars, parking for personal cars, and charging stations as important or very important infrastructure features.
- In terms of amenities, comfortable, climate-controlled waiting areas; real-time information, and safety features came in as the most popular options and were rated as important or very important by over 80% of respondents.

The survey also provided respondents an opportunity to respond in terms of preferred locations for Mobility Hubs. Survey participants both responded to the five (5) locations proposed by the algorithm and had an opportunity to propose their own locations.

Mobility Hub citing criteria were ranked from top to bottom as follows:

- Transit stops with the highest number of riders (27.5%)

- Transit stops where riders can have access to the most destinations (24.7%)
- Transit stops in underserved neighborhoods (18.1%)
- Transit stops where transit riders need to travel longer distances to reach transit (15.3%)
- Transit stops with high-quality bicycle and pedestrian infrastructure (14.4%).

Out of the five (5) locations for mobility hubs, the percentage who affirmed the usefulness of each hub was as follows:

1. The West Palm Beach Tri-Rail Station (70%)
2. Congress and Palm Beach Lakes, near the Tanger Outlets (49%)
3. Dixie and 23rd Street, near the Northwood neighborhood (46%)
4. Military and Hibiscus, just north of the commercial development at Military and Okeechobee Blvd (41%)
5. Dixie and Korn, near the Shops at Palm Coast Plaza (23%)

When users were asked to propose their own Mobility Hub locations, these locations were the most popular:

1. Downtown locations other than the Tri-Rail Station, such as along Clematis Street
2. The Palm Beach International Airport
3. The Okeechobee corridor, particularly at the intersection with Military Trail (note that this intersection is technically outside of city limits)
4. The Belvedere corridor
5. The Town of Palm Beach (on the island east of the City of West Palm Beach)

5.6 Suggestions and Recommendations

5.6.1 Recommended mobility hub locations for West Palm Beach

The GIS-based analysis proposed five mobility hub locations within the City of West Palm Beach. Then survey respondents affirmed the usefulness of these locations as follows:

1. The West Palm Beach Tri-Rail Station (70%)
2. Congress and Palm Beach Lakes, near the Tanger Outlets (49%)
3. Dixie and 23rd Street, near the Northwood neighborhood (46%)
4. Military and Hibiscus, just north of the commercial development at Military and Okeechobee Blvd (41%)
5. Dixie and Korn, near the Shops at Palm Coast Plaza (23%)

A regional mobility hub at the West Palm Beach Tri-Rail Station can be confirmed as a logical option. In addition to scoring the highest in the GIS-based scoring, this site is confirmed by existing plans for this Tri-Rail station to serve as a county-wide transit center and by the substantial support for this location among survey participants.

A district mobility hub at the Congress and Palm Beach Lakes/ Outlet Mall location is also confirmed by a review of existing plans. This is the site of an existing park-and-ride facility and is identified as a transit hub by the Palm Beach Transportation Planning Agency (PBTPA).

Another logical location for a district mobility hub is the Tent Site, identified as a potential mobility hub location by the Downtown West Palm Beach Mobility Study (2018). This site was not identified by the GIS process because the current process precludes mobility hubs from being clustered too close to each other (less than 1.2 miles apart). However, this location serves two major planned transit corridors, the Okeechobee corridor and the US-1 corridor, each of which have multimodal plans developed for them.

The proposed Military and Hibiscus mobility hub location is probably not of great importance. If there were to be a mobility hub in this area, it would likely be located at the intersection of Military and Okeechobee, slightly to the south. This again is at the intersection of two major proposed transit corridors, though land use intensity is not highly supportive in this area. Note that the PBTPA plans for another transit hub further east along Okeechobee, closer to Jog Road.

Dixie and 23rd Street and Dixie and Korn are reasonable locations for neighborhood mobility hubs. They are not at major confluences of transit service, but both are along the US-1 corridor, which is planned for multimodal improvements and a complete-streets style redesign. Notably, the Dixie and 23rd Street proposed location serves a relatively socioeconomically disadvantaged location.

Two other locations not identified by the GIS process are worthy of further consideration:

The West Palm Beach BrightLine station could serve as a regional mobility hub. However, as this property is privately owned and managed, the planning process for such a hub must take this into consideration. The BrightLine station serves as regional transit infrastructure, connecting the City to Fort Lauderdale, Miami, and other cities to the south and Orlando to the north. Fortunately, BrightLine has integrated BrightBikes and Circuit shuttles into its services, providing an important intermodal connection at this station. Note that the GIS analysis process only allows one transit hub within 1.2 miles, which is part of why this location was not selected. Also, BrightLine ridership data was not available for the analysis process. The BrightLine station is about 0.5 miles away from the proposed transit hub at the Tri-Rail station, so these two station areas are far apart enough to be planned separately. However, strong connections between the two station areas should be part of the mobility hub planning considerations.

Another potential location for a regional mobility hub is the Palm Beach International Airport. As the Airport is managed by an independent authority, the planning process for such a mobility hub location will have to be specialized. It is unclear if bike share or Circuit shuttles could feasibly serve this location. However, improved transit service, a designated transit waiting area, and real-time transit information could offer significant improvements. The Airport was also a location frequently mentioned by survey participants as an ideal location for a mobility hub.

Table 34 summarizes the recommended mobility hub locations for the City of West Palm Beach.

Table 34: Summary of Mobility Hub Recommendations for the City of West Palm Beach

Mobility Hub Location	Identified by GIS?	Existing Plans that Address this Location	Mobility Hub Type
West Palm Beach Tri-Rail Station	Y	Vision 2050	Regional
West Palm Beach BrightLine Station	N	Vision 2050	Regional
Palm Beach International Airport	N	Vision 2050	Regional
Congress and Palm Beach Lakes/ Outlet Mall location	Y	Vision 2050; Palm Tran Transit Development Plan	District
Okeechobee and Military	Y	Okeechobee Corridor Plan	Neighborhood
Dixie and 23rd Street	Y	US-1 Corridor Coffee Book	Neighborhood
Dixie and Korn	Y	US-1 Corridor Coffee Book	Neighborhood

5.6.2 Recommended mobility hub infrastructure and amenities for West Palm Beach

Each mobility hub should be planned individually, accounting for the transportation, land use, and other community contexts surrounding the proposed mobility hub locations. There might be a few standardized designs, however some level of design flexibility should be provided to take into account the distinctive issues of each area. Funding from non-transit sources can be used in the design and construction of mobility hubs to make them distinctive for each community, if desired. Public-private partnerships may allow the provision of micromobility options.

Based on the input provided by survey respondents and the shared mobility services currently available in West Palm Beach, Table 35 provides a generalized recommendation for infrastructure and amenities by level of hierarchy.

Table 35: Recommended Mobility Hub Infrastructure and Amenities for West Palm Beach Mobility Hubs

Mobility Hub Level	Infrastructure	Amenities
Regional	Climate-controlled waiting area Shared bike station Bicycle and scooter parking area Bicycle and scooter charging facilities Vehicle parking area Boarding area for Circuit Shuttles Designated area for ride-hailing and taxis Level boarding area	Phone and computer charging stations Call for Help Facility or other safety features Real-time transit information
Regional, Park-and-Ride Style	Climate-controlled waiting area Bicycle and scooter parking area Bicycle and scooter charging facilitiesVehicle parking area EV Charging Designated area for ride-hailing and taxis Spaces for designated car share Level boarding area	Phone and computer charging stations Real-time transit information Call for Help Facility or other safety features
District	Sheltered waiting area with ample seating Shared bike station Bicycle and scooter parking area Bicycle and scooter charging facilitiesBoarding area for Circuit Shuttles (if applicable) Designated area for ride-hailing and taxis Level boarding area	Real-time transit information Safety features, as appropriate
Neighborhood	Sheltered waiting area with ample seating Bicycle and scooter parking area Level boarding area	

Note: All mobility hubs should provide waste disposal facilities, seating, lighting, sidewalks and safe, proximate, high-quality pedestrian crossings in the vicinity, wayfinding and orientation signage.

6 Reflection on Planning Process for Mobility Hub Selection

The proposed GIS process laid out in Task #2 of this project has proven to be a robust process for identifying possible mobility hub locations in two highly divergent urban areas: Gainesville and West Palm Beach, Florida. The process has demonstrated itself capable of identifying a range of mobility hub locations based upon objective, readily available data at the regional scale. By changing the weighting of the five criteria under consideration, different value systems can be represented within the analytical process. However, the need for a stakeholder driven planning process to make the final determination of suitable mobility hub locations has also been affirmed. Stakeholder input, through public surveys, reviews of existing planning documents, and conversations with interested stakeholders, have demonstrated that other considerations may need to be taken into account that are not part of the data analysis process.

Currently the GIS analysis process precludes two mobility hubs to be located within 1.2 miles of each other. It is logical that there needs to be at least some physical separation between mobility hub locations. However, in downtown contexts, it may make sense for several mobility hubs to be located quite close. Changing the minimum buffer between mobility hub locations may be suitable in more congested conditions.

Furthermore, it is important to note that the GIS analysis process cannot take into account existing plans, activity that is planned or desired but is as yet unrealized. The GIS process operates off existing transit ridership and land-use patterns and cannot anticipate planned or expected changes. Therefore, the GIS process did not identify a potential mobility hub at the Palm Beach International Airport because at this time the level of transit ridership to and from this location is low. However, with future improvements to services and facilities, this could be a viable mobility hub location. Therefore, as indicted by our study, a GIS-driven mobility hub location process should be coupled with a robust stakeholder-driven process. The GIS analysis can provide meaningful input and identify promising locations, but ultimately this data must be reviewed by stakeholders who are involved in a decision-making process with broader considerations.

A major practical limitation associated with our mobility hub identification methodology is that the cost of project implementation is not accounted for. In mobility hub implementation, one should consider the investment of establishing the mobility hubs, including land cost, operation, and investment for facilities, which will vary by place and scale. Additionally, we are not certain whether the mobility hub locations identified through this quantitative approach is preferred by local travelers and residents. With this consideration, we conducted a survey with local residents to ask them to evaluate the six mobility hub plans discussed above. Further conversations with stakeholders identified the importance of land availability for Mobility Hub development. In most cases, limited public land holdings in desired Mobility Hub locations may limit the potential for many additional Mobility Hub features. In some cases, public-private partnerships may allow for the development of new or improved Mobility Hubs, but of course this is contingent on the cooperation of the private entities involved. Available land may be the primary limitation in terms of the range of Mobility Hub infrastructure that can be provided, particularly for land-intensive vehicle parking and even for less land-intensive bicycle and scooter parking. The stakeholders noted that best practices depending upon the amount of available land would be a useful supplement to this research project.

Finally, most studies on mobility hub (MH) users have focused on intentions prior to hub implementation rather than post-implementation behavior. This thus leaves a gap in understanding user responses and behaviors once MHs are in operation. Future research could prioritize examining real-world usage patterns and preferences to better inform hub design and placement.

Our tool developed for the project uses publicly and widely available datasets, which ensures its transferability to other areas and regions. Collaborating with local stakeholders, our research team will also apply the tool to identify mobility hubs in West Palm Beach, FL. To promote public awareness and widespread adoption of the tool, we have developed a project web page (https://jacobyan0.github.io/MobilityHub/) that contains a story map that introduces this project and the downloading options for the tool (i.e., a set of ArcGIS toolbox and the underlying Python code). The tool also allows agencies to adjust some parameters (e.g., weights) tailored to their needs and the local contexts.

Appendix

Appendix 1: Popular Mobility Hub Locations

Below maps visualize the response from the questions *"Click on the red pins to select up to 3 mobility hubs that you would be most likely to use."*. The color of the circles (darker colors indicate higher frequency) and numbers indicate the times they were selected.

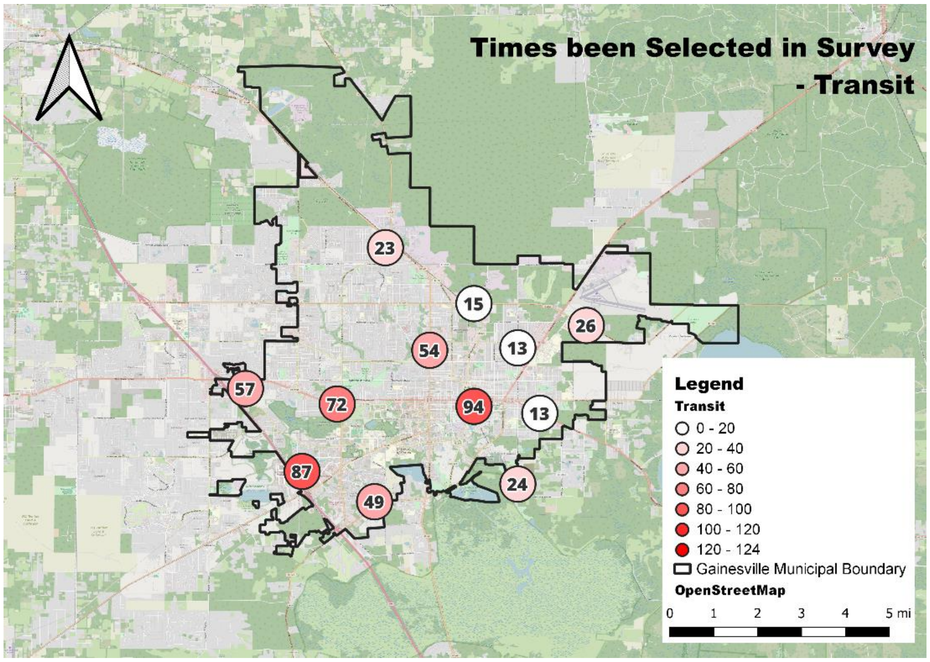


Figure 86: Mobility Hub Selected by Respondents (the "Transit" Scenario)

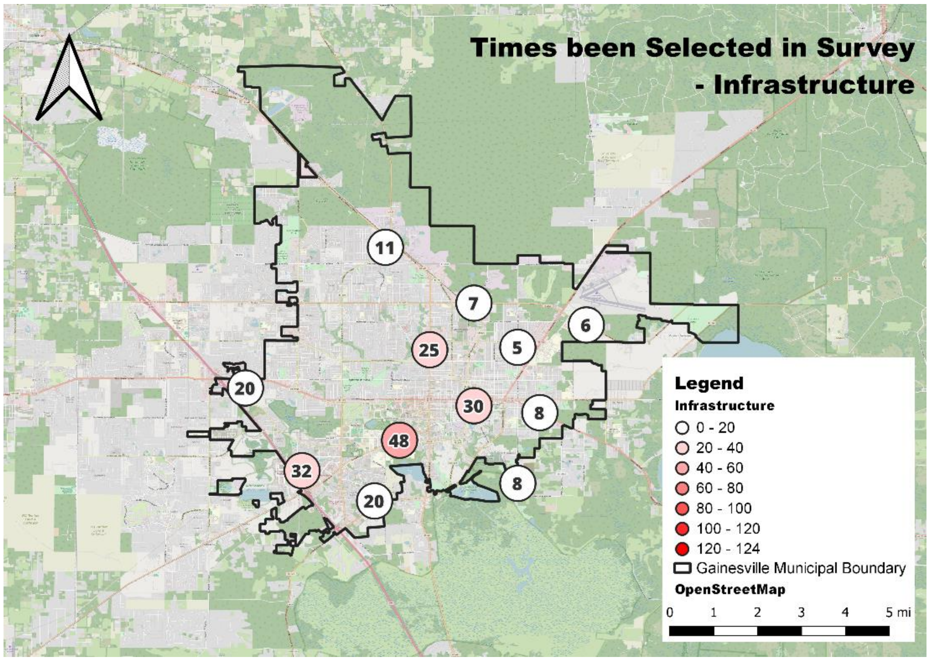


Figure 87: Mobility Hub Selected by Respondents (the "Infrastructure" Scenario)

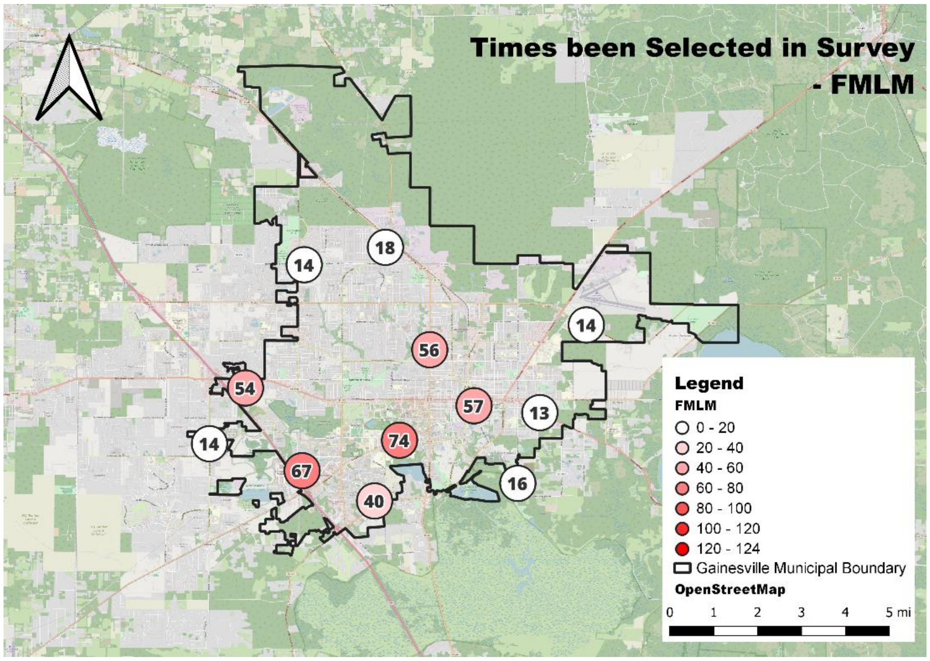


Figure 88: Mobility Hub Selected by Respondents (the "FMLM" Scenario)

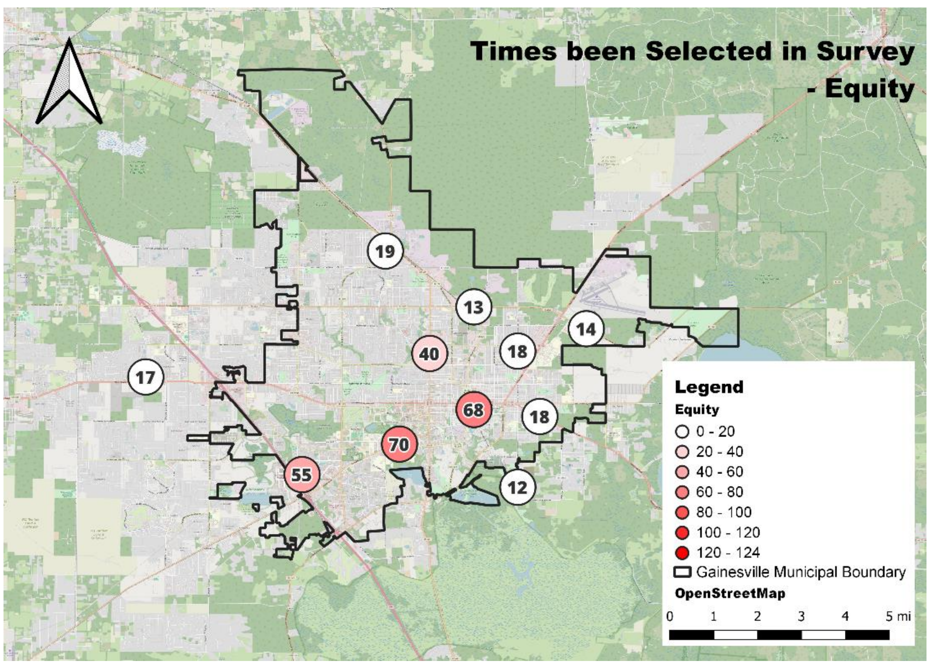


Figure 89: Mobility Hub Selected by Respondents (the "Socio-demographic" Scenario)

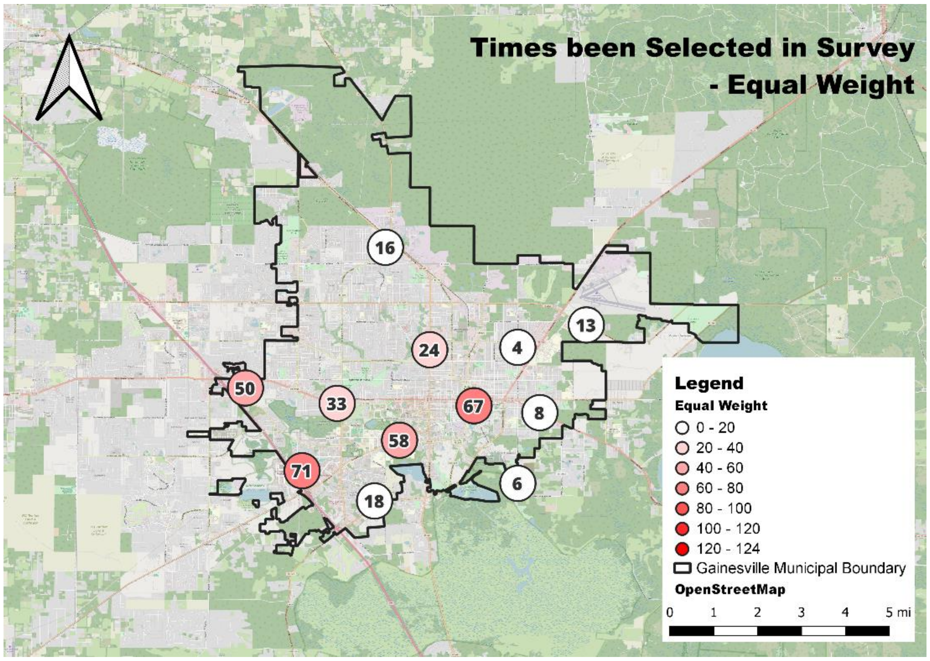


Figure 90: Mobility Hub Selected by Respondents (the "Equal Weight" Scenario)

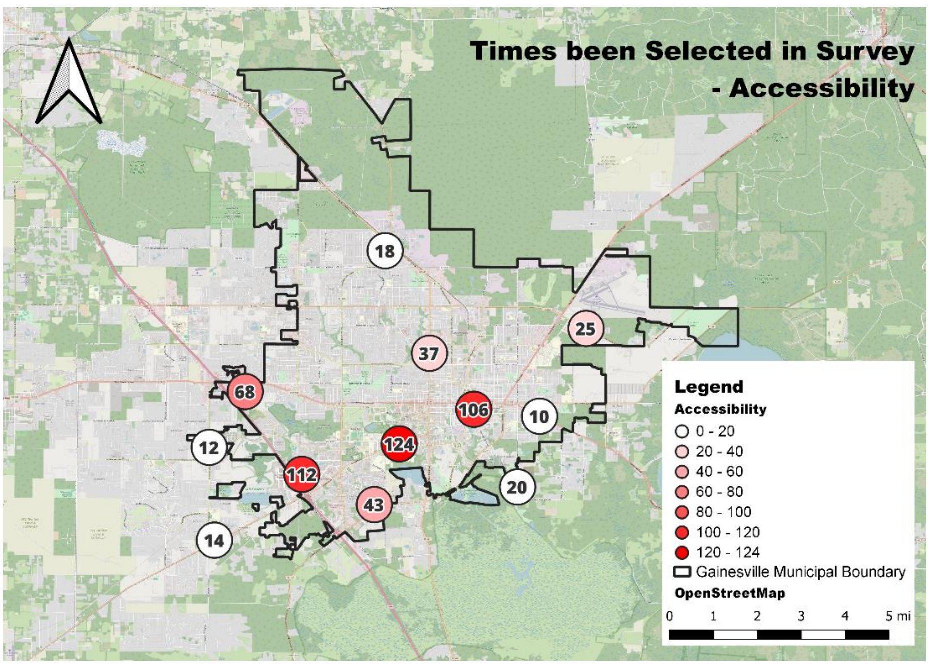


Figure 91: Mobility Hub Selected by Respondents (the "Accessibility" Scenario)

Appendix 2: Suggested Movements Proposed by Respondents

Below maps visualize the response from the question "*Click on the hubs that you feel are in inconvenient or undesirable locations. For each selected hub, if you believe there is a more suitable location nearby, drag the yellow pin to move it to that position*". The color of the circles (darker colors indicate higher frequency) and numbers in parentheses indicate the times they were selected. The lines show the movements made by the respondents.

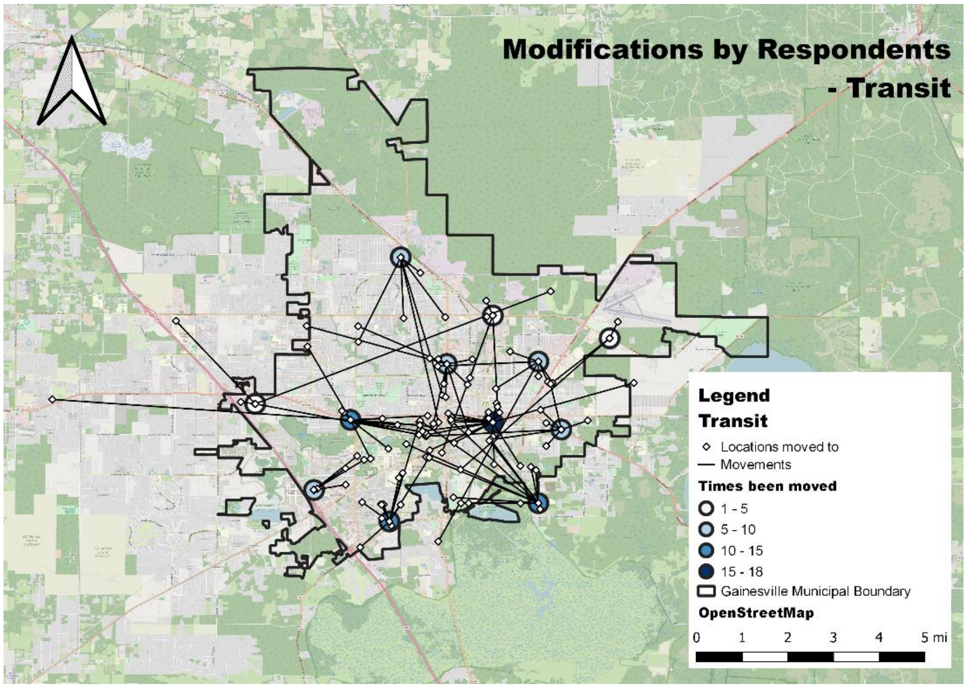


Figure 92: Suggested Movements by Respondents (the “Transit” Scenario)

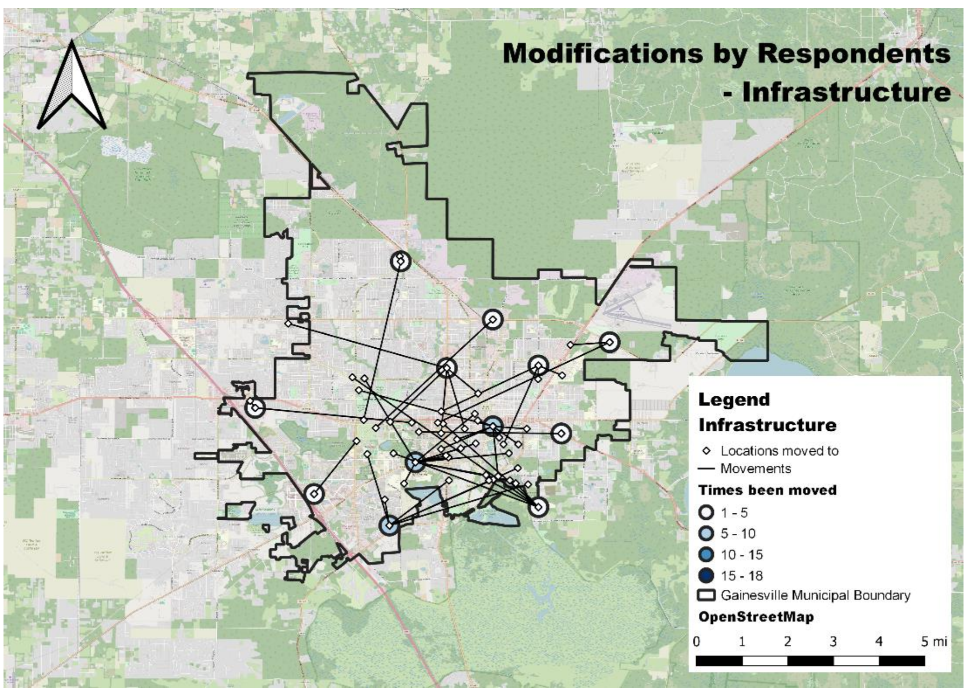


Figure 93: Suggested Movements by Respondents (the “Infrastructure” Scenario)

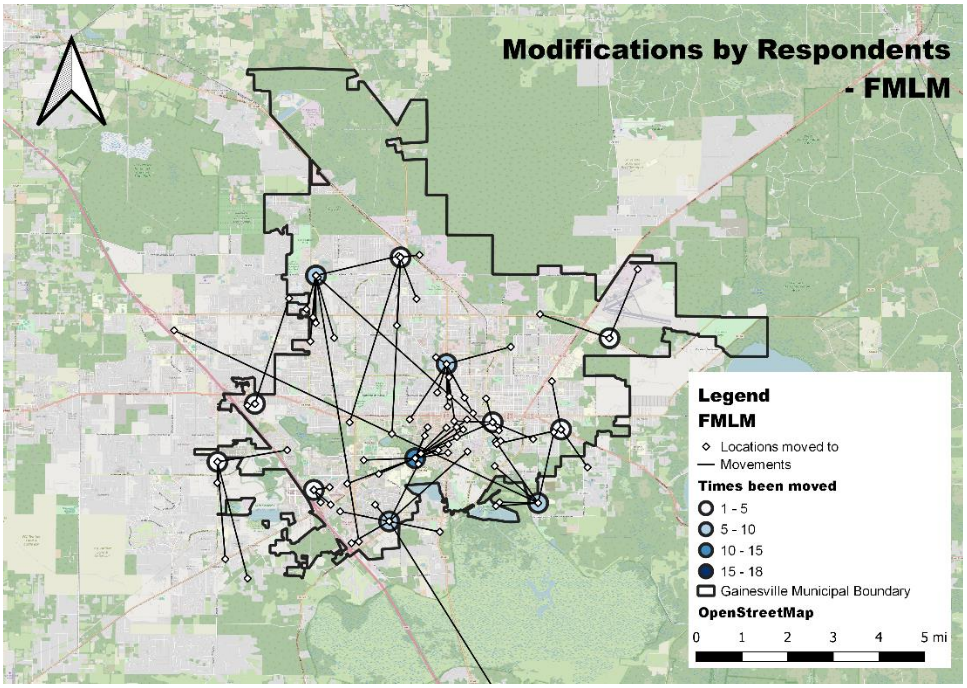


Figure 94: Suggested Movements by Respondents (the "FMLM" Scenario)

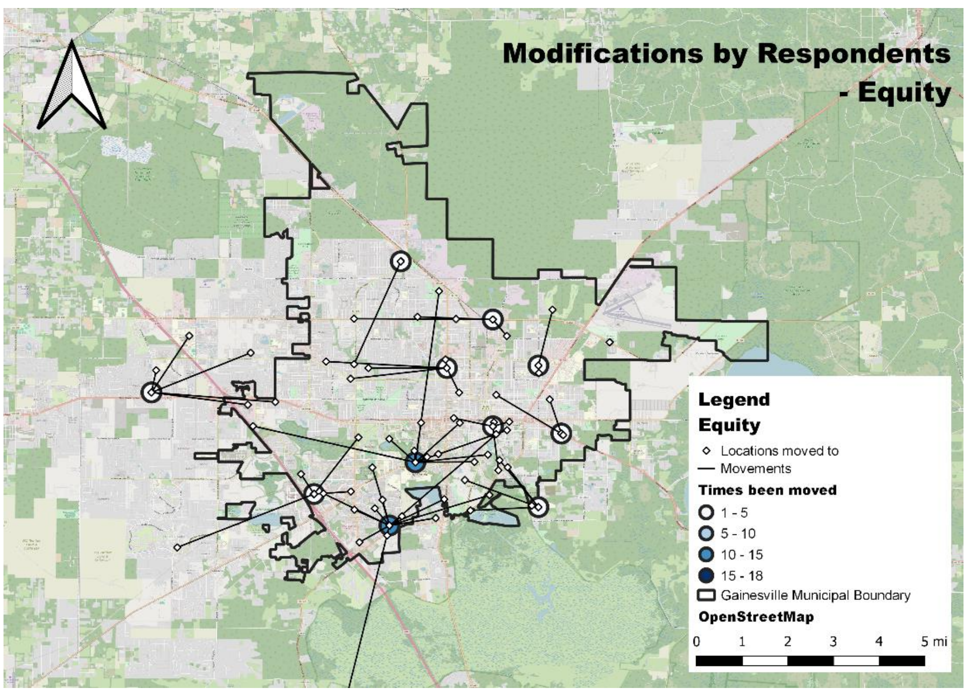


Figure 95: Suggested Movements by Respondents (the "Socio-demographic" Scenario)

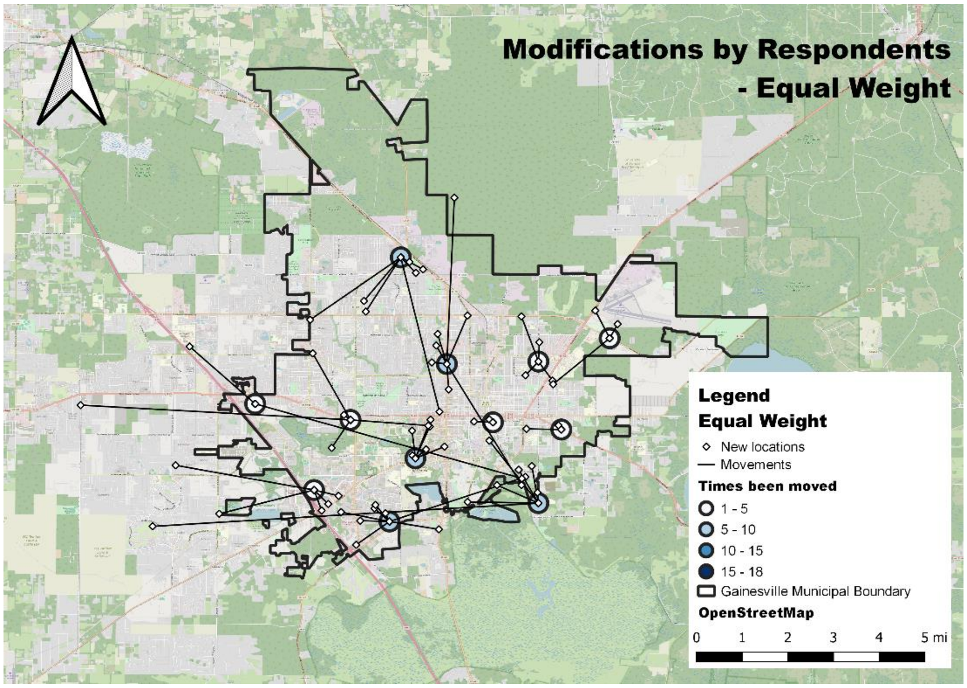


Figure 96: Suggested Movements by Respondents (the "Equal Weight" Scenario)

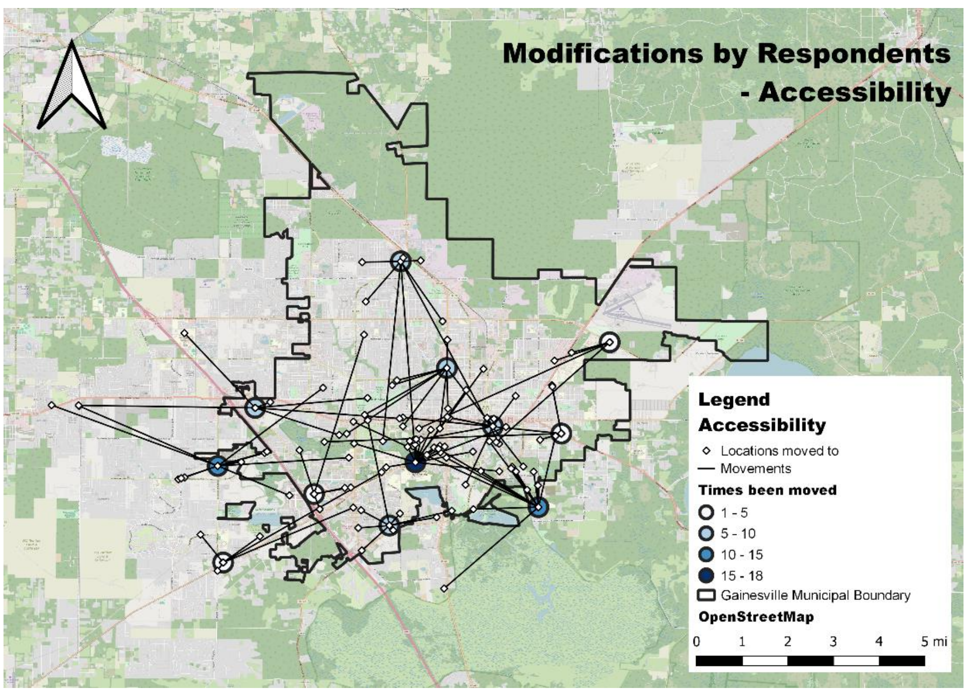


Figure 97: Suggested Movements by Respondents (the "Accessibility" Scenario)

Appendix 3: Comments by Respondents Regards Unpopular Mobility Hub Locations

Below tables summarize the open-ended comments from the questions *"Click on the hubs that you feel are in inconvenient or undesirable locations. For each selected hub, if you believe there is a more suitable location nearby, drag the yellow pin to move it to that position"*.

Table 36: Selected Reasons for Respondents Disliking a Mobility Hub (the “Transit” Scenario)

MH #	Reason for Disliking
14	Should be closer to campus destination and apartments with lots of bike lane and sidewalk access.
8	The oaks mall stop has poor access to the actual mall. There is a steep hill you climb up or down to get to the stop, or you are forced to walk all the way around. The stop used to be in the actual oaks mall parking lot which was much better.
8	The Northwest portion of Gainesville needs more transportation options.
10	At edge of campus
9	Should be closer to the university
9	Near the museum, not many busses go there
3	Far north where its inaccessible for most riders.
3	Bad area
6	No so many traffic in the area.
5	Not serving the boys and girls club, one love, NW grille and Timberway neighborhood. Move nine or add a hub please
15	Too far out from the main city, not a lot of people will use it.
15	Too out of the way and very close to a national park.
15	Probably low ridership given rural/suburban location
16	Very close to another hub (Butler Plaza), not really necessary in my opinion
16	It serves only one community that is very out of the way from everything.
16	Far from stops useful to me
1	It's too far

Table 37: Selected Reasons for Moving a Mobility Hub (the “Transit” Scenario)

MH#	Reason for Moving
4	Closer to Bus 75
4	Closer to airport
14	More apartments
14	Safety
14	Doesn't need to be that close to the highway. Student living is much close to the intersection of 34th and Archer
8	Closer to neighborhoods on 62nd st
8	The North West portion of Gainesville needs more transportation options.
8	In University of Florida
8	Close to shopping center and other offices.
13	depot park is popular/a frequent visited area
13	Fill in space better
13	Too out of the way.
13	There are many students that use the busses at this area with many different bus routes
10	Closer to Bus 5
10	Closer to Bo Diddley Plaza, safety of University Ave
10	It would be closer to campus. will be more convenient for a lot of the students
10	More north nearer to more people
10	it's to access

9	I would prefer an on campus location since I would have to walk to the hub.
9	Having a mobility hub on campus seems like it would be a helpful tool to use for students who want to go travel off campus in Gainesville.
9	In a busy intersection that is close to the university.
6	It a more convenient destination. Higher traffic area.
6	Fill in space better
6	it's easy to walk
15	Closer to town; nearer more parks/cemetery/people
15	Closer to apartment
15	Good for game days when many people are in one area waiting for a bus or ride share when roads are closed
16	On a bigger road
16	This is where I live.
16	closer to more common student housing
16	shands is very important
1	Brought it closer to campus for better access to Publix and Aldi
1	closer to campus
1	Closer to parks, not Walmart
1	Bus 1

Table 38: Selected Reasons for Disliking Each Hub (the "FMLM" scenario)

MH#	Reason for Disliking
hid	text
1	Not a lot of buses go to that area so how could one use the mobility hub if there's limited ways to get to it
1	Far from where I go most of the time
14	Too close to existing places of parking and transit
14	there already is one at the walmart stop. it should be easier for people who live on sw 35th pl to get to butler plaza to places like aldi, trader joe, etc
14	People are unlikely to use this hub for long distance travels
13	It is close to where I would want it to be, but still too far away and difficult to reach
11	this hub seems to be positioned a little far away from where a lot of people might use it
10	Could be closer to the area of Santa Fe Blount Hall or the continuum/2nd Avenue apartments
5	can walk there
5	I would move it slightly further north since the location picked here is relatively well served already, while other areas are not
12	Its too far from campus and student living
12	Low traffic area, not suitable for building hubs
15	in between the other two hubs
15	Far from where I go most of the time
2	another hub close by
2	Far from where I go most of the time
4	Multiple modes of transit already exist at the airport
4	Already near a airport, no need for a hub
4	Far from where I go most of the time

8	Too close to existing places of parking and transit

Table 39: Selected Reasons for Moving Each Hub (the “FMLM” scenario)

MH #	Reason for Moving
1	Near student housing and publix and food
14	Moved closer to Archer Rd. a main road in Gainesville.
13	More options in combining mode of transport- carpool then walk - & better access to multiple areas of town, not just UF campus.
13	Closer to more apartments
13	it's cheaper from there
13	the college is so big and needs more transportation for students that dont have a way of getting around
11	Access to supermarket
10	Near or on top of bus transfer station
10	Could be closer to the area of Santa Fe Blount Hall or the continuum/2nd Avenue apartments
5	Closer to campus
5	having one near the busiest Walmart is a convenient place
5	More access for more people in walking distance
5	The north east lacks easy to get to bus stops and lines. Stops prioritize students and the university, and tend to ignore the east side and north east side working class. The area I chose services a lot of neighborhoods and puts it closer to several scho
12	I use the library here
12	Reitz union
16	Closer to my apartment and more accessible for everyone in the neighborhood
16	New location probably more useful for out-of-town commuters (e.g. park and ride), who make up bulk of traffic in GNV. 34th is major transit corridor already & needs additional bike/ped friendly infrastructure..
16	Larger student community in this area
15	it will be cheaper
2	This way, there is a travel hub equidistant from point 12 and 1
2	I use the library here and do my shopping at Thornebrook
2	near redcoach and flix station when students travel
2	Denser area
4	easier access to main stores
8	Need one closer to that ocatin

Table 40: Selected Reasons for Disliking Each Hub (the “Infrastructure” Scenario)

MH#	Reason for Disliking
3	Seems far and disconnected.
3	I do not think having a hub around a bunch of car dealerships would be helpful
6	I do not think the area around here will be of much benefit.
4	I think that this area's use of personal transport will always surpass the use of a hub
15	Seems far and disconnected
1	Seems far and disconnected

Table 41: Selected Reasons for Moving Each Hub (the “Infrastructure” Scenario)

MH #	Reason for Moving
13	Because it's close to my location
13	closer to campus and my apt
13	it's cheaper from the location
14	closer to campus and my apt
8	closer to campus and my apt
11	closer to campus and my apt
10	closer to campus and my apt
10	1111 w university ave and downtown and uptown makes sense and Santa Fe College
10	Because it's easy for me to walk to
10	Moved it closer to Depot Park for more convenient access to the park
10	Because it has all the facility
16	It's will be more cheaper
3	closer to campus and my apt
6	closer to neighborhood with potential riders and not opposite a school (= daily congestion)
6	Closer to walmart
5	It would be amazing for a hub to be near Timberway or in the shopping center with NW grille
5	it's cheaper
5	closer to some dorms
4	closer to campus and my apt
15	No hubs are in a convenient place to serve these communities
15	major intersection
15	easy to locate
1	closer to campus and my apt

Table 42: Selected Reasons for Disliking Each Hub (the “Socio-demographic” Scenario)

MH#	Reason for Disliking
13	a very high density area for vehicles
13	I still love this location, but it is not as underserved
14	Too far from neighborhoods near Vet Park. Need more routes and more busses per route.
15	It was in the middle of nowhere, meanwhile depot park is busy
15	I wouldn't use these anyway. Moving doesn't matter
15	While the location was underserved, there are few residents that live in the area so I don?t know how it would get much use

Table 43: Selected Reasons for Moving Each Hub (the “Socio-demographic” Scenario)

MH #	Reason for Moving
13	Seems like better fit if prioritizing underserved areas. SE side is food desert. Having mobility hub here could improve access to grocery stores/make east-west travel easier. Lots of RTS service on- and around-campus already. Versus new location very lit

3	Center of the unversity campus
14	More popular place for supermarkets
5	more retail store in the area for people to travel to
5	I moved it to a place where I often need to travel by car due to lack of bus routes connecting me from SW 34 to NW 34
7	Moved to the Oaks mall because past the highway is past where I normally need to go.
16	To offer safe access to Sweetwater park. It is currently very unsafe for wheelchair users to try to access it via pedestrian paths.
16	Closer to my apartment. Much easier to walk to than original location.
16	Because it will be cheaper
15	It was in the middle of nowhere, meanwhile depot park is busy
6	think that areas has more residents

Table 44: Selected Reasons for Disliking Each Hub (the "Accessibility" Scenario)

MH#	Reason for Disliking
1	I rarely go to this area of Gainesville
1	Not many buses that go to those areas so difficult for transfers
1	Not sure if the surrounding is dense enough to allow for multimodial options
1	Its too far from campus and student living
14	Because there is already a transfer station nearby which can be upgraded
14	Too far
11	I have nothing to do there.
11	Location on a busy main road is dangerous. Better placed on a park
10	It is already a well developed area with parking, cafe etc.
12	Didnt feel centrally located
12	Too far
17	its too far from campus and student living
17	Already close to a better potential hub site
17	Too far from the city
15	Low population density
15	It is far away from urban area
16	That far south is not a nash equilibrium
16	Too far out resources would be better used in town
4	It?s too far from campus and student living
4	airport does not seem like a good area to prioritize imo
5	Too far from busy side of campus
13	Already close to a better potential hub site
13	It is too far away from where I would be wanting to board.

Table 45: Selected Reasons for Moving Each Hub (the "Accessibility" Scenario)

MH#	Reason for Moving
1	closer to campus and my apt
1	near bus station for Flix and Redcoach
14	Moved 2 close to Archer Rd.

14	More central to student living
8	further out - better park and ride options
11	Closer to Campus
10	it's easy to locate
10	Prefer to have it closer to University and Main st.
10	It would be more convenient for residential areas
12	celebration pointe is a popular location
12	to over an area without any hubs
12	Access to supermarket
17	dense neighborhood nearby
15	Too far out. Better to have something near depot park.
15	further out - better park and ride options
16	Closer to markers and main avenues
16	Bigger road
16	To provide safe pedestrian and wheelchair access to Sweetwater Wetlands Park
4	This moves the hub closer to an area that is more friendly for pedestrians
4	More centralized location, access to many key parts of the city.
5	On campus NEEDS a hub
5	Closer to Aldi
13	Closer to the hospital
13	Having a hub on campus that students can easily access would be a helpful tool for students who want to travel off campus in Gainesville.
13	Shands has enough parking, Engineering department (especially NEB) is completely inaccessible

Table 46: Selected Reasons for Moving Each Hub (the "Equal Weight" Scenario)

MH#	Reason for Disliking
1	Surrounding didn't feel dense enough
4	too far away from the places that I frequent.
15	Far from stops useful to me
15	Surrounding didnt feel dense enough
15	Hubs should be more centrally located
8	I hardly go there
14	too far away from the places that I frequent.
14	Low pedestrian transit in area
14	The busses here are unreliable right now
11	Hubs should be more centrally located
16	It serves only one community
16	Far from stops useful to me
16	Very close to another hub
16	Lower traffic area.
16	Hubs should be more centrally located

Table 47: Selected Reasons for Moving Each Hub (the "Equal Weight" Scenario)

MH#	Reason for Moving
1	Closer to major road
15	Need to connect other side of interstate
8	Puts it into a area where transportation is still running
3	the college needs better ways of transportation
3	This is more toward the center of the medical buildings and more foot traffic.
16	Larger student community
16	so many people live on sw 35th pl, especially at the enclave and gainesville place and we are underrepresented in terms of our ability to go to places in butler plaza without a car
9	To have a hub equidistant from point 12 and point 1
9	Moved Hub 7 closer to SW 20th Ave because lots of people, and traffic there and many bus pass though
9	further out, better park and ride options
6	closer to my neighborhood, all would be too far to be worthwhile otherwise
6	to have a hub equidistant from point 1 and point 10

Appendix 4: Existing Plans for Mobility Hub Development in Gainesville

Gainesville transit development plan

In the recent Five-Year Major Update of the Ten-Year (FY2020 – FY2029) Transit Development Plan (TDP)[11], Gainesville Regional Transit System (RTS) identified key objectives and initiatives. A few of the goals related to MH development are to understand demographic characteristics and existing mobility demand; solicit citizen feedback on RTS services, plans, and projects; improve the quality and convenience of transit services; continue creating relationships with stakeholders to coordinate multimodal mobility services and improvements.

Landscape analysis in the TDP shows that Gainesville's development landscape is dynamic, with over 100 projects ranging from mixed-use developments like Butler Town Center to new residential complexes such as The Standard and Hub on Campus. Future land use codes prioritize mixed-use and higher-density developments, promoting walkable, bikeable, and transit-friendly communities. The city is exploring innovative mobility solutions like micro-transit and autonomous vehicles to improve accessibility, particularly in areas with limited transit options. Gainesville's demographic profile features a substantial student population from the University of Florida and Santa Fe College, concentrated around campus areas. Income data indicates a higher prevalence of low-income households, particularly in student-heavy neighborhoods. A notable percentage of households lack personal vehicles, emphasizing the importance of transit. The transportation disadvantaged population is substantial, underscoring the need for comprehensive mobility solutions. Commuting patterns reveal significant inbound and outbound commuting flows, particularly to major employment centers like the University of Florida. Alternative modes of transportation, such as biking and walking, are more prevalent in Gainesville compared to state and national averages. Employment density maps highlight areas with high transit ridership potential, primarily around educational and medical centers, as well as downtown.

[11] http://go-rts.com/files/COA/RTS%20TDP%20-%20FINAL.pdf

RTS has actively engaged the public in the development process of the TDP. Activities included direct involvement like stakeholder interviews, on-board and online surveys, workshops, and open house events. Information was also distributed through legal notices, direct contacts, website and social media promotions, and electronic communications. These efforts demonstrate the city's commitment to engaging stakeholders and incorporating community feedback into mobility planning. Key findings from this highlight opportunities for transit enhancements in the TDP. RTS riders, primarily students and transit-dependent individuals, expressed the need for improved services, emphasizing better communication with the community and enhanced sidewalk access. Recommendations include increased frequency, expanded service areas, improved signage and shelters, and strengthened network connectivity. While support for premium limited stop service varied, respondents favored corridors like Archer Road and 13th Ave for potential implementation.

Several other studies examined in the TDP, including the SR 26 / University Avenue Multimodal Emphasis Corridor Study, Multimodal Level of Service Report (2017), and Go Enhance RTS Study, placed emphasis investing in transit and alternative mobility. They all focus on enhancing infrastructure to support various transportation modes, improving pedestrian and cyclist safety, fostering connectivity, and creating walkable communities, aligning with the goal of promoting sustainable transportation in Gainesville.

Note that the TDP was completed right before the COVID-19 pandemic. Due to COVID-19 disruptions, transit ridership has plummeted and has not yet fully recovered (80%-90% recovery rate) as of Spring 2024. Gainesville RTS is currently developing a Transit Restoration Plan to inform future developments as ridership patterns are expected to have changed in the post-COVID era. Regardless, we believe that most findings in the TDP still hold today.

Transit, bike & pedestrian, and multimodal infrastructure

The 2014 Go Enhance RTS Study[12] revisited the 2010 Rapid Transit Feasibility Study, examining options for premium transit improvements in an east-west corridor of Gainesville and Alachua County (see Figure 98). It recommended a transportation systems management (TSM) approach with limited-stop service along Corridor A, showing higher ridership growth compared to other alternatives. Further assessment of Bus Rapid Transit (BRT) for potential federal funding is scheduled for completion in 2025.

Figure 2-3: Refined Corridor Alternatives

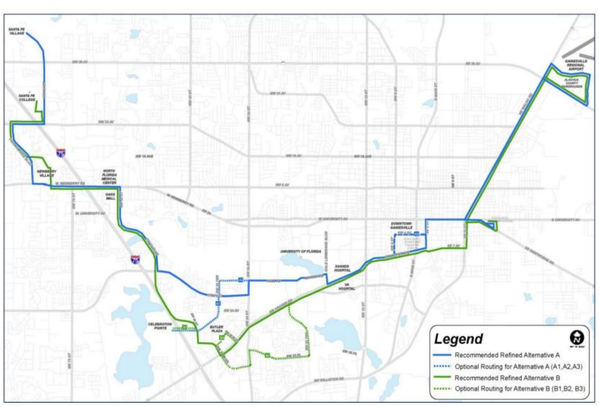
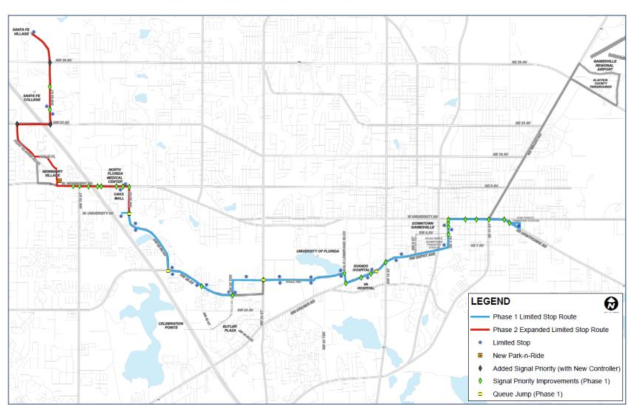


Figure 3-1: Recommended Locally Preferred Alternative - TSM



[12] https://go-rts.com/files/brt/Executive_Summary.pdf

Figure 98: Recommended Transit Corridor Alternatives
(Source: RTS, 2014)

The 2017 Multimodal Level of Service Report produced by North Central Florida Regional Planning Council (NCFRPC)[13] provides a thorough analysis of automotive/highway, bicycle, pedestrian, and transit modes of travel within the Gainesville Metropolitan Area Boundary. It includes level of service estimates for various roadway facilities, offering recommendations for enhancing multimodal development. The following maps, extracted from the Report, illustrate the overall level of service for bicycles, pedestrians, and transit within the Gainesville Metropolitan Area (see Figure 99).

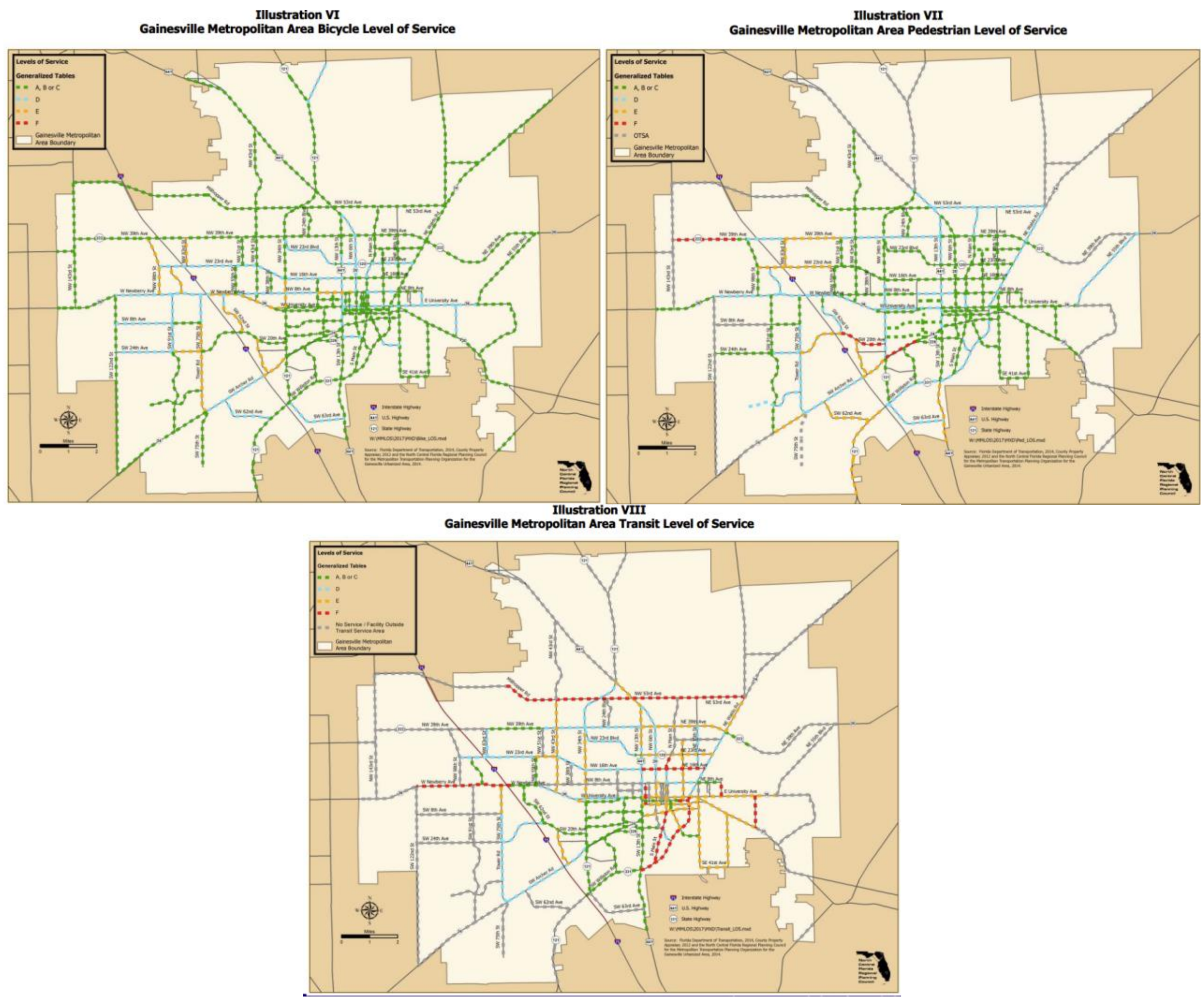


Figure 99: Bike, pedestrian, and transit level of service in Gainesville
(Source: NCFRPC, 2017)

[13] http://www.ncfrpc.org/mtpo/publications/LOS/LOS17RPTGT.pdf

The SR 26 / University Avenue Multimodal Emphasis Corridor Study[14], adopted in 2014, outlines projects to enhance transportation along University Avenue. These include raised medians, improved pedestrian crossings, and corridor-wide upgrades to transit facilities (see Figure 100). These improvements aim to increase comfort and safety for transit riders and promote transit use.

Figure 17 Conceptual Rendering of Potential Option for New Pedestrian/Bikeway Corridor

Figure 100: Conceptual design for pedestrian/bikeway corridor in SR 26 study
(Source: Sprinkle Consulting, 2015)

Other relevant plans

The 2040 Long Range Transportation Plan (LRTP)[15] developed by the Gainesville Urbanized Area Metropolitan Transportation Planning Organization (MTPO) in 2015 aims to create a balanced multi-modal network (see Figure 101). The plan identifies various transit projects, including increased frequencies and operating hours for city routes, intercity transit services, and the construction of a Transit Center at Santa Fe College. Additionally, it highlights Intelligent Transportation Systems (ITS) projects, bicycle and pedestrian facilities, and roadway capacity improvements.

[14] http://www.ncfrpc.org/mtpo/publications/univavemultimodel/sr26_phase_2_report_final_submittal.pdf
[15] http://www.ncfrpc.org/mtpo/publications/LRTP2040/2040%20LRTP%20Summary%20Report_012216.pdf

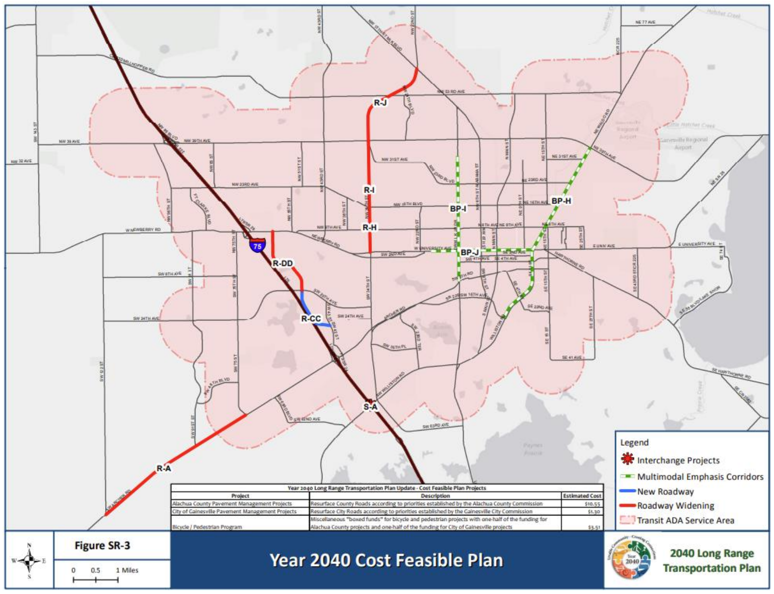
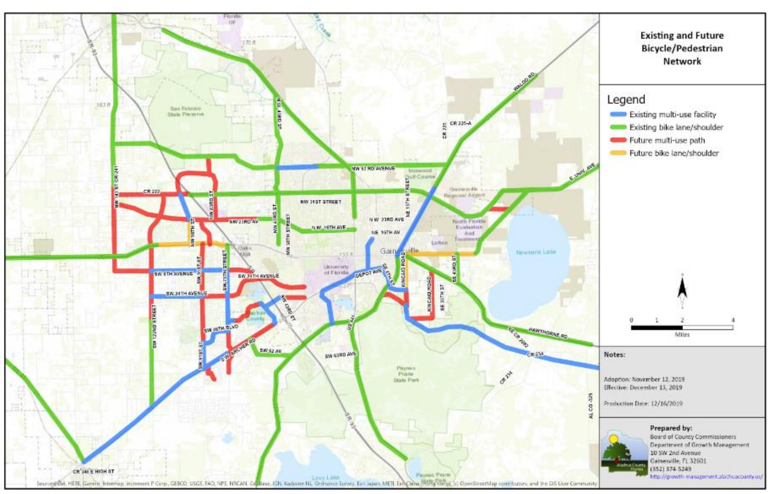


Figure 101: Year 2040 cost feasible plan projects in LRTP (Source: Atkins, 2015)

The Alachua County Commission amended its Comprehensive Plan 2019-2040[16] in 2010 to enhance mobility options in coordination with land-use and development changes, referred to as "The Alachua County Mobility Plan"[17] (see Figure 102). Through these changes, the county aims to increase mode share for cycling, walking, and transit, thus reducing single-occupancy vehicles use and greenhouse gas emissions. The plan incentivizes transit-oriented and traditional neighborhood designs. Key features include an alternative concurrency management system, transit-oriented development incentives, and a multimodal infrastructure plan within the Urban Cluster Boundary (UCB).

Map 8. Existing & Future Bicycle and Pedestrian Network



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[16] https://growth-management.alachuacounty.us/CompPlan/Transportation

[17] https://icma.org/sites/default/files/302848_Alachua%20County%202.pdf

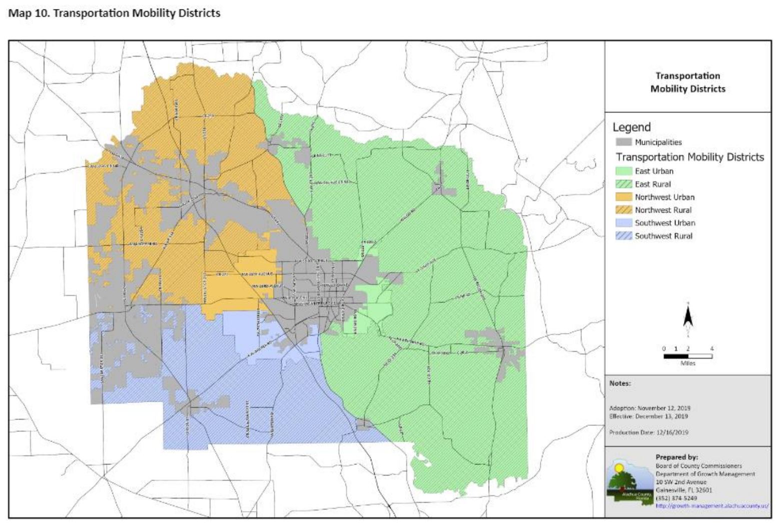

Figure 102: Transportation mobility element map in Comprehensive Plan 2019-2040

The 2018 University of Florida Transportation & Parking Strategic Plan (TAPS)[18] aims to improve safety, efficiency, and community partnerships over the next decade. Recommendations include creating a Bicycle and Pedestrian Zone, implementing parking management strategies, and enhancing alternative transportation modes. The plan also emphasizes collaboration with Gainesville RTS to enhance transit efficiency and proposes multiple routes to improve connectivity (see Figure 103).

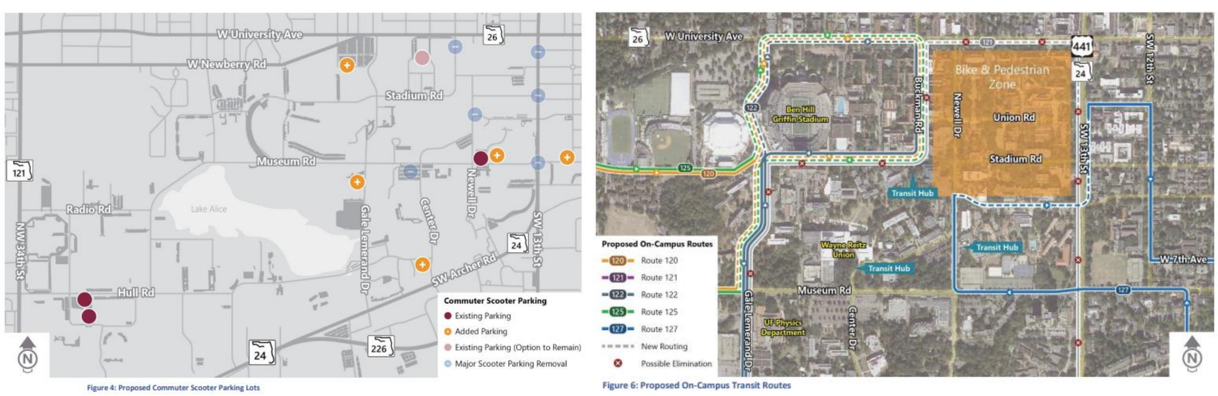

Figure 103: Proposed scooter parking and transit routes in TAPS

Gainesville mobility hub analysis by Arcadis

In 2019, Arcadis and Transportation for America collaborated to identify potential mobility hubs in Gainesville and the appropriate modes for each hub. [19] The hubs were identified using a combination of 27 different layers of data in five different layer groups; the data layers are displayed in Figure 104.

[18] https://taps.ufl.edu/wp-content/uploads/2020/11/TransportationStrategicPlan.pdf
[19] Mobility Hubs Identification: Arcadis Mobility Toolkit Pilot for City of Gainesville

A. Physical	B. Economic	C. Demographic	D. Access	E. Behavior
1. Streets 2. Bus Lines 3. Bike Lane 4. Bike Share Stations 5. Bus Stops 6. Parking Lots 7. Other Transportation Facilities 8. Public Attractions 9. Shopping Centers 10. Hospitals 11. Schools 12. Underutilized Land	1. Employment density 2. City planned development	1. Population density 2. Household income 3. Education level 4. Percentage of non-English-speaking household 5. Race	1. Accessibility to job centers by transit 2. Accessibility to recreational areas by transit 3. Average commute time 4. Average commute time if using public transit	1. Congestion friction 2. Average travel time by driving 3. Average travel time by public transit 4. Value experience (function of cost and time)

Figure 104: Criteria and variables used by Arcadis to identify MHs in Gainesville

The city was divided into 450-foot by 450-foot tiles, and each tile was scored from zero to six for each attribute. A score of six indicated most suitable for a mobility hub, and a score of zero indicated least fit for a MH. The scores were aggregated per layer group, and each layer was given a certain weight depending on the scenario.

Five scenarios were analyzed in this project: (1) equal consideration of all layers, (2) emphasis on access, (3) emphasis on economic, (4) emphasis on physical, and (5) emphasis on demographics. The results of the analysis for each scenario are displayed in Figure 105, as well as the frequency with which each potential MH emerged.

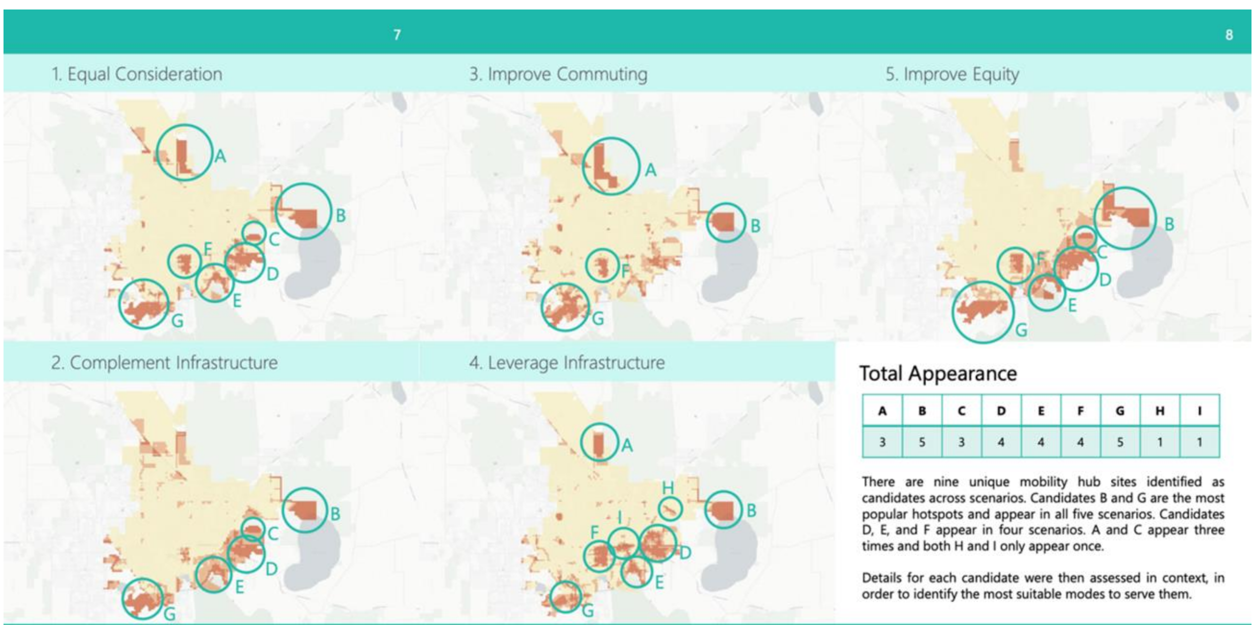

Figure 105: Potential MH candidate sites for each scenario (Source: Arcadis, 2019)

After identifying the candidate MHs, each site was evaluated for suitability and potential modes. As a result, 1 site was recommended to be dropped from consideration, 2 sites were recommended for bus/bus rapid transit (BRT), 2 sites were recommended for light individual transportation and BRT, 2 sites were recommended for shuttle, and 1 site was recommended for light individual transportation.

Although the work done by Arcadis informs the potential areas in Gainesville where mobility hubs may be built, they do not guide the city in identifying the specific sites for mobility hub development. In addition, there was no community engagement included in the process. These limitations have been a major motivation for the work performed in the current project.

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