MWCOG and DC Department of Transportation

Delivery Microhub Feasibility Study

June 2023

Table of Contents

List of Figures and Tables

1 INTRODUCTION

A 2019 District Department of Transportation (DDOT) study in the District of Columbia's Penn Quarter and Chinatown neighborhoods documented passenger vehicles and delivery vehicles blocking curbside loading zones more than 50% of the time, forcing commercial vehicles to double-park in travel lanes, block bus zones, or circle for available curb space. These congestion and safety hazards only worsened during the COVID-19 pandemic, when e-commerce and other deliveries skyrocketed.

DDOT seeks ways to encourage delivery in the District of Columbia by modes other than conventional trucks and cars, to help address the safety, congestion, and quality of life issues seen across neighborhoods. Success likely requires an accompanying land use component – a delivery microhub. Microhubs are defined for this project as small-scale, last-mile transshipment sites that can shorten last-mile trips to encourage non-vehicle delivery modes. DDOT, with support from the Metropolitan Washington Council of Governments (MWCOG) has created this study to explore the public sector's influence over delivery and new delivery innovations, like a microhub.

This report identifies a variety of delivery use cases that may or may not benefit from a microhub and provides a decision-making framework that jurisdictions need to consider from determining the need for a microhub through to developing the operational context, implementation details, and evaluation. These decisions and questions are woven into the following sections and include what areas to serve, siting considerations and needs, operational structures, and regulatory or financial incentives potentially necessary to support the pilot. The framework draws from lessons learned in research of case studies, literature, and stakeholder interviews. This document also identifies best practices from last-mile delivery case studies in different types of urban landscapes with different constraints.

2 PROJECT SCOPE

Subsequent steps toward deploying a pilot delivery microhub in the District of Columbia include working with community stakeholders and delivery operators to identify a suitable framework, neighborhood, and site for the pilot. Following that selection, we anticipate operations in late 2023 or early 2024, followed by an evaluation of the impacts of the pilot.

Table 1: Next Steps

Task	Status
Best Practices and Market Research	Complete. Interviews completed with Amazon, NYC DOT, and University of Washington in February and March 2023.
Stakeholder Engagement and Detailed Use Cases	Interviews with operators and community stakeholders occurred in May 2023.
Operational Framework for Pilot	The project team will develop an implementation plan; draft agreements between the District of Columbia, operators, and community stakeholders; determine the site; and set an implementation timeframe. This will begin in July 2023.
Evaluation Framework	The project team will develop an evaluation framework for the pilot that includes goals and evaluation metrics as well as criteria for program continuation after the six month evaluation period.
Implementation and Monitoring of Pilot	DDOT, the project team, and operating partners will implement a pilot. The project team will monitor the pilot for six months based on the evaluation framework.
Evaluation and Report	Evaluation will take place for six months, supported by the project team, once the pilot commences. After six months, the project team will compile a report on the success of the program and potential expansion.

3 BEST PRACTICES AND USE CASES

The Best Practices and Use Cases section describes the types of deliveries that currently occur in the District of Columbia, discusses operations and potential benefits of delivery microhubs serving those delivery cases, and identifies other places developing ways to address those challenges.

BENEFITS OF A MICROHUB

Key questions to ask to determine need for and potential benefits of deploying a microhub in any jurisdiction include:

- What are the safety, congestion, emissions, equity, etc. challenges surrounding delivery in your city? And which of those challenges are you looking to solve with a delivery microhub?
- Are delivery challenges more prevalent in residential areas, commercial areas, or mixed-use areas?
- What are your goals for a microhub? Examples include mitigating congestion, noise, and pollution.
- Which vehicle types are of interest in addressing these challenges? The range of types is changing quickly, but currently includes e-cargo-bikes of various formats, electric handcarts to accompany walking deliveries, and other small vehicles.

Microhub research has focused on the environmental and sustainability benefits, but some research shows that microhubs have traffic safety, conflict management, and labor benefits. Some issues that cities see, such as parcels being stolen from porches or food delivery vehicles blocking travel lanes, may not be addressed by a microhub. Instead, delivery strategies like parcel lockers may be a solution. Similarly, if most problematic deliveries are related to restaurant takeout or delivery or ultrafast convenience store deliveries, a microhub is not the best operational model. Coordinated curb management on the blocks generating meals or groceries for delivery is the more appropriate tool to reducing safety and congestion challenges. However, issues like box trucks double parking in travel lanes, bike lanes, or bus lanes to make deliveries are prime examples of issues that can be addressed through a microhub.

Environmental and Sustainability Benefits

Microhubs have several environmental and sustainability benefits, including the potential to reduce delivery trips, reduce truck (vehicle) miles traveled (VMT), and alleviate congestion in urban areas. Due to consolidation and other loading activities taking place in microhubs, fewer half-empty and polluting trucks enter the city center. This also reduces VMT. Microhubs alleviate traffic congestion by providing a space for delivery operators to sort and optimize load distributions before entering dense urban spaces (Katsela et al. 2022; Janjevic and Ndiaye 2014). Microhubs are located close to the final consumer, allowing delivery providers to use environmentally friendly transportation modes for short trips. E-cargo bikes can cover an average of distance of 20 miles per day and can replace traditional delivery vehicles on a 2:1 basis in dense urban environments (New York City Department of Transportation 2021). Similarly, combining microhub delivery and e-cargo bikes can reduce greenhouse gas emissions by 30%-40% per package compared to conventional delivery vehicles (Conway et al. 2017). In a London e-cargo bike and microhub case study, air pollution fell 81% and CO_2 emissions fell by 88% (Clarke and Leonardi 2017). Cities often see livability benefits from microhubs as well, including reduced noise and air pollution, traffic, and congestion (Ballare and Lin 2020).

Traffic Safety and Conflict Management Benefits

A microhub can reduce the number of large trucks driving into dense urban areas for deliveries. Microhubs can also move loading and unloading actions to off-street locations. This reduces the number of conflicts on streets where delivery trucks previously had to unload in a travel lane. Other technology, like curb reservations and smart loading zones, can help reduce circling and resulting conflicts (Chiara et al. 2022). Some microhub pilots have included accompanying bicycle and pedestrian infrastructure upgrades to encourage the use of e-bikes. Better bicycle infrastructure can reduce the number of bicycle conflicts and crashes (J. Lee and Kim 2019).

Operational Benefits

Microhubs may lower the total operational labor and associated time and cost for freight companies because the time required to unload at a microhub and make a last-mile delivery is less than the time needed to deliver a package traditionally (K. Lee, Chae, and Kim 2019). Microhubs can support off-hour deliveries. This can save up to 35% in costs (Conway et al. 2017). In terms of labor costs, wages are often lower for gig and delivery workers who staff microhubs. These cost savings may be offset by the need for more employees to carry out smaller e-cargo bike deliveries compared to one delivery truck driver (J. Lee and Kim 2019).

Equity Benefits

Historically, freight systems have been inequitable. Research has shown a pattern of both freight warehouses and highways (the backbone of the freight trucking and delivery system) being built in communities of color (Yuan 2018; Weingroff 2017). This development pattern led to negative externalities of freight systems, such as exposure to air pollution, noise, and traffic, that have had a larger impact on low-income communities and communities of color. The Urban Freight Lab at the University of Washington defines an equitable freight system as a system that "ensures everyone has access to the things needed to survive and flourish and reduces the barriers to making that possible" (Fried 2022a). Microhubs are a key tool for an equitable freight system. Microhubs can reduce truck travel into cities and neighborhoods – key for communities of color that, in a Seattle example, were exposed to three times the delivery truck volume density of other communities, despite making only half the online purchases (Fried 2022b). Sustainable last mile delivery modes used at microhubs can also reduce truck traffic, which can have safety benefits for communities who see high crash numbers around logistics centers (Katsela et al. 2022). However, microhubs, e-cargo bikes, and other sustainable freight pilots have been concentrated in affluent areas of cities – a key consideration for future microhub pilots (Fried 2022b).

DELIVERY USE CASES

Several key questions to ask to understand the potential use cases that are best suited to microhub operations in your jurisdiction include:

- Which types of deliveries are most common in your area?
- Would the microhub address deliveries to homes, businesses, or both?
- Are the deliveries creating local challenges time-sensitive or urgent? Are they primarily food or grocery deliveries or parcel deliveries?
- If parcel delivery, is it small parcels or large parcels?
- Which providers carry out most of the delivery operations? Are these large providers (e.g., USPS, UPS, FedEx, Amazon, DHL, etc.) or small providers?

Delivery use cases can be roughly summarized as shown in Table 2 that also includes examples and an initial assessment of how suitably a microhub might serve that use. Delivery use cases can be split into two general categories (home delivery and business delivery) and then into subcategories of each.

Home delivery can be split into food delivery and parcel delivery, and each can be further classified in ways that distinguish the time-sensitive nature of the product being delivered. Food delivery includes subcategories like grocery delivery, including both on-demand grocery delivery and scheduled grocery delivery, and meal delivery, which is primarily on-demand delivery like UberEats. Parcel delivery includes small parcel delivery, like United States Postal Service mail delivery or Amazon delivery, and large parcel delivery, which includes deliveries like heavy furniture items that cannot be done in a small truck.

FedEx and UPS define small parcels as packages less than 150 pounds and packages smaller than 108 inches in length and 165 inches in width. Large parcels exceed those limits and may need to be shipped via freight shipping, which is separate from small parcels. Large parcels are often too large for certain last-mile delivery vehicles and may not work well in a microhub.

The **business delivery** category also includes food and parcel delivery, as well as courier services and office supply deliveries. Deliveries to businesses include the same kinds of deliveries that come to homes—small and large parcels, meals and other perishables—often from the same shipping companies. However, businesses also receive lots of deliveries from other businesses (called B2B). Food delivery to businesses includes restaurant supply deliveries and office grocery deliveries, which can be on-demand or scheduled. Parcel delivery to businesses has similar characteristics as to homes. Business delivery also includes courier services and office supply deliveries. Courier services are typically same-day deliveries to businesses of small items like documents. Office supply deliveries are typically larger deliveries to offices. If B2B deliveries in your area are often shipped via a third-party carrier, they may be more conducive to microhub operations.

Table 2: Delivery Use Cases

	Home Delivery				Business Delivery					
Type of Delivery	Food Delivery		Parcel Delivery		Food Delivery		Parcel Delivery	Courier Services	Office Supply	
Product Delivered	Grocery Delivery	Meal Delivery	Mail and Small Parcels	Large Parcels	Restaurant Supply	Office Grocery Delivery	Mail and small parcel delivery	Large Parcels	Courier Services	Office Supply
Typical Delivery Length	1 or more days, but 30-60 mins in on-demand services	30-60 minutes (on-demand)	2 or more days	2 days to several weeks	Same day or 1+ days	Same day or 1+ days	2 or more days	2 days to several weeks	Same Day	2 or more days
Type of Delivery Operation	Multi-delivery rounds	Single-delivery round (point to point)	Multi-delivery rounds	Multi-delivery rounds	Multi-delivery rounds	Multi-delivery rounds	Multi-delivery rounds	Multi-delivery rounds	Single-delivery round (point to point)	Multi-delivery rounds
Typical Type of Vehicles Used	Vans, small delivery trucks, personal passenger vehicles	Personal passenger vehicles, bikes	Small delivery trucks, delivery vans, Postal Service vehicles, personal vehicles	Small delivery trucks, delivery vans	Delivery trucks, refrigerated trucks	Delivery Trucks	Delivery trucks, vans, Postal Service vehicles	Delivery trucks, vans	Vans, cars, bicycles	Delivery trucks, vans
Average Size of a Single Delivery	Several grocery bags, palette	Single bag or box	1-2 parcels	Typically, one large and/or heavy parcel	Several boxes, palette	Several grocery bags or boxes	Often multiple parcels	Typically, one large and/or heavy parcel	Typically, one parcel or envelope	1-2 parcels
Origin Land Use	Grocery store or food warehouse	Restaurant	Consolidation Center or Depot	Consolidation Center or Depot	Food Supplier or Warehouse	Grocery store or food warehouse	Consolidation Center or Depot	Consolidation Center or Depot	Typically business to business	Supplier or consolidation center
Destination Land Use	Residential (all densities)	Residential (all densities)	Residential (all densities)	Residential (all densities)	Restaurants	Office	Office	Office	Typically business to business	Office
Collection/Pick Up Service Available? e.g., ship to store for pick-up, ship to delivery locker for pick-up	No	No	Yes	No	No	No	Yes	No	No	No
Who carries out delivery operations?	Grocery store or food warehouse	Restaurant or on-demand gig workers	Parcel carrier (USPS, Amazon, FedEx, UPS)	Parcel carrier (Amazon, FedEx, UPS) or logistics company (DHL, FedEx, UPS)	Suppliers	Grocery store or food warehouse	Parcel carrier (USPS, Amazon, FedEx, UPS)	Parcel carrier (Amazon, FedEx, UPS) or logistics company (DHL, FedEx, UPS)	Courier service	Parcel carrier (USPS, Amazon, FedEx, UPS)
Example	Giant's PeaPod, InstaCart	Uber Eats	Amazon Prime small delivery to a single-family home	Large furniture delivery to a single-family home	Coastal Sunbelt Produce	Whole Foods Market and Amazon Delivery	Mail or parcel delivery	Office furniture delivery	Washington Express Courier	Amazon Business
Could a microhub be useful?	No	No	Yes	Yes	No	No	Yes	Yes	Maybe	Yes

Regardless of the end destination of the delivery, if most of the delivered items are perishable, a microhub may increase the delivery time and not be a conducive option to solving local delivery challenges. Additionally perishable deliveries would require temperature control and/or refrigeration at the hub and on the last-mile delivery mode. Where delivery trips are more predictable and a larger portion is scheduled in advance or recurring, customized delivery routes supporting hand carts, e-bikes, or e-cargo bikes can be refined and optimized at the microhub.

Small providers may have more specialized and/or dedicated markets and service areas with limited opportunities to make deliveries more efficient through a microhub. Large operators may have more package deliveries and may have more opportunities to create additional operational efficiencies using a microhub. Large operators are typically more interested in participating in delivery microhub approaches. Decision-makers may need to contact the carrier(s) directly to understand how they operate. Multi-round deliveries (multiple stops along a delivery route) are more efficient for a microhub, while single-round (point-to-point) deliveries are not as efficient for e-cargo bikes or handwalkers unless the end location is close to a microhub.

When to Use a Microhub?

Urgent deliveries that may be time-sensitive or temperature controlled are not good options for a microhub. Deliveries via a microhub are usually route-based, and a time-sensitive package may not be able to arrive within a set window. For temperature-controlled or perishable deliveries, a microhub may increase the delivery time and not be a conducive option. Additionally perishable deliveries would require temperature control and/or refrigeration at the hub and on the last-mile delivery mode.

Microhubs work best for deliveries that are non-perishable, small in size and weight, and have a short last-mile delivery trip. As such, home and business parcel deliveries are the best candidates for microhub delivery. Very few existing microhubs have an explicit focus on grocery, restaurant supply, or on-demand food delivery from restaurants, in part due to the time-sensitive nature of those deliveries being incompatible with an intermediary stop at a microhub. Ghost kitchens can be co-located at microhubs, but ghost kitchens and on-demand food delivery are not typically the main delivery type at a microhub. Large, heavy deliveries cannot be made with small vehicles like e-cargo bikes, which are commonly used at microhubs. With this and the District of Columbia delivery context in mind, parcel delivery to both residences and businesses is the best use case for a microhub.

Still, a key question for launching a microhub remains: do delivery companies see potential benefits to themselves from participating in a delivery microhub pilot or program? The following chapters describe the dynamics that answer this question.

CASE STUDIES

Examples of microhubs throughout the United States, North America, and Europe demonstrate how last-mile delivery operations can make use of small-scale sorting, staging, and distributing facilities, the benefits of doing so, the attributes that support operations, and the necessary obstacles that need to be crossed to be successful. **Error! Reference source not found.** describes microhubs developed since 2009. From these, three were chosen for their applicability to the District of Columbia context: Seattle's Neighborhood Delivery Hub, New York City's Commercial Cargo Bike Pilot; and London's Last Mile Logistics Hub. A summary of each follows the table.

Table 3: Examples of Operational Microhubs

Case Study	Location	Year	Delivery Use Case	Additional Context
Seattle Neighborhood Delivery Hub	Seattle, Washington	2021	Parcel delivery and food delivery using e-cargo bikes	Delivery trucks offload parcels at the hub onto an e-cargo bike or a parcel locker. Then, last-mile deliveries done via e-cargo bikes and customer package pickup is done via parcel lockers.
Commercial Cargo Bike Pilot	New York City, New York	2021	Parcel delivery to residences using e-cargo bikes	The pilot launched with UPS, DHL, and Amazon and 100 bikes. As of January 2021, there are 6 participants and over 350 bikes in the pilot. Commercial cargo bicycles enrolled in the pilot can load and unload wherever commercial vehicles can, & at designated cargo bike corrals
UPS Urban Solutions E-Bike	Portland, Oregon	2019	Parcel delivery to residences using e-cargo bikes	A UPS truck will drop off a container full of four cargo pods in a staging area on the PSU campus. The trike operator will then load one pod at a time and make deliveries from the staging area. At the end of the day, a UPS truck will retrieve the empty pods and bring them back to the warehouse.
Urb-E Cargo Bikes	Los Angeles, New York City, Boston	2019	Parcel delivery to businesses using e-cargo bikes	Urb-E provides e-bikes and e-containers for businesses to use for zero-emission delivery.
Santa Monica Zero Emission Delivery Zone	Santa Monica, CA,	2021-2022	Zero-emission vehicle delivery zone	Zero-emission delivery vehicles receive priority curb space for loading/unloading in a one-mile test zone in Downtown Santa Monica.
Ecofriendly Cargo Bike Delivery Project	Miami, Florida	2020	Parcel delivery using e-cargo bikes	DHL Express is partnering with REEF Technology to pilot the use of four new low-power electric-assist e-Cargo Cycles for deliveries across Miami.
B-Line	Portland, Oregon	2009	Parcel delivery to businesses using e-cargo bikes	B-Line serves Portland's urban core, delivering parcels and groceries within a 2.5 mile radius of the city center using e-assist trikes and a refrigerated truck for longer food deliveries.
San Francisco E-Bike Delivery Program	San Francisco, California	2022	Food delivery using e-cargo bikes	San Francisco's Department of the Environment is piloting a program to provide free e-bikes to delivery drivers to be used as delivery e-bikes for food deliveries.

FreshDirect Grocery Delivery	New York City	2021	Food delivery using e-cargo bikes	REEF has 150 bikes and 20 hubs in New York City, where they partner with Fresh Direct for grocery delivery.
Amazon Electric Delivery Vehicles	US – various location	2021	Parcel delivery via electric delivery vehicles	Amazon is making deliveries made with custom-built Rivian electric delivery trucks.
New York City Neighborhood Loading Zones	New York City	2019	Parcel delivery to residences using e-cargo bikes	NYCDOT created Neighborhood Loading Zones in residential areas. These loading zones are curb spaces that have been marked for short-term loading on narrow streets.
Project Colibri	Montreal, Canada	2019	Parcel delivery to residences using e-cargo bikes	Montreal provided a vacant bus depot to be used as a consolidation space for delivery trucks to unload packages to be delivered by zero-emission e-cargo bikes to their final delivery destination
London Last Mile Logistics Hub	London, United Kingdom	2020	Parcel delivery to residences using e-cargo bikes	London transformed parking spaces in an underused parking garage into a parcel consolidation hub for final delivery by e-cargo bikes.
UPS Hamburg Micro Hubs	Hamburg, Germany	2012	Parcel delivery using e-cargo bikes	UPS set up four mini distribution centers in Hamburg's city center.
Brighton and Hove City Council eCargo Bike Accelerator Project	Brighton and Hove, United Kingdom	2020	Parcel delivery using e-cargo bikes	Brighton & Hove City Council is supporting local businesses and organizations to use and switch to e-cargo bikes for deliveries of goods and services. To do this they have a subsidy for businesses that apply to switch to a third party e-cargo bike delivery service.
Beaugrenelle and Chapelle Logistics Hotels	Paris, France	2013 and 2018	Microhub loading and unloading, last-mile parcel delivery	The Beaugrenelle and Chapelle logistics hotels are multi-use, multi-story urban warehouses that provide a space for freight trucks to unload parcels that are delivered by last-mile delivery modes like e-cargo bikes or on foot. The Beaugrenelle logistics hotel only accommodates truck deliveries, while the Chapelle logistics hotel incorporates a railway terminal and distribution center.

Seattle Neighborhood Delivery Hub (Seattle, WA)

One of the earliest microhub delivery hub pilots in the United States when it launched in 2021, the Seattle Neighborhood Delivery Hub in Seattle's Uptown neighborhood was a research project from the University of Washington's Urban Freight Lab, Seattle Department of Transportation, Reef, AxleHire, BrightDrop, and Coaster Cycles. It ran for four months. The hub served as a centralized sorting and staging location for delivery trucks to unload packages onto e-cargo trikes or parcel lockers, with a ghost kitchen on site for food delivery via e-trike.

Seattle's Neighborhood Delivery Hub was located at 130 5th Avenue North in Seattle's Uptown neighborhood, in close proximity to high-density residential apartments, public transportation, and the Seattle Center Complex, an arts, tourism, entertainment, and sports complex centered around the Space Needle. The Neighborhood Delivery Hub site was zoned as Seattle Mixed zoning, a mixed-use zone where both residential and commercial development are allowed.

Project Partners

The University of Washington's Urban Freight Lab (UW UFL) collaborated with the Seattle Department of Transportation (SDOT) and several of its affiliated commercial partners, including Reef, AxleHire, BrightDrop, and Coaster Cycles, to pilot the Neighborhood Delivery Hub. The Urban Freight Lab has fifteen private partners and does a yearly project with partners to test or research an urban freight technology. Urban Freight Lab's members chose a microhub pilot as the yearly project in 2020. As such, the Seattle pilot was largely a private sector-led initiative.

The microhub site itself was on property that Reef owned and already operated as a parking lot and host to two ghost kitchen trailers. The site also provided an existing electrical connection for charging and access for vans and delivery trucks. Other partners wanted to participate in the pilot to test their own technology. AxleHire, a logistics startup with delivery routing software, coordinated deliveries and created routes. BrightDrop, a General Motors company, created the electric pallet used in the pilot and installed a storage container on the site to store electric pallets. Coaster Cycles created the custom e-cargo trikes with an attachment for the BrightDrop electric pallet. The University of Washington was the project convener and evaluator and installed and operated an on-site common carrier parcel locker. The Seattle Department of Transportation facilitated use of city streets and data sharing.

Project Goals

The Seattle Neighborhood Delivery Hub pilot had several goals. The pilot aimed to test new urban logistics technologies and vehicles and identify the benefits of microhubs in urban environments. Pilot partners had a larger goal of marketing new fuel-efficient and resource-efficient strategies, reducing emissions and congestion, and improving city livability and sustainability.

The Seattle Neighborhood Delivery Hub pilot was an opportunity to test a microhub to understand how it could factor into delivery operations. Deliveries were shipped to an AxleHire coordination center warehouse where they were sorted onto delivery trucks and driven to the neighborhood delivery hub. Parcel deliveries were then loaded onto BrightDrop's pallets and delivered throughout the Uptown neighborhood to residences using e-bikes. Consumers also had the option to pick up their package at the common carrier parcel locker on the site. The two ghost kitchen trailers served on-demand food services and delivery drivers would pick up food from the microhub site in passenger cars operated by DoorDash and other gig carriers. Customers also had the option to pick up their food from the site. Coaster Cycles' e-cargo bikes were not used for on-demand food delivery.

Pilot Practices

Most of the UFL partners had created or were in the process of creating new vehicle models or new technologies and wanted an opportunity to test them with support from the local government. The Seattle pilot was one of the first times that BrightDrop's electric pallet was used, and Coaster Cycles created custom trikes for the pilot. The University of Washington used the pilot as a chance to study common carrier parcel lockers.

SDOT also employed a unique data approach to better understand e-cargo bike delivery operations within the city streets. SDOT set up data-sharing agreements between AxleHire (the main data provider) and SDOT, creating a Memorandum of Understanding about what data would be shared, how, and how often to both set a precedent for future pilots and gain insight to inform future policy and infrastructure decisions. In particular, SDOT wanted to see the data to better understand how microhubs may help Seattle achieve zero-emission delivery goals. SDOT and the UFL used cameras with vehicle recognition technology, GPS tracking sensors, parking occupancy sensors, and video footage of e-cargo bike delivery driver behavior to monitor microhub operations. AxleHire shared GPS route data from the e-cargo bike routes for the comparison truck routes. This data gave SDOT a comprehensive understanding of delivery operations, including miles traveled, number of packages delivered, number of stops per route, infrastructure usage, speed, battery usage, interaction with other vehicles, bikes, and pedestrians, and activities at the site itself, including parking occupancy, parking duration, and distribution of vehicle types at the site.

Pilot Supports

While the pilot was supported by the Seattle Department of Transportation and the UW UFL, the private sector spearheaded the project and needed few to no incentives for the project. Most microhub pilots have required some level of financial or regulatory incentive, but the Seattle pilot did not.

The Seattle Neighborhood Delivery Hub utilized very few public policy supports. The partners already had a site, and Reef handled permitting and zoning confirmation. SDOT was only involved for data sharing and to facilitate access to Seattle's streets. SDOT stakeholders shared they were wary of overregulating the pilot and impacting success.

Key Findings

- Overall, neighborhood delivery hubs can enable productive and more environmentally sustainable urban last-mile delivery compared to traditional cargo vans.
- E-cargo bikes can replace a truck mile for mile. UFL researchers found that e-cargo bikes traveled 50% less miles per package and one e-cargo bike mile could replace 1.4 truck miles.[1]
- The Seattle Neighborhood Delivery hub reduced carbon dioxide emissions by 30% per package delivered. The only notable emissions came from internal combustion trucks delivering packages to the hub.
- The e-cargo bike removed 0.65 truck miles per package delivered, leading to an overall reduction of 356 truck miles in the Uptown neighborhood during the four-month-long pilot.
- During the pilot, the e-cargo bikes completed about eight deliveries per hour, while a truck on a similar route completed 19 deliveries an hour. However, this may have occurred because of e-cargo bikes riding on sidewalks, driver unfamiliarity with e-bikes, and routing software that did not provide the most efficient route.

The Seattle Neighborhood Delivery Hub has a few takeaways for the District of Columbia context. It was in a parking lot, suggesting that microhubs can successfully operate in a parking lot. There was limited government involvement, but there was significant support from private sector operators. It will be important to have support and initiative from the private sector and institutional partners to participate in a microhub. Partners like an e-bike company and delivery routing company may be more important than a delivery partner, especially if a partner is willing to have delivery carriers ship to their warehouse location and then drive the packages to the microhub location.

Commercial Cargo Bike Pilot and Microhub Delivery Pilots (New York City, NY)

New York City has two efforts that are relevant to the District of Columbia: a commercial e-cargo bike pilot program and a microhubs pilot (currently in development).

NYC Commercial Cargo Bicycle Pilot Program

New York City Department of Transportation (NYC DOT) launched the Commercial Cargo Bicycle Pilot Program in 2019 to encourage the use of e-cargo bikes for sustainable

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[1] Urban Freight Lab, 2021. https://www.seattleneighborhoodhub.com/_files/ugd/86f1fc_55a01fbac0a34d20b3946aa41eefc16d.pdf

commercial deliveries. NYC DOT's goal with the pilot is to allow New York City, businesses, and third-party delivery carriers to test e-cargo bikes and understand how e-cargo bike deliveries can and should fit into New York City's streetscape. NYC DOT has seen success with the pilot and has begun the rule-making process to make the commercial cargo bike program permanent.

Pilot Partners

NYC DOT launched the Commercial Cargo Bicycle Pilot in December 2019 with Amazon, UPS, and DHL. The three delivery carriers had a total of 100 bikes involved at the time. In January 2021, the pilot expanded to six companies (adding FedEx, Reef, and NPD Logistics) with over 350 bikes. The pilot started with a six-month test period, but has continued in operations and will become a permanent program.

Pilot Goals

NYC DOT's pilot supports the OneNYC strategic plan's goal of sustainability, improved freight mobility, and congestion reduction. NYC DOT's specific goals for the pilot included:

- Reducing congestion, illegal parking, and double parking from trucks and vans
- Enhancing safety by using smaller, more context-appropriate vehicles for last-mile deliveries
- Reducing greenhouse gas emissions by using e-bikes

NYC DOT has also encouraged protected bike lane network expansion. This supports cargo bike delivery by maximizing cyclist safety and comfort when traveling to corrals to make the delivery.

Pilot "Microhub" Structure

The Commercial Cargo Bicycle Pilot does not include a traditional microhub, but instead uses curbside cargo bike corrals and on-street parking spaces. These corrals are designated cargo bike-exclusive loading areas, marked by bollards and pavement markings in the curb lane. These corrals typically remove a few spaces of on-street parking. The corrals increase the supply of publicly available bike parking and provide additional space for cargo bikes to load, unload, and stage on street. Cargo bikes can also park in any metered parking space for deliveries. These corrals are related, but different infrastructure from the proposed curbside microhub option described later in this case study.

NYC DOT's focus of the pilot was addressing the negative externalities associated with truck delivery. As such, the pilot was not focused on a specific neighborhood or site, but on areas with high numbers of delivery trucks. NYC DOT deployed cargo bike corrals around Manhattan first, where carriers had the greatest demand, greatest volume of deliveries, and the most difficulty finding curb space to load, unload, and make deliveries. After success in Manhattan, NYC DOT expanded the pilot into Brooklyn.

NYC DOT does not have a formalized top-down cargo bike corral site selection process. Instead, carriers can submit a form to request a cargo bike corral in a specific location and NYC DOT will evaluate the site to see if it can support a corral. If NYC DOT decides to site a cargo bike corral at the site, NYC DOT staff will give a presentation to the local Community Board on bike corrals.

Pilot Practices

NYC DOT's Commercial Cargo Bicycle Pilot Program features several innovative practices. The pilot uses e-cargo bikes, with a variety of models and manufacturers, and was the first pilot Amazon participated in in the United States. NYC DOT also worked to change a New York State law that prohibited e-bikes wider than 36 inches. Many e-cargo bike models, especially trikes with a cargo space on the back, are wider than 36 inches and restrictive laws can limit the makes and models of e-bikes used. Each bike in the program makes roughly four to eight trips per day, with about five deliveries per trip.

NYC DOT's commercial cargo bike corrals are intended to remove trucks from last-mile deliveries in New York City's dense, urban environment. Delivery trucks usually park at a dispatch point (often an on-street parking spot – there are no designated dispatch points) and deliveries are transloaded onto e-cargo bikes, which then make the last-mile delivery. This is separate from a potential curbside microhub under the forthcoming microhub pilot program. Some corrals are also located outside of grocery stores or other commercial locations, such as Whole Foods, for e-bike delivery. Delivery companies or businesses can request a cargo bike corral in front of or nearby their business if they have a lot of deliveries from the business location. NYC DOT does not have a standard set of criteria for review when processing cargo bike corral requests.

Pilot Supports

NYC DOT's Commercial Cargo Bicycle Pilot Program relies on significant public government support. NYC DOT has not included any financial incentive to participate in the program to date and would like to have participants pay to use the corrals in the future, but provides informal incentives like safety, e-cargo bike infrastructure, and reliable, dedicated bike space. NYC DOT stakeholders shared that they have considered financial incentives, like rebates for e-bike purchases, to encourage more delivery companies to participate, especially smaller companies that do not see a strong business case. NYC DOT also provides significant support in terms of siting and corral construction. Companies fill out a form to request a corrals, and NYC DOT handles all of the site evaluation, planning, design and construction of the corral. NYC DOT also handles all community interaction and presentations to increase public support and demonstrate the community benefits of a microhub.

Key Findings

- The majority of cargo bike deliveries occur during the work week and during daytime hours.
- The majority of cargo bike deliveries are to residential addresses. These streets are often side streets. E-cargo bikes are better equipped than trucks to make those deliveries without double parking or unloading on the sidewalk.
- Each cargo bike in the pilot covers an average of 20 miles per day and can replace delivery trucks on a two to one or one to one basis. The majority of trips are about 3 miles, and have on average about five stops.
- NYC DOT has done community outreach for each corral that is installed. The most common complaint from the community is the loss of overnight parking space. NYC DOT has concerns that the community sees cargo bike corrals as an industry benefit, rather than a community benefit.
- NYC DOT required program participants to sign a data sharing agreement. Companies share a monthly report (usually an excel sheet) with zip codes of deliveries and the time for the delivery.
- NYC DOT worked to make a business case for companies to encourage other delivery carriers to sign on. Large delivery carriers with a high volume of deliveries often have a stronger business case for e-cargo bike delivery than small carriers.
- The corrals do not include battery charging equipment, but some carriers have shared that they would like to have charging equipment installed so bikes can charge on-route in the future.

Even though the program is not a microhub program, the NYC DOT Commercial Cargo Bicycle Pilot Program has some key takeaways for the District of Columbia.

- *Government Role*: NYC DOT has taken on a significant role in the pilot, handling all construction and planning. While DDOT may not create an on-street corral for a microhub, companies may be more likely to participate if DDOT creates a turnkey microhub that can be handed over to the delivery carrier to use with little to no financial pressure.
- *Community Engagement*: NYC DOT has also done significant community engagement to understand community concerns and understand if there is a concern about the location of the corral. DDOT will likely need to do similar levels of community engagement.
- *Operators*: NYC DOT had three partners (Amazon, UPS, DHL) when they started the pilot, and the new partners have all been large delivery carriers. A large delivery carrier may have a stronger business case to participate in a microhub, and outreach should be done with them early in the process to get a partner signed on.

- *Delivery Location*: NYC DOT focused on Manhattan, where the negative externalities from trucks were the most common. Even so, 80% of deliveries were to residential addresses. The density of land uses, especially high-density multifamily residential, is important to consider when looking at microhub sites in the District of Columbia.

NYC Microhubs Pilot

As part of the Commercial Cargo Bicycle Pilot Program, NYC DOT identified a need for additional e-cargo bike and urban freight solutions. Around the same time, the Manhattan Borough President made turning half of e-commerce deliveries into cargo bike deliveries by 2026 a campaign promise and released a report in 2022 outlining a blueprint to addressing e-commerce delivery challenges. Microhubs were highlighted as a possible solution in the blueprint. In July 2022, NYC DOT released a Request for Expressions of Interest (RFEI) for a microhub pilot. Twenty-three respondents submitted responses to the RFEI. Respondents ranged from full-service logistics companies interested in participating in microhub pilot programs to smaller companies interested in operating a single aspect of a microhub supply chain.

Pilot Goals

NYC DOT outlined the goals of the pilot program in the RFEI. These include:

- Promote last-mile delivery operations that are efficient, sustainable, and equitable and support and build healthier and more vibrant communities.
- Reduce delivery traffic in congested areas by consolidating multiple deliveries from different suppliers at central location(s).
- Identify opportunities and challenges to conduct and better organize loading and unloading activities at designated off-street or curbside locations.
- Establish a method for distribution that is mutually beneficial to all street users and balances the utility, functionality, and competing interests of the public realm.
- Develop partnerships with industry and community/stakeholders to better facilitate development and implementation of efficient, sustainable, and equitable freight operations.

Microhub Site Selection

NYC DOT is early in the site selection process and has not yet identified specific microhub locations or facilities. Staff worked with industry partners to determine where most deliveries occur throughout New York City to gauge where demand for a hub is greatest. They are now analyzing additional factors to match where partners might want a microhub with their pilot program goals. With the siting work, NYC DOT is considering other hub amenities to support delivery operations, like access to transit and bike facilities, shared use lockers, and worker amenities like restrooms. NYC DOT staff are also considering an equity component to siting microhubs and attempting to understand whether truck trips to and from the microhub outweigh the benefits of a microhub. Timing and hours of the microhub are another question. If microhubs are near residential buildings, operating hours may have to be restricted to daytime hours to prevent community disruptions. Loss of overnight parking has been a community concern with the cargo bike corral pilot, but NYC DOT has not considered exclusive or time-restricted curbside microhubs.

Microhub Design

NYC DOT staff are also early in the design process for microhubs. NYC DOT will likely install both on-street and off-street microhubs, but these will likely not be paired together. Off-street microhubs could be in empty parking structures, while on-street spaces would be on the curb with enough space for a truck to pull in and unload (about four car parking spaces). NYC DOT is still considering how security needs will impact microhub design, including cargo bike parking and parcel security. NYC DOT is also deciding whether the microhub space will be reserved for one operator.

RFEI responses indicated that companies do not want a shared microhub space because it can complicate operations and security. A shared space model would also require NYC DOT to identify a technology partner to create a space reservation system. The NYC microhubs will likely be designed for a single operator, rather than a shared space, in the short term. However, NYC DOT does not want to privatize microhubs in public space along curbs or create several microhubs next to each other for different operators.

RFEI responses indicated that respondents would like to see several different facility characteristics and amenities, including:

- Off-street sorting and lighting
- Storage pods, space for storage pods, and charging and lighting infrastructure at the pods
- Secure location with a fence or monitored security or a public location with 24/7 availability
- Building access for trucks (eight feet or more clearance height, minimal congestion, low speed limits)
- Space for sorting, conveyor belts to distribute packages for individual routes, short-term storage, forklift space, bike/trailer loading space, refrigeration units for temperature sensitive goods, storage for e-bikes and trailers, parking for vans, and parking for employees
- Employee amenities including restrooms, locker rooms, kitchen/lunch/break area, and dispatcher space

- On-site repair station for bikes and trailers

Key Findings

- Zoning considerations: Respondents prefer medium-high density commercial and residential areas. Facilities should be located in areas zoned for light industrial uses (woodworking shops, repair shops, and wholesale service and storage facilities); high-density commercial areas, and high-density residential areas.
- Respondents prefer indoor operations for a microhub.
- Respondents prefer a private, secure site for a microhub.

NYC DOT's RFEI and initial planning work includes some important takeaways for the District of Columbia context:

- *Location*: The microhub will likely need to be off-street and indoors to entice delivery partners to use it. DDOT will need to consider whether the microhub is a shared space or for a single delivery carrier. This decision will likely have implications about what partners are interested – a microhub for one company will limit the number of partners, but may make it easier to find a delivery partner.
- *Zoning*: Zoning will be a key location determinant as well, and may need to be something discussed with a delivery partner to understand what zoning they find most effective for their delivery operations.

Amazon Hackney Last Mile Logistics Hub (Borough of Hackney, London, United Kingdom)

Amazon launched its first United Kingdom microhub in July 2022 in the London borough of Hackney. This hub replaced the proposed microhub in the London Wall Carpark near the Museum of London (cancelled because of the Museum of London's planned move to a new location). The Hackney microhub is the first in a series of UK delivery microhubs Amazon has launched, including hubs in Wembley and Southwark in London.

Program Goals

Like Seattle, the Hackney microhub is primarily a private sector initiative. Amazon Logistics wanted to transition away from delivery trucks that receive large fines for double parking and are subject to congestion pricing in central London. To make that transition, Amazon needed central logistics centers from which to dispatch cargo bikes and e-bikes on shorter delivery routes. The Hackney microhub fits into Amazon's larger goal to electrify and decarbonize Amazon's European transportation network to reach net zero carbon emissions by 2040.

There was not a push from London governments to pilot a microhub, but both the City of London and the Greater London Authority have supported Amazon's microhubs.

Microhub Design

The Hackney microhub is located at Amazon's UK headquarters at Principal Place in the Borough of Hackney, at the edge of Shoreditch and the City of London. There were unused motorcycle parking spaces in Amazon's Principal Place underground parking garage, which Amazon decided to turn into a microhub. The microhub is about 5,000 square feet and can support 15 e-cargo bikes and 10 walkers. The parking garage features double height access, so small delivery trucks can access the underground parking facility to unload packages. The hubs generally do not handle sorting and consolidation. Amazon handles consolidation at a larger consolidation center outside of London and sends small trucks to the microhub to drop off packages that are distributed by the e-cargo bikes. The hub features space to store bikes, space for dispatchers (two desks and a set of lockers), a charging cabinet for e-bike batteries, and wifi coverage. Drivers can use the office tower's lobby and restrooms. Amazon employs two dispatchers, and partners with delivery service providers, who hire e-cargo bike drivers and walkers.

Microhub Siting

Amazon created an innovative tool and algorithm to site microhubs. The tool layers data about the number of packages delivered per day in all of London with van travel and parking distance to delivery, and then compares those overlays to the operational distance of e-cargo bikes. The tool then drops a pin on the map in the ideal microhub location. Amazon representatives shared that microhubs ideally should be located in the epicenter of density and package delivery locations. A van can deliver across a nine-hour period, but bikes need to shuttle between delivery locations and the central hub, so the microhub should be located in a central spot (like a hub and spoke system). The "spokes" for each bike route are about two to three miles from the central hub. Amazon is currently working on creating routing algorithms for e-cargo bike routes that include bike regulations.

Microhub Practices

Another innovative feature of Amazon's Hackney microhub is their staffing model. Amazon partners with delivery service providers (DSPs) to staff both the Hackney microhub and other Amazon microhubs in the UK. Amazon has two DSP models. DSP 1.0 features an established logistics operator that gets a set delivery volume, which allows them to hire delivery employees for that set delivery volume. This is the model at the Hackney microhub. DSP 2.0 is similar, but logistics companies use Amazon-branded vans for deliveries.

Amazon's Hackney microhub utilizes limited public policy support, since Amazon owned the land. The Hackney Borough Council assisted with zoning changes and permitting as necessary. However, even with the Hackney Borough Council's help, the permitting process took six months and $150,000. In other locations, like Wembley and Southwark, Amazon has wanted to use Council land, which has increased public policy supports. Amazon also works closely with the local Council for engagement to ensure no major community backlash. Amazon stakeholders shared that if a site or location didn't work operationally for a microhub and the community did not support the site, they likely wouldn't put a microhub there, regardless of Council support.

Key Findings

- *Fire Safety*: A major challenge was getting fire safety standards for battery charging. Amazon had to create a hermetically sealed locker that only charges when doors are shut. If a fire started, the fire services have to cut the charging wires and drag the locker out of the garage.
- *Community Support*: Community support is key for a microhub. Amazon did very little community support before the Wembley microhub launched in West London. The microhub routing software routed bikes through a park, which angered local residents. Amazon stakeholders shared that they thought they would deploy microhubs and the community would be supportive, but that was not always the case.
- *Site*: The site is the most important piece of the microhub. Sites that require fewer zoning changes and less permitting may offer benefits even if the location is not the top location for a site.
- *Siting Analysis*: Amazon used proprietary data about the number and density of packages that are delivered per day across all of London, as well as their routing software, for the siting analysis. It is unlikely that this analysis could be replicated by the public sector without an explicit private sector data-sharing partnership, but population and employment proxies can be used to estimate suitable service areas with high demand for delivery.

The Hackney microhub has several implications for the District of Columbia context:

- Amazon as a Partner: Amazon is building a second US headquarters in Arlington, Virginia, and Amazon UK stakeholders shared that Amazon is looking to replicate the UK microhubs in the US context at some point in the future. There may be an opportunity to partner with Amazon on a microhub in the future.
- Parking Lot Locations: The Hackney microhub is located in an Amazon garage. DDOT could replicate a microhub in a parking garage, like Amazon's hub. This may also support an indoor microhub, which NYC DOT RFEI respondents indicated they prefer, that includes simpler access to weather protection, worker comfort facilities, electricity, and potentially wi-fi connectivity.

BEST PRACTICES FOR MICROHUBS AND URBAN LOGISTICS OPERATIONS

Microhubs may seem like a fairly new delivery innovation, but consolidation of urban freight delivery has a long history of research, piloting, and success. The United States Postal Service has operated microhubs (its neighborhood post offices) for as long as it has existed. As urban freight and logistics have grown more complicated with a proliferation of related stressors–like congestion and emissions–and new business models, private operators are now delving into last-mile consolidation and distribution centers, either on their own or as part of a consortium with other carriers. Microhubs have the potential to provide environmental benefits, improve traffic safety, lower operational costs, and equitably benefit historically marginalized communities. Municipalities like the District of Columbia aim to organize this activity to benefit the public as well as the carriers.

Microhubs’ characteristics can be organized into the following categories:

- *Single-Carrier or Shared Use Microhubs*
- *Vehicle Models*
- *Technology Needed*
- *Microhub Location*
- *Infrastructure and Access*
- *Governance of a Microhub*
- *Stakeholders and Community Partners*

Key questions that may impact operational practices and logistics include:

- What is the **average size** of a delivery? Are the deliveries made usually smaller, more compact items (e.g., household goods, home office supplies) or larger more cumbersome items (e.g., furniture, bulk items)?
- What **type of vehicles** are typically used for deliveries? What type of vehicles will be used for deliveries out of the microhub?

Single-Carrier or Shared-Use Microhubs

A microhub can serve a single operator or can be shared among multiple operators. One of the first decisions a city or municipality needs to make is whether the microhub will be a single-carrier microhub or a shared microhub. Freight operators noted in interviews that their preference is to operate within a single-carrier microhub.

Single-operator microhubs are often developed and operated by a large third-party logistics company like FedEx, UPS, or DHL that can guarantee a sufficient and consistent volume of deliveries to invest in a microhub’s real estate and operations. The operator is responsible for transporting delivery packages from its large logistics center, often in a suburban location, to the microhub; operating the microhub; and coordinating last-mile delivery to multiple final destinations with either carrier employees and vehicles, or contract delivery employees and vehicles. Examples of this type of microhub are UPS's microhubs in Hamburg, Germany, and DHL and Reef's Ecofriendly Cargo Bike Delivery Project in Miami, Florida.

Shared microhubs serve multiple operators under a variety of operational approaches. These approaches include:

- *Third-Party Microhub*: A single delivery operator or multiple operators deliver packages to the microhub where the third-party operator sorts and delivers goods to an end-receiver using micro-distribution vehicles. Early in the pilot process, local municipalities are often more involved in a third-party microhub. The third-party operator may only carry out last-mile deliveries, rather than owning the site outright. Examples of this type of microhub are the B-Line in Portland, Oregon; the Seattle Neighborhood Delivery microhub in Seattle, Washington; and Gnewt Cargo's operations in London.
- *Third-Party Small Business Microhub*: Similar to a third-party microhub, several small businesses ship their parcels to one location, where a delivery company bundles parcels together to combine deliveries. The Collaborative Urban Logistics and Transport (CULT) Partnership in Antwerp is an example of this type of microhub. In the CULT partnership, seven companies have agreed to ship their parcels to a location on the outskirts of Antwerp, where Bpost bundles parcels together and delivers the parcels using emissions-free modes.
- *Shared Microhub with Exclusive Time Windows*: A microhub space where operators book time windows during which they have exclusive access to a designated location to transload goods from a larger vehicle to a micro-distribution vehicle for final delivery. An example of this type of microhub is Project Colibri in Montreal, Canada.
- *Shared Microhub with Designated Spaces*: A shared microhub space where multiple operators have exclusive designated space within a shared microhub location from which they conduct independent transloading and local micro-distribution. Examples of this type of microhub are the Beaugrenelle and Chapelle logistics hotels in Paris, France.

Cities beginning to explore delivery solutions typically choose a single-carrier microhub or a third-party microhub for pilots. These microhubs are smaller, easier to test, and typically have more support from delivery carriers like FedEx or UPS. If these pilots are successful, cities begin to test more complicated types of microhubs, like the shared microhubs with exclusive time windows or designated spaces.

As a result of the shared operations, the governance structure and facility partnership agreements between varied stakeholders is more complicated to coordinate needs and activity, often requiring public involvement. The Governance and Stakeholders and Community Partners sections go into more detail on structures.

Vehicle Models

Once a city or operator has decided to pilot a microhub, decision makers (planners, city staff, and most importantly delivery operators) need to choose the type of vehicles for the microhub, since the vehicle models can greatly impact the hub size and technology included. The range of vehicle types for a microhub and last-mile delivery are changing quickly with evolving technology and regulatory landscapes. Delivery microhub vehicles can include small, sustainable last-mile delivery options like e-cargo bikes or light electric freight vehicles. These delivery vehicles can navigate smaller streets and find smaller parking spaces in dense, urban locations more easily than large semi-trailers or delivery trucks. However, larger items can be too big to deliver using small modes like a cargo bike or handcart. The characteristics of the service area will also influence which vehicle models best support operations. Stating a preference early on in the planning process will influence which facility sites are selected and which operators will be partners in achieving program goals.

E-Bikes

An e-bike is a bicycle that uses an electric assist motor that allows riders to travel longer distances than traditional bicycles. Pedal assist e-bikes activate the electric motor by pedaling. This e-bike has a top speed of 20 miles per hour and has an average capacity of 100-200 pounds. Throttle-assist e-bikes operate similarly to a moped or motorcycle, with a throttle on the bike handlebars that provides direct power to the e-bike motor without needing to pedal. Throttle-assist e-bikes have top speeds between 20 miles per hour and 28 miles per hour, depending on the model and have an average capacity of 100-200 pounds. E-bikes are best for courier delivery or other small deliveries that do not need a large amount of cargo space.

E-Cargo Bikes and Trikes

The vehicle of choice at most microhubs is an e-cargo bike. E-cargo bikes are designed to carry heavier loads of deliveries. These bikes have maximum speeds of 28 miles per hour and a typical payload of 770 pounds. Delivery operators use e-cargo bikes for mail and package delivery, food delivery, and other small volume deliveries. However, e-bikes may be too fast and too wide for comfortable operations in standard bike lanes, most of which are five feet in width.[2] While most e-cargo bikes are less than 48 inches in width, they may inhibit safe passing within a standard single-direction bike lane, especially one without a painted buffer. E-cargo bike delivery drivers may end up riding on sidewalks because of operator discomfort in the bike lane and a lack of space for unloading or parking in the bicycle lane.

An emerging model of e-cargo bike is the e-cargo trike or four-wheeled bikes. Many e-bikes used in previous microhub pilots have been trikes. These provide additional stability for a cargo trailer. One example of these are Coaster Cycle's e-cargo bikes used in the Seattle Neighborhood Delivery Microhub pilot. Four-wheeled e-cargo bikes are a newer option for last mile deliveries. These bikes typically look more like a small delivery truck, with about 2 cubic meters of cargo space. However, four-wheeled bikes may have additional regulatory challenges in which they may no longer be considered a bicycle by law.

The model chosen by delivery operators varies based on the use case and supply chain, but the supporting infrastructure at a microhub should accommodate any model. Some examples are included in the images below.

Figure 1: FedEx Long John E-Cargo Bike

Source: FedEx

[2] NACTO, Urban Bikeway Design Guide. https://nacto.org/publication/urban-bikeway-design-guide/bike-lanes/conventional-bike-lanes/#:~:text=%E2%80%9CThe%20recommended%20width%20of%20a,AASHTO

Figure 2: Box E-Cargo Trike

Source: Bunch Bikes

Figure 3: E-Cargo Bike with a Mini Shipping Trailer

Source: University of Washington

Figure 4: E-Cargo Bike with Mini Shipping Trailer and Weather Protection

Source: REEF Technology

Figure 5: Four-Wheeled E-Cargo Bike

Source: Zoomo

Light Electric Freight Vehicles

A light electric freight vehicle is a bicycle, moped, or other small compact vehicle (about the size of a golf cart) with electric assist technology or a drive mechanism. These vehicles are designed for the distribution of goods in public spaces and have a limited speed, typically under 30 miles per hour. Purolator, a Canadian-based electric vehicle company, used light electric freight vehicles for microhub deliveries in pilot projects in both Toronto and Montreal (*Business Insider* 2020).

Figure 6: Light Electric Freight Vehicles

Source: Purolator

Small Distribution Vehicles

Small distribution vehicles are a common type of vehicle used for last-mile delivery currently, both with and without a microhub. These vehicles are small vans or vehicles about the size of a golf cart with a payload of up to 1,675 pounds. These vans can be electric, but not all vans are.

Figure 7: Small Electric Delivery Van

Source: Amazon

Technology Needed

Microhub facilities feature a wide range of technology, depending on the use case and vehicles operated for last-mile delivery trips. Most microhubs include electric charging, especially if the microhub uses electric last-mile delivery vehicles. Level 2, 240-volt electric charging and battery charging are the usual types of charging technology for electric vehicles and e-cargo bicycles. Operators can also decide whether to employ additional technology, such as last mile routing software, parking availability prediction software, and advanced vehicle form factors, including electrified hand carts. Cities need to decide if they want to test additional delivery technology at a microhub facility and within the service area, like smart loading zones, automated enforcement, or geofencing. Such technology can be necessary to support associated policies like a zero-emissions delivery zone or congestion charge.

Electric Vehicle Charging

If the typical vehicle utilized to deliver parcels out of the microhub is an electric vehicle, charging on site is important to maintain operational efficiency. Electric vehicles need to be charged when not in use – either in between deliveries or overnight. Chargers can be either indoors or outdoors. If they are outdoors, chargers need to be located close to existing electric connections or longer timelines and more installation costs are likely. This may impact hub siting criteria since electric vehicle charging requires a connection to a wall outlet. Most charging infrastructure is Level 2 charging infrastructure that requires a 240-volt wall outlet.

Battery Charging

Most e-bikes and e-cargo bikes use a rechargeable electric battery. In general, lithium-ion batteries are the most common type of batteries. These can range from smaller batteries that weigh between six and eight pounds with a range of about twenty miles to more expensive forty-pound batteries that promise a range of 100 miles. Most batteries can handle a few small trips (less than 10 miles), but need to be swapped out between trips for all-day e-bike use (Temporelli et al. 2022). Some manufacturers recharge batteries with solar powered canopies directly on the e-cargo bike while some manufacturers use a battery swap system, where batteries that need to be charged can be swapped out for a charged battery. Decision-makers need to consider an e-bike's type of battery charging when choosing an e-bike partner for the microhub.

Last-Mile Delivery Routing Software

Some operators using microhubs have introduced specialized last-mile delivery routing software that identifies the most efficient routes for delivery. Depending on data available, the software can design routes that avoid congestion or other parameters, like left hand turns, and prioritize streets with bike facilities for bike couriers. Delivery companies can contract with companies like AxelHire, Cavolo, Curbhub.io, Beans.ai, Stoovo, or OptimoRoute, who provide individual drivers with routes. However, most software is set for efficient routing of trucks, not small last-mile vehicles. A Seattle pilot found that existing routing tools did not provide the most efficient bike-friendly route (University of Washington Urban Freight Lab 2021).

Smart Loading Zones

Companies like Pebble by Sidewalk Labs, CurbFlow, and Automotus, among others, have partnered with cities to create "smart loading zones" that can be reserved via mobile app, often for a fee similar to a metered space. These loading zones provide delivery drivers with a dedicated space to unload that can be booked ahead of time, rather than circling the block or unloading in a travel lane. DDOT partnered with CurbFlow in 2019 for a similar curb space loading zone pilot, where drivers could coordinate curb space through an app. Smart loading zones are typically enforced by the municipality, regardless of the technology provider.

Enforcement Technology

Microhubs and similar technology like smart loadings zones sometimes use enforcement technology. Enforcement is typically the responsibility of the city or municipality. In curbFlow's Columbus pilot, curbFlow created an enforcement companion app, which was embedded in the City's parking enforcement devices. This notified the City of parking infractions in real time.

Geofencing

Geofencing technology can be used to highlight the microhub and surrounding delivery zones. Geofencing technology could share curb, street, and/or delivery zone policies and regulations to all delivery carriers and employees to optimize microhub use.

Microhub Location

Microhubs are most effective and successful in high-demand, high-density areas with high volumes of last-mile deliveries. Successful microhubs are in locations that minimize operational costs for delivery operators, meet city requirements, and address community concerns around truck traffic from increased deliveries.

To date, microhubs have not been explicitly sited to ameliorate an area's negative and inequitable impacts from transportation and freight activities. In some cases, microhubs are sited in locations that exacerbate existing community concerns. One microhub operator shared they had to change a microhub location in London because of community concern about increased e-bike traffic through neighborhoods.

High demand is necessary to justify the need for a microhub in that location and to keep the microhub sustainable and efficient (University of Washington 2020). Often, high demand is driven more by residential density than commercial density, but often mixed-use downtown locations can balance the schedule of routine and one-off delivery orders better (Novotná et al. 2022; de Oliveira et al. 2019; Ballare and Lin 2020).

Beyond high-demand areas, a microhub should serve areas in the city where delivery activities are difficult because of limited curb space for large vehicles, limited access on streets, and restricted traffic conditions (University of Washington 2020). Location parameters to consider when evaluating location include residential, commercial, and employment density; pedestrian and bicycle infrastructure, road classifications, vehicle speeds, level of traffic congestion, traffic calming measures, and land use restrictions (Katsela et al. 2022).

A key aspect of microhub location is zoning. Zoning can be a land use restriction for microhubs as it may not allow microhubs in central downtown cores or residential areas. Microhubs are typically allowed under mixed-use zoning. Paris's logistics hotels are zoned as mixed-use developments and are located in residential neighborhoods. These hotels are typically underused sites that are rezoned for the logistics hotel. The Beaugrenelle logistics hotel is a former parking lot rezoned for mixed-use and the Chapelle logistics hotel is an old railway terminal rezoned for mixed-use. Seattle's Neighborhood Delivery Microhub is also located in a mixed-use zone. Further description of microhub service area and facility siting criteria is in Section 5.

Infrastructure and Access

Most microhubs are in off-street locations with unique infrastructure needs. Each microhub has unique infrastructure needs based on site characteristics, delivery characteristics, and vehicle characteristics. Infrastructure examples are highlighted in Table 4. More specific information on infrastructure needs and best practices will be presented in Section 5.

Microhub Management and Support

Delivery providers typically operate microhubs. However, city governments usually provide significant support to a microhub, especially in a pilot program. Cities can benefit from sustainable urban delivery and as such, often support the implementation of microhubs. This is commonly done through regulations, infrastructure support, financial support, and planning support, as detailed in Table 5. Cities need to decide which of these tools to use to regulate, encourage, or manage a microhub

Stakeholders and Community Partners

The delivery landscape is cross-jurisdictional across multiple levels of government and a wide variety of community partners. Delivery microhubs include a variety of stakeholders and community partners, including retailers, delivery and logistics providers, residents, municipal governments, delivery employees, and end-consumers receiving the delivery. Common stakeholders and community partners are shown in Table 6. It is important for city-led pilots to engage stakeholders early in the process to understand if delivery operators are interested in a microhub and to understand community concerns around delivery.

Small providers may have more specialized and/or dedicated markets and service areas with limited opportunities to make deliveries more efficient through a microhub. Large operators may have more package deliveries and may have more opportunities to create additional operational efficiencies using a microhub. Large operators are typically more common to be interested in participating in delivery microhub approaches.

Table 4: Microhub Infrastructure Needs

Infrastructure Need	Description
Vehicular Access	Microhubs need vehicular access for large delivery trucks to drop off parcels and for last-mile delivery modes to enter and exit the microhub. Access should be consolidated to a single curb cut to avoid conflict with high pedestrian-traffic areas.
Physical Building or Shelter	Many microhubs have a physical building or shelter to protect loading areas from weather. Indoor operations benefits include weather protection for goods, staff, and equipment; overnight storage; battery charging and electric vehicle charging; space for loading; fewer interactions with pedestrians or other vehicles; and temperature control. Outdoor operations require a secure fenced-in area and temporary or semi-permanent structures for administrative spaces, repair bays, charging and storing electronics and batteries, and loading space.
Internal Loading	Microhubs should provide an interior space for loading, vehicle queuing, parking, storage, transshipment, electric vehicle charging, and other delivery needs. This could be a shared space or there could be individual loading bays and spaces for each carrier.
Protected Bike Network	Access to a protected bike network is important for e-cargo bikes. A protected bike network provides safe bicycle transportation routes for employees and for local deliveries.
Pedestrian Network	Access to the connected pedestrian network is important for last-mile deliveries on foot. A connected pedestrian network provides safe walking routes for deliveries made on-foot.
Flexible Loading Zones	Flexible loading zones provide spaces for a variety of delivery vehicles to unload. These zones should be used for any freight activity, from truck unloading to food deliveries.
E-Bike Parking	E-bike parking provides a parking space for e-cargo bikes. E-bike parking provides a space for bikes to charge between deliveries at the microhub and for bikes to park on deliveries. Bike parking should be designed to fit both e-cargo bikes and regular e-bikes. It should also be designed to lock bikes quickly and easily for efficient delivery.
Utilities Connections	Many delivery operators need delivery and unloading sites with utilities, internet connections, and electrical connections. Microhubs should provide utility connections when possible and microhub sites should be chosen with these in mind.
Employee Amenities	Many delivery operators need employee amenities for their staff at the microhub and delivery staff. Employee amenities can include a bathroom, locker room, kitchen or break room, and workspace for a dispatcher. Amenities may also include temperature control, like heat in the colder months and air conditioning in warmer months.
Parcel Lockers	Parcel lockers are small storage units that are located very close to the final delivery point. Often used as a deterrent to package theft, these units can benefit delivery operators as well by consolidating destinations and shortening trips. These can be accessed by consumers using a unique numerical code to unlock a specific locker, who can pick up their package at a locker rather than having it delivered directly to their home. Lockers can be located at a microhub or can be co-located in high-density residential buildings or retail locations.
Refrigeration	Consumers are ordering more and more perishable packages that require refrigeration or other temperature controls. A microhub that handles perishable packages, grocery, or other food deliveries requires refrigeration technology at both the microhub and on the last mile delivery vehicle. Refrigeration technology in delivery vehicles has traditionally been included on large trucks or tractor-trailers. However, some vehicle manufacturers are beginning to create new all-electric refrigeration technology that can be installed on smaller last mile delivery vehicles. (Cullen 2021)

Table 5: Microhub Governance Tools

Tool	How It Works	Example
Regulations	A city can use regulations to influence microhub operations and set freight policies. Cities can structure regulations as an incentive to participate in a microhub, such as waivers to zone-based vehicle access restriction, extended delivery time windows, or waivers to the zoning or building code. Regulations can also be a tool to push delivery operators to participate in a microhub, such as commercial operator licensing restrictions and off-hour delivery mandates for trucks or larger vehicles. Some regulations also shape the benefits to the areas surrounding a microhub, such as off-hour delivery mandates or low/zero emission delivery zones.	▪ Off-hour delivery mandates[3] ▪ Low/zero emission delivery zones ▪ Green curbside loading zones in commercial and residential neighborhoods ▪ Commercial operator licensing restrictions[4] ▪ Commercial electrical vehicle or cargo bike procurement support ▪ Extended delivery windows ▪ Zone-based vehicle access restriction waivers ▪ Low-speed electric vehicle and e-cargo bike size requirement waivers ▪ Waivers or exemptions to the zoning or building code
Infrastructure	Infrastructure policies and provision can encourage and push delivery operators to participate in a sustainable microhub pilot. Cities can provide connected pedestrian and bike infrastructure or off-street loading and staging spaces to encourage delivery operators to use a microhub. Cities can also create road access restrictions or pass parking reductions that make traditional freight delivery unattractive to delivery operators. Off-street or on-street staging infrastructure is the most common way that cities support a microhub, especially in a limited pilot where a city may not operate the microhub or enter into a public-private partnership.	▪ Pedestrian and bicycle infrastructure provision ▪ Road access restrictions to encourage smaller, sustainable commercial vehicles ▪ Off-street or on-street staging areas ▪ Priority lane access ▪ Priority and dynamic loading zone and curb access ▪ Cargo bay requirements to accommodate clean deliveries ▪ Complete streets policies ▪ Parking reductions ▪ Traffic calming measures
Finance	Microhubs and other urban freight consolidation efforts are costly to implement and operate. Delivery operators may choose not to take on the extra cost of using a microhub. Financial tools like subsidies, favorable loans, and covering real estate costs, are important for governments looking to implement a microhub.	▪ Subsidies for delivery fleet electrification ▪ Subsidies for sustainable urban freight programs ▪ Tax credits and rebates for electric delivery modes ▪ Direct start-up subsidy ▪ Real-estate or facility cost subsidy ▪ Loans or grants ▪ Emission fee waiver ▪ Congestion charge

[3] Off-hour delivery mandates shift deliveries from peak periods to off hours (typically overnight hours). Off-hour delivery mandates for large trucks require operators to drive their vehicles into the city overnight, and last-mile deliveries with smaller vehicles can be made during regular business hours. This can decrease truck congestion and make last-mile delivery from a microhub a more attractive option.

[4] Commercial operator licensing restrictions can be used in a few ways. Cities may choose to restrict access to areas of the city, similar to a low-emission zone or zero emission zone, and only allow commercial operators who participate in the microhub to deliver in those zones.

Tool	How It Works	Example
		▪ Licensing fees
Planning	Microhubs need significant support from a city's planning department and other city staff. Cities often enter a public-private partnership for a larger microhub program or are stakeholders or partners in a pilot program.	▪ Public-private partnership ▪ Organizational support and partner coordination ▪ Data sharing and reporting agreements ▪ Stakeholder engagement ▪ Planning divisions and authorities for urban freight and delivery management ▪ Planning division coordination with elected officials

Table 6: Microhub Stakeholders

Sector	Stakeholder	Role	Interest in a Microhub
Public Sector	Local Government – City Departments	▪ Establish a microhub ▪ Develop policies and regulations for a microhub ▪ Inter-governmental coordination In some cases, may oversee microhub operations	Reduce negative externalities associated with traditional freight and truck deliveries
Public Sector	Local Government – Elected Officials	▪ Develop policies and regulations for a microhub	Reduce negative externalities associated with traditional freight and truck deliveries, especially for constituents
Public Sector	Local and Regional Agencies	▪ Support a microhub ▪ Provide input from regional partners	▪ Establish regional collaboration ▪ Establish regional delivery policies
Public Sector	State and Federal Policymakers	▪ Provide input from state and federal partners	▪ Pilot new transportation technology
Private Sector	Delivery Operators	▪ Partner in development of the microhub ▪ Commitment to use the microhub ▪ Use the microhub for last-mile deliveries ▪ Use storage, sorting, and loading facilities at the microhub	▪ Provide competitive delivery service while minimizing delivery costs ▪ Provide fast and efficient delivery service
Private Sector	Third-Party Logistics Providers	▪ Use the microhub for last-mile deliveries ▪ Use storage, sorting, and loading facilities at the microhub ▪ In some cases, may oversee operations of the microhub	▪ Provide competitive delivery service while minimizing delivery costs ▪ Provide fast and efficient delivery service
Private Sector	Last-Mile Delivery Employees	▪ Complete last-mile deliveries	▪ Worker safety ▪ Potential to make more deliveries and more income due to faster bike routes
Private Sector	Vehicle and Technology Providers	▪ Develop technology, such as e-cargo bikes ▪ Enter procurement agreements with microhub operators and delivery companies	▪ Pilot new technology ▪ Develop partnerships with local governments and delivery providers
Private Sector	Real Estate	▪ Provide land for a microhub, either through a sale or partnership	N/A
Other Stakeholders	End-User Consumers	▪ Order and receive deliveries	▪ Ship packages and parcels affordably ▪ Receive affordable, on-time deliveries ▪ May prefer sustainable deliveries

Other Stakeholders	Businesses - Retail	▪ Fulfill orders and ship deliveries ▪ Receive deliveries	▪ Ship packages and parcels affordably ▪ Receive affordable, on-time delivery
Other Stakeholders	Businesses - Restaurant	▪ Receive food and other perishable deliveries ▪ Fulfill on-demand delivery orders	▪ Receive affordable, on-time delivery ▪ Provide on-time order delivery
Other Stakeholders	Universities and Researchers	▪ Develop research on delivery microhubs, which can inform policies and pilots	▪ Microhubs and business
Other Stakeholders	Business Improvement Districts (BIDS) (including Transportation Management Associations)	▪ Represent business interests	▪ Represent business interests, including on-time and affordable delivery, reduction of truck traffic on streets near the business, and sustainable delivery
Other Stakeholders	Neighborhood and resident organizations	▪ Represent neighborhood interests ▪ Represent the interest of community members	▪ Represent neighborhood, community, and resident interests, including on-time and affordable deliveries, safety, reduction of emissions and greenhouse gases, and sustainable delivery.
Other Stakeholders	Community-based organizations and non-profits	▪ Represent the interest of community members	▪ Represent community interests, including safety, reduction of emissions and greenhouse gases, equity, and sustainable delivery.

DELIVERY MICROHUB CHARACTERISTICS

Physical characteristics of a delivery microhub include those of the facility itself and also of the surrounding area.

Delivery Zone and Service Area Characteristics

As noted previously, microhubs are most effective and successful in high-demand, high-density areas with high volumes of last-mile deliveries. Not all areas in a city generate enough package delivery demand or have enough operational challenges to inspire a delivery carrier to change their operational model and sustain a microhub between a regional distribution center and the final destination. Sociodemographic, infrastructure, and built environment demand and access characteristics can help identify service areas with a higher feasibility for efficient delivery via a microhub. Population, demographic, and land use characteristics contribute to the density of delivery destinations and frequency of deliveries (demand), while the multimodal transportation network connections, congestion, and safety contribute to the ease in which a delivery vehicle, bicycle, or pedestrian with a hand cart can deliver to residences or businesses (access).

Characteristics Supporting High Delivery Demand

Areas that support adequate demand for last-mile parcel delivery via a microhub facility have a larger and more concentrated collection of delivery orders and delivery addresses within a set radius surrounding the microhub site. Housing and employment density contributes to the number of delivery destinations, given that most of the parcel delivery contributing to roadway congestion, safety impacts, and VMT is destined to residential addresses or business addresses.

Sociodemographic Characteristics

Sociodemographic characteristics like the size of a household, household composition, and household income can influence behavior to order home delivery of packages. Larger households with more individuals or households with more disposable income are more likely to order more packages at a higher frequency. More households concentrated in one area makes it more efficient to deliver parcels to a final destination. Sociodemographic characteristics influencing consumer purchasing habits concentrated in one area have been shown to support demand for a microhub (Rudolph, Nsamzinshuti, Bonsu, Nidaye, & Rigo, 2022). *In the geospatial analysis completed for DDOT, these characteristics have been simplified into a measure of population density to understand where residents are concentrated.*

Housing Characteristics

More residents concentrated in a smaller, more intense land use (such as a multifamily apartment building rather than a neighborhood of single-family homes) makes it more efficient to deliver parcels to multiple final destinations. *In the geospatial analysis completed for DDOT, this characteristic has been simplified into a measure of housing unit density to understand where housing units are concentrated.*

Employment Characteristics

Similar to sociodemographic characteristics, employment characteristics like the concentration of employees can influence the number of deliveries. More employees concentrated in one area makes it more efficient to deliver parcels to a final business destination.[5] *In the geospatial analysis completed for DDOT, this characteristic has been simplified into a measure of employment density to understand where employees across all sectors are concentrated.*

Characteristics Supporting Microhub Operations Access

Access characteristics are transportation network conditions that relate to how feasible it might be for a delivery carrier to switch their operating model to a microhub and smaller-scale vehicles for last-mile deliveries. This feasibility of altering delivery modes depends on the ability for a large freight vehicle to access the microhub facility itself to offload packages to smaller vehicles and the ability for a pedestrian, bicycle or e-bike to safely travel through the surrounding delivery zone once packages swap vehicles. Mode shift through a microhub may also be more viable in the eyes of an operator if the microhub increases time efficiencies or prevents the operator from incurring fees or fines related to delivery zone access. Access characteristics identified include roadway congestion, pedestrian friendliness, and level of bicycle stress.

Level of Roadway Congestion

Higher levels of traffic congestion slow down vehicles and trucks on their delivery routes, adding time and fuel costs to routes. Higher levels of roadway congestion can indicate streets or blocks where it is more common that there are travel lane obstructions from double parking or streets where it is harder to find a loading/parking space. Drivers may choose to double-park or park illegally, rather than finding a curbside loading or parking space to unload. Alternative last-mile modes may function more efficiently on heavily

[5] Restaurants generally generate more deliveries than offices or retail businesses. However, restaurant delivery (both on-demand meal delivery and restaurant supply) are time sensitive and temperature-controlled. These are not good choices for a microhub.

congested streets and may reduce instances of double-parking. *In the geospatial analysis completed for DDOT, level of roadway congestion has been measured though traffic volumes per road lane to measure congestion across all roads in the* District of Columbia*.*

Pedestrian Friendliness

Pedestrian friendly areas are areas with connected street grids, sidewalks, and intersections and blocks that are designed to be pedestrian friendly. Pedestrian friendly areas make it easier and safer to conduct a delivery operation via pedestrians and hand trucks. *In the geospatial analysis completed for DDOT, pedestrian friendliness was a previously-prepared data layer, available on Open Data DC.*

Connected Bicycle Network

Closer and more connected access to a bike network provides safer and simpler last-mile routing for cargo bike delivery. Key to a connected bicycle network is its level of stress for riders, which quantifies the amount of discomfort that cyclists feel when they ride on a specific street. Low-stress bicycle networks typically involve more than traditional bike lanes and instead involve protected or separated bike lanes, cycle tracks, trails or multiuse pathways, and streets with lower speed limits, which attract a broader population of cyclists. Low-stress connected bicycle networks may increase comfort for e-cargo delivery bike riders. *In the geospatial analysis completed for DDOT, this characteristic is symbolized as level of bicycle stress, which can identify road segments with a connected network, or with conditions that cyclists feel comfortable on, and areas that are not bicycle-friendly.*

While level of bicycle stress encompasses more than bicycle lanes, bicycle lanes are typically about five feet wide. This may be too narrow for many e-cargo bikes and cargo-bikes, which are typically less than 48-inches in width, but may be too wide and too fast for a five-foot bike lane.

Delivery Microhub Facility Criteria

Criteria for the site and facility of the delivery microhub itself can be divided into two categories: infrastructure and technology. Infrastructure criteria include substantial physical features and elements either within the facility or adjacent to it in the public realm that would allow a microhub facility to function well and serve its surrounding delivery zone. Technology criteria, which could be considered a sub-category of infrastructure criteria, refer to components of utilities or hook-ups that aid in operations. Many technology criteria may not be necessary for a microhub and could be added into a site (i.e., the site could be retrofitted) once a physical location is found based on operator preferences. Operators often have a list of necessary criteria for operation and an additional list of “nice to have” options. Private versus public ownership of a facility may also influence facility criteria. It may be easier to test new technology on a private site.

Infrastructure Criteria

Infrastructure criteria necessary for a microhub site include curb access, shelter, loading and distribution space, storage space, employee amenities, and vehicle and bike parking. A microhub is technically a small warehouse and requires about 8,000 to 10,000 square feet collectively to function well.

Highway Access

Large delivery trucks need to be able to access the microhub to drop packages off before the parcels are loaded onto last-mile vehicles. When siting a microhub, an ideal location would be a site near within a half-mile ofhighway, highway ramp, and/or truck route.

Curb Access

Regardless of whether a microhub is on-street or off-street, a microhub should have ready curb access for delivery vehicles to load and unload unless there is an alley or loading dock. A loading zone is at minimum 40 feet along the curb, with at least six to eight feet of direct sidewalk access. If the site is on-street, dedicated loading zones are important, as well as enforcement to ensure their availability. If the site is off-street, access to curb cuts to an off-street parking space or loading bay and curb ramps are essential.

Shelter

While some microhubs are outdoor microhubs with limited to no protection from weather, case studies and conversation with delivery carriers indicate that successful microhubs should have some sort of shelter and protection from the elements, rather than a purely outdoor microhub. Best practice research indicates that benefits of sheltered, indoor microhubs include:

- Weather protection for parcels, reducing damage to package contents;
- Weather protection for equipment (particularly electric batteries), mitigating chances of damage and wear;
- Weather protection for employees, improving working conditions and morale;
- Increased security for packages and equipment, especially overnight and outside of operating hours;

- Private and more secure overnight storage, allowing for more efficient last-mile routing for less time-sensitive deliveries;
- Fewer conflicts with pedestrians and other vehicles during loading, unloading, sorting, and staging activities;
- Ability to better control temperature, allowing for greater capacity to store perishable or sensitive packages and improving working conditions and morale for operator staff;
- Indoor shelters have simpler connections to utility hookups, increasing the ability to charge batteries at the microhub site.

An outdoor microhub still requires some form of structure – even if the structure is semi-permanent – to provide security, package storage, equipment and vehicle storage, and administrative employee space. For example, the Seattle Neighborhood Delivery Microhub stored cargo bikes in shipping containers on the parking lot microhub site while not in use. Other operators have discussed a structure adapted from a box truck or storage pod.

Loading, Storage, and Distribution Space

A microhub should have sufficient space for sorting and loading packages. While the total space necessary depends somewhat on the volume of packages flowing through the microhub, this space should include: A) square footage to transfer parcels from the incoming truck to a consolidation area for parcels along a set route, and B) square footage to then transfer parcels into the last-mile delivery vehicle. An individual microhub may also require space for conveyor belts or other infrastructure to distribute packages to individual routes and forklifts.

A microhub should have storage space for vehicles and bikes as well. This may also include infrastructure like storage racks or shipping containers for parcels during the day, but this is unlikely. Operators have indicated they prefer not to leave packages in the facility overnight or for long periods of the day. If the microhub is a shared facility, the microhub should have separate facilities for each operator. If the microhub is a shared facility between multiple operators, the microhub should have separate space reserved for each operator and secured from one another when operations staff are not working in person. This reserved space allows each operator to manage their parcels more securely and through their own standard procedures. Generally, operators need about 2,500 square feet of storage to load, unload, and store deliveries.

Vehicle and Bike Parking and Storage

Microhubs should feature on-site, protected storage for e-cargo bikes, cargo-bikes, small vans, and other delivery vehicles used in the last-mile delivery routes. These may be parking spaces for small vans or indoor spaces for bike parking. Microhubs should also include sufficient space and room to accommodate safe battery charging. This space may need to be separated or have protective elements to protect the microhub in case of an electrical or battery fire. Generally, operators need about 4,000 square feet of storage space for vehicle parking and battery charging and about 3,000 square feet for space for other vehicle repair or storage needs. For information on safe battery charging needs, see Battery Charging below.

Employee Amenities

A microhub should feature amenities for delivery drivers and administrative employees working on site, as well as readily available transit access to the site. These on-site amenities should include a bathroom,[6] locker room, kitchen area, rest area for delivery drivers (both first-mile and last-mile drivers), and desk or office space for a dispatcher or other administrative staff. In general, operators use about 3,000 square feet for employee amenities and infrastructure.

While not explicitly an employee amenity, transit availability near a microhub is important to many employees and operators. Employees can take transit to the hub, rather than driving, which would require parking accommodations and/or additional fees. Additionally, microhub proximity to transit could aid in employee recruitment and/or retention.

Technology Criteria

Technology criteria support the operational efficiency of a microhub. These criteria range from charging capacity on the site to lighting and internet connectivity.

Electric Vehicle Charging

If a microhub uses electric vehicles, the site must have an electric connection to help enable charging between routes or at the beginning or end of operating hours. Most electric vehicles today require a wall outlet connection. Chargers can be indoors or outdoors, but they will need to be located close to the wall outlet connection. Most charging infrastructure for electric vehicles is Level 2 charging infrastructure, which requires a 240-volt wall outlet, but electrical requirements and capacity needs may change as electric vehicles evolve. Electric vehicle chargers, which often require more power than an e-cargo bike charger, may require an upgrade of the nearest utility transformer. This may be paid for by the utility company but can often be a required expense of the facility owner where the charger will be installed. The cost is often included in permitting costs. Some cities, including the District of

[6] It is unclear if operators prefer to have a single stall bathroom to serve people of any gender or multiple bathrooms. This will likely depend on the standard operating procedures of the delivery operator.

Columbia, have created specific permitting applications and checklists for a 240-volt outlet for EV charging, which includes a checklist for permitting EV chargers and upgrades.[7]

Battery Charging

Most e-bikes and e-cargo bikes use a rechargeable lithium-ion electric battery. Most batteries can handle a few small trips (less than 10 miles) but need to be swapped out for a replacement battery or re-charged between trips for all-day e-bike use. As such, a microhub site requires electric capacity for battery charging and storage space for the batteries to charge. This storage space is generally included in overall vehicle storage needs, which are about 4,000 square feet. Some manufacturers recharge batteries with solar powered canopies directly on the e-cargo bike while some manufacturers use a battery swap system, where batteries that need to be charged can be swapped out for a charged battery. In general, e-bike batteries can be charged by putting the battery into a charger, which then connects to a wall outlet, similar to an electric vehicle charger.

Regardless of how the battery is swapped out or charged, all battery charging should be done in a safe way that meets all fire department and fire code requirements. One case study city built a custom hermetically sealed locker to charge batteries in order to meet fire code requirements. The fire department required a way to easily prevent battery fires and a fail-safe shutoff. The locker only charges the batteries when all doors to the locker are shut and locked, and if a fire occurs the fire department can simply cut the cord to the locker. Battery charging risks can also be significantly decreased if the battery and accompanying charger is from a reputable company that meets Consumer Product Safety Commission regulations and guidelines.

Internet and Cell Phone Connections

Many delivery operators use online algorithmic platforms for their last-mile routing and scheduling system, sorting programs, and day-to-day operations. Delivery drivers and riders often use smartphones or other hand-held scanning devices for last-mile delivery operations such as inventory management, proof of delivery, navigation and route management, real-time updates, communications with coworkers and customers, age or ID verification and signature collection as needed, parcel sorting in the delivery vehicle, and order confirmation. As such, a microhub should have both an internet/Wi-Fi connection and cell service. Amazon installed Wi-Fi coverage in the underground parking lot of their Hackney microhub because

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[7] District of Columbia Electric Vehicle Charging Station Permit Application Process: https://ddot.dc.gov/sites/default/files/dc/sites/ddot/page_content/attachments/%28Final%29%20EV%20Charging%20Workflow%5B42%5D.pdf

there was no existing Wi-Fi at that level. Underground microhubs in parking garages may also need extended cell service if there are issues with service range.

Lighting

Microhubs should include lighting throughout all areas of the site or facility. Lighting provides additional safety and security for microhub operations.

Temperature Control

Microhubs may need some form of temperature control for both employees working in the microhub.[8]. Temperature control for employees means moderating temperatures to a comfortable range for employees. This includes air conditioning in the summer and heating in the winter. Amazon had to retrofit their garage in Hackney with heating and fans for temperature control to use the site as a microhub. This may increase electricity and energy needs of the microhub.

Equity & Safety Characteristics

Previous microhub pilots have not explicitly included equity and safety considerations when siting a microhub. Many previous microhub pilots have used a site that was readily available to the project, rather than going through a systematic siting process to select a location. Available sites for previous pilots have often been owned by a pilot partner, such as Amazon owning their garage in London and Reef owning the parking lot used in the Seattle pilot. Areas burdened with abundant freight access and delivery options or that lack good pedestrian or bicycle connectivity should receive special consideration when identifying a microhub facility site. Many freight deliveries come in via highways and major arterials from suburban warehouses or suppliers outside of the metro area. These roadways can bisect low-income communities and BIPOC communities or form a barrier between communities, limiting access to opportunity. Alleviating some truck traffic in these neighborhoods can have a positive impact on health by alleviating exposure to emissions and pollutants. Areas that are heavily burdened by environmental factors may benefit from a freight mode shift (i.e., to a cleaner vehicle for last mile delivery), reducing rates of asthma, respiratory infections, and other respiratory cancers. Reduction of truck traffic can also reduce noise pollution and other factors that decrease quality of life, such as high crash rates or injury rates from trucks double parking.

Equity considerations also need to be made in the context of realistic operations. Access to transit for hub employees, access to jobs and destinations, and safety risks are important

[8] While perishable goods also may need some form of temperature control, perishable goods are not applicable to a microhub in District of Columbia.

equity considerations for siting a microhub. Operators interviewed noted that siting a hub where employees can easily reach their workplace makes it easier to recruit and retain last-mile delivery staff. While cities and decision-makers may want to site a microhub in an area that would see significant equity benefits from a microhub, operators may have concerns about safety or infrastructure in those areas. This should be an ongoing conversation with the operators and should not exclude locations that would see an equity benefit because of operator concerns.

An equity and safety analysis will highlight places that should be prioritized for a microhub based on existing transportation and environmental burdens, while simultaneously avoiding creating new burdens.

Asthma

The CDC's PLACES dataset shows prevalence of asthma by census tract. Higher asthma numbers may indicate higher numbers of air pollution, some of which comes from trucks.

Diesel Particulate Matter

Areas with high concentrations of diesel particulate matter in the air may increase health risks for community members and may indicate areas that are already truck burdened.

Transportation Needs Index

DDOT previously created the moveDC Transportation Needs Index to measure transportation equity and understand locations of concentrated need for improved transportation services, better access to jobs and destinations, and safer streets. When combined with health and environmental data, this index highlights areas of equity emphasis where safety and mobility improvements are needed.

The moveDC Transportation Needs Index is comprised of:

- Proximity to Frequent Transit: Areas with lower access to frequent transit have a greater transportation need.
  - Access to Rail - areas within ½-mile walking distance of rail stations with train frequencies of 5 minutes or better during peak and midday
  - Access to Bus – areas within ¼-mile walking distance of bus stops with bus frequencies of 10 minutes or better during peak and midday
- Access to Jobs and Destinations: Areas with lower access to jobs and destinations have a greater transportation need
  - Access to Jobs and Access to Destinations - jobs and destinations in the region that can be reached in:

- Within a 20-minute walk
- Within a 30-minute bike ride on low-stress streets
- Within a 30-minute bus ride
- Within a 30-minute train ride
- Within a 45-minute train and bus ride (that involves a transfer from one to the other)
- Within a 45-minute drive

- Safety Risks: Areas that are closer to safety risks have a greater transportation need
  - High-stress/low-comfort cycling routes
  - Sidewalk gaps
  - Vision Zero high-crash corridors

4 OPERATIONAL FRAMEWORK GUIDANCE

LESSONS FOR THE DISTRICT OF COLUMBIA

Microhubs generally work best for deliveries that are non-perishable (and therefore less time-related pressure), small in size and weight, and have a short last-mile delivery trip. District of Columbia government staff noted the most issues with home parcel delivery and commercial business supply when discussing priority project outcomes. Delivery operations and safety issues identified related to delivery trucks and vans double parking and blocking travel lanes, bike lanes, crosswalks, and sidewalks. As such, home and business parcel deliveries are the best candidates for a microhub delivery pilot in the District of Columbia, and what the three case study examples have focused on for their deliveries.

A scan of best practice research and the case study interviews identified a set of common microhub challenges. These include zoning, project partners, and community support. These challenges are all present in the District of Columbia context, but the District of Columbia also has some unique challenges given the local context. Challenges for microhub operation in the District of Columbia include:

- **Zoning and Location:** A microhub should be located on a site that minimizes operational costs for operators and maximizes benefits for the local community. The microhub should also be located within appropriate zoning (typically mixed-use, commercial, or light industrial). If a parcel does not have a complimentary zoning designation, zoning and permitting changes may need to be made to the parcel.
- **Operator Support:** Many pilots, including the three case studies, had operator and delivery carrier support, if they weren't run by an operator like Amazon or Reef. Operator support is crucial for a microhub: it is important to ensure that DDOT is not attempting to launch a new service with a courier company or other carrier who needs to generate customers or a market share while testing new practices.
- **Type of Delivery:** The type of delivery is another challenge for microhub operation. Business-to-business delivery with small businesses or home deliveries from small businesses may be challenging due to low volumes of delivery orders and unpredictability of destinations that increase complexity with last-mile routing. Some pilots have had to subsidize small business package deliveries in microhubs because these packages have very low volumes per day.
- **Federal Land:** About 29% of the District of Columbia is federal land. Federal land may present additional security challenges and acquisition challenges for operating a microhub on a federal site, even in a parking lot. Federal land should be avoided for a microhub pilot site to avoid long delays around permitting and land use negotiations that may delay microhub pilot operations.
- **National Park Service Roads and Land:** Commercial vehicles are not allowed on National Park Service roads. This may limit potential areas for a microhub, as a microhub will need to be sited in areas where trucks traveling to and from the microhub can access the site. Additionally, there may be some National Park Service concerns about commercial cargo bikes on National Park Service roads, trails, and park land. This may limit the delivery zone around microhubs. A microhub will likely face scrutiny and is less likely to have community support if it is placed on parkland or the community feels that e-cargo delivery bikes are discouraging other users on trails. Additionally, there may be regulations prohibiting commercial cargo bikes from riding on trails and through parkland. Other municipalities have created similar regulations, which have impacted microhub siting.

Community Partners

Community and stakeholder relationships are a key aspect of microhub planning and operations. Microhubs need both an operator partner and community support to be successful over the long-term. A microhub pilot is an opportunity to test delivery technology, but to also evaluate the benefits and potential impacts to the surrounding community. As such, the community where a microhub will be located should be engaged early in the process to give the community information on the potential benefits of a microhub, but to also understand what the community response could be. Positive community interest may expedite the launch of a hub and keep all parties involved happy. Negative community response can slow down a pilot launch or even stop a pilot before it launches. Still, concerted outreach and education about the program may mitigate concerns.

Potential community partners in the District of Columbia context include, but are not limited to:

Table 7: Potential Community Partners

Stakeholder	Meeting goals and expected outcomes
Department of Energy and Environment (DOEE)	Connect with staff to discuss any current work of the division with electrification and how their pilot or ongoing programs could be "plugged into" the DDOT microhub pilot.
Department of For Hire Vehicles	Connect with staff and gather data on recent infractions. Strategize potential issues and mitigation strategies.
DDOT Curbside Management Division	Connect with staff to discuss existing challenges and problem areas related to parcel delivery. Strategize potential issues and mitigation strategies, including policies related to commercial loading zones.
DDOT Active Transportation Branch	Connect with staff to identify the best bike routes within the identified microhub service area and connect with the Recreational Trails Program team to understand policies surrounding commercial cargo bikes on trails
DDOT Equity staff	Connect with staff to review siting analysis and discuss equity concerns around a microhub
DC Sustainable Transportation Coalition	Connect with DCST and partners via a brief memo announcing pilot goals and potential microhub service areas; offer opportunity for stakeholders within DCST to meet to identify potential partners in the suitable service areas.
BIDs	Connect with the BIDs that represent any of the suitable microhub service areas; identify existing challenges, problem areas, public perceptions, and potential partners; discuss viable microhub sites based on site needs.
Advisory Neighborhood Commissioners	Connect with Advisory Neighborhood Commision commissioners once a microhub service area has been located for the pilot; review area challenges and problem areas; highlight any potential neighbor concerns and discuss mitigation strategies; provide option of presenting to the Advisory Neighborhood Commission at a monthly meeting

Council of the District of Columbia Councilmembers	Connect with the Council of the District of Columbia Councilmembers that represent any of the suitable microhub service areas; identify existing challenges, problem areas, and potential partners; highlight any potential neighbor concerns and discuss mitigation strategies.

APPLYING A DELIVERY MICROHUB SITING METHODOLOGY TO THE DISTRICT OF COLUMBIA

Calculating the suitability of a microhub site within an interested jurisdiction involves combining the indicators described above. This was done for DDOT via weighted input factors as specified in the table below. The methodology followed three primary steps:

1. Create two sets of neighborhood/service area indicators (one set for Demand, one set for Access) that will be combined to create a suitability score imposed as a raster grid covering the entirety of the jurisdiction. Concentrations of suitability that make up a reasonable service area will be identified.
2. Add geographic layer(s) on top that indicate key facility characteristics and potential compatible locations, such as specific land uses that can be converted to a delivery microhub, within highly suitable areas service areas.
3. Once the top sites are identified, an additional review will include comparison of highly suitable facility sites for their impact on areas of equity concern, identified through another layer(s) of specific demographic or health factors.

Step 1: Composite Neighborhood/Service Area Suitability

This analysis will create two sets of neighborhood and service indicators (one for Demand and one for Access) that will be combined to create a suitability overlay covering the entire district. This overlay will identify areas where a microhub could be more efficiently located.

Table 8: Demand and Access Factors

Factor	Category	Weight	Description	Source for District of Columbia Data
Population Density	Demand	6	More residents concentrated in one area makes it more efficient to deliver parcels to a final home destination.	▪ 2019 ACS 5 Year Survey ▪ Census Block Groups
Employment Density	Demand	3	More employees concentrated in one area makes it more efficient to deliver parcels to a final business destination	▪ 2019 ACS 5 Year Survey ▪ Census Block Groups

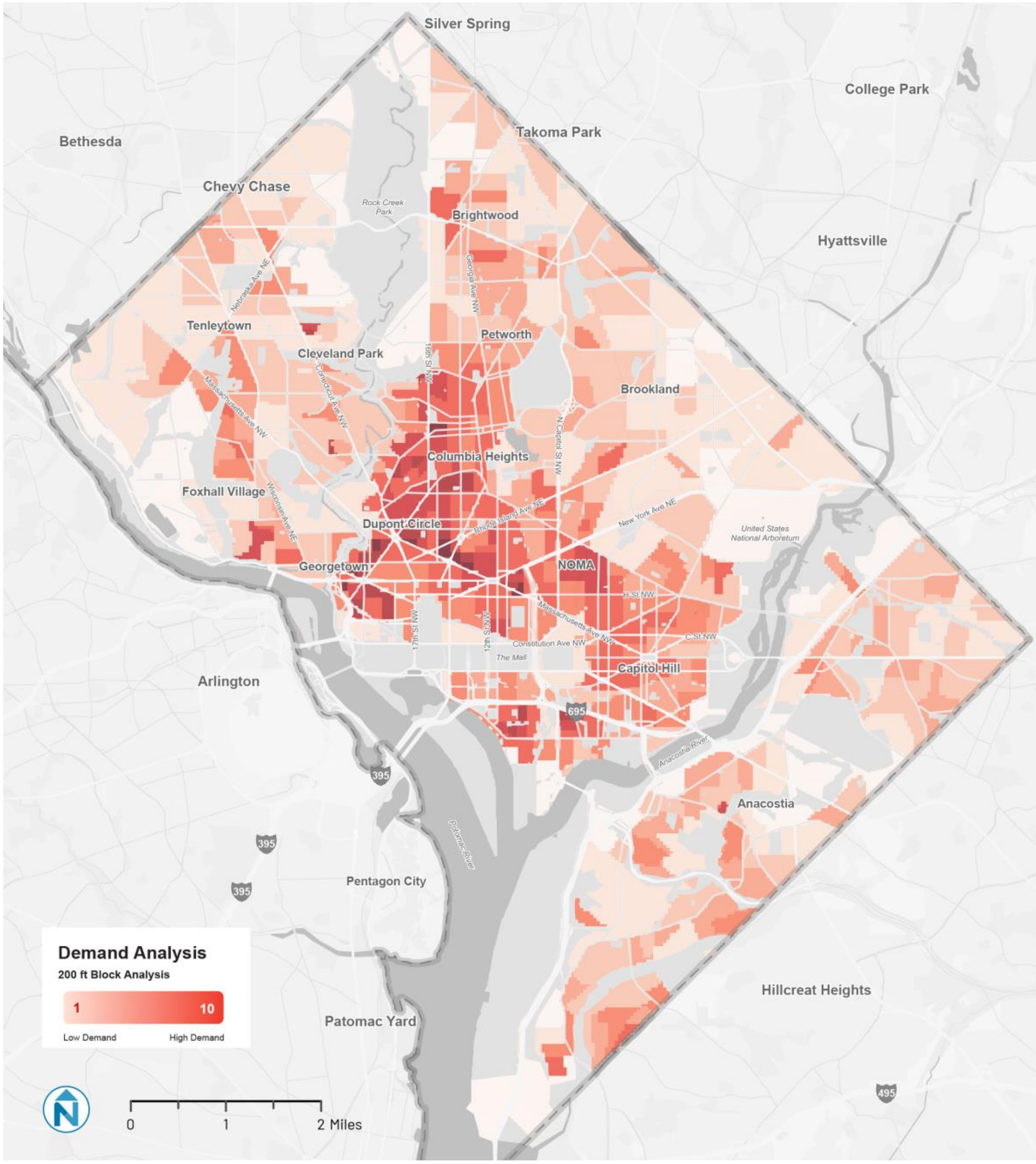
Housing Unit Density	Demand	1	More residents concentrated in a smaller, more intense land use (such as a multifamily apartment building rather than a neighborhood of single family homes) makes it more efficient to deliver parcels to a final destination. A greater concentration of consumers in one area will likely order more packages.	▪ Open Data DC - Common Ownership Lots
Level of Roadway Congestion (Avg Speed)	Access	4	Higher levels of traffic congestion slow down vehicles and trucks on their delivery routes. Alternative last-mile modes may work better.	▪ Open Data DC – Roadway Block
Pedestrian Friendliness	Access	3	Better crosswalk networks make it easier to conduct a delivery operation via pedestrians and hand trucks	▪ Open Data DC - Sidewalks
Level of Traffic Stress (Cycling)	Access	3	Closer and more connected access to a bike network allows cargo bike delivery modes safer and simpler final-mile routing	▪ Open Data DC – Roadway Block ▪ ½ Mile Distance

Three demand analysis layers will be created:

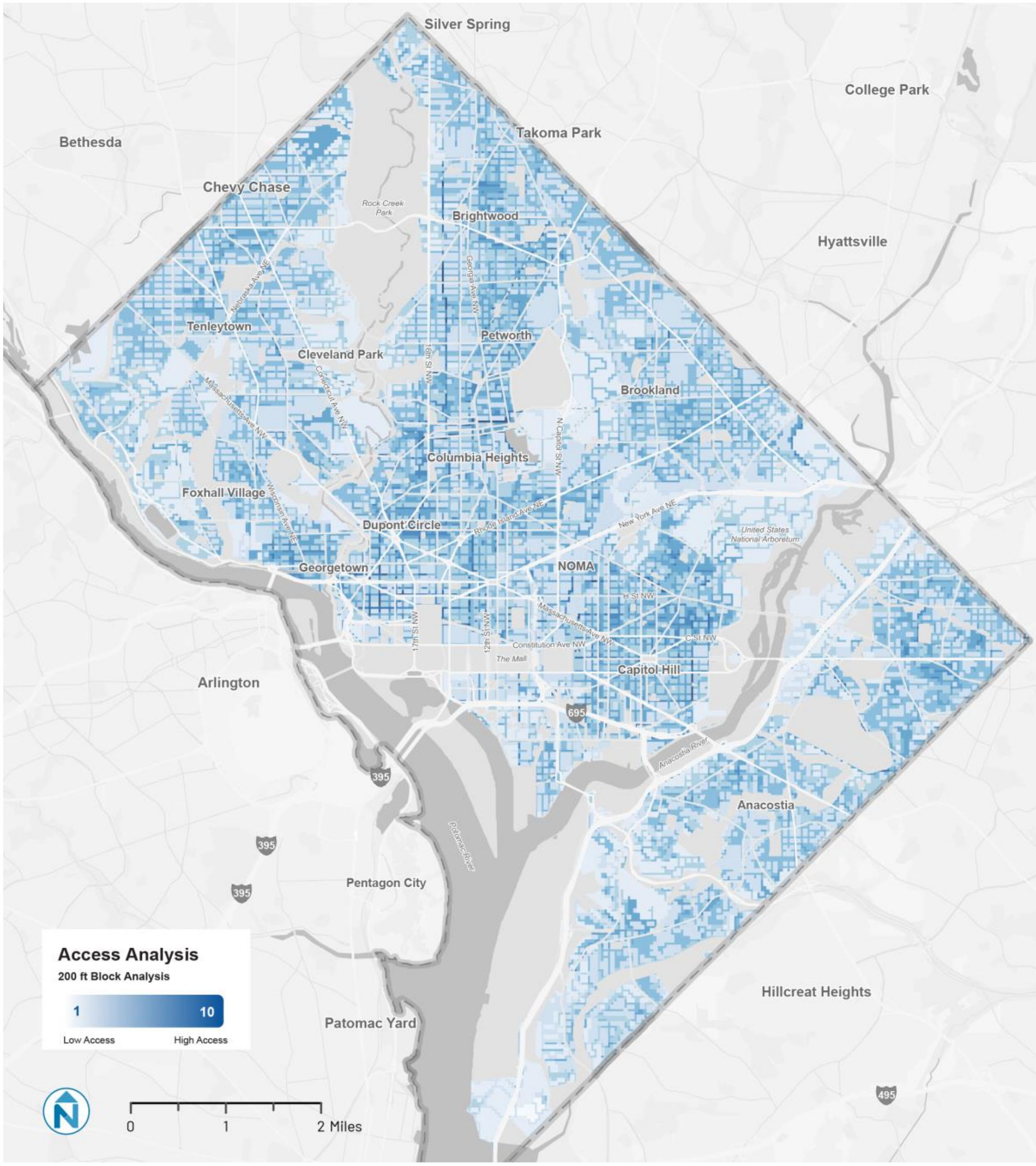
1. Demand Analysis
2. Access Analysis
3. Combined Demand and Access Analysis

Delivery Demand Analysis in the District of Columbia

The composite Delivery Demand Analysis score estimates the frequency and quantity of delivery requests based on the factors of population density, employment density, and housing unit density. Demand is concentrated in areas closest to the District of Columbia's core including the neighborhoods of Columbia Heights, Dupont Circle, Foggy Bottom, Mount Vernon Square, and parts of the Southwest Waterfront. Predictably, the score is highest in the densest residential neighborhoods of the District of Columbia.


Silver Spring
College Park
Takoma Park
Bethesda
Chevy Chase
Rock Creek Park
Brightwood
Hyattsville
Tenleytown
Petworth
Cleveland Park
Brookland
Columbia Heights
Foxhall Village
Dupont Circle
United States National Arboretum
Georgetown
NOMA
Capitol Hill
The Mall
Arlington
Anacostia
Pentagon City
Hillcreat Heights
Patomac Yard
Demand Analysis
200 ft Block Analysis
1
10
Low Demand
High Demand
0
1
2 Miles

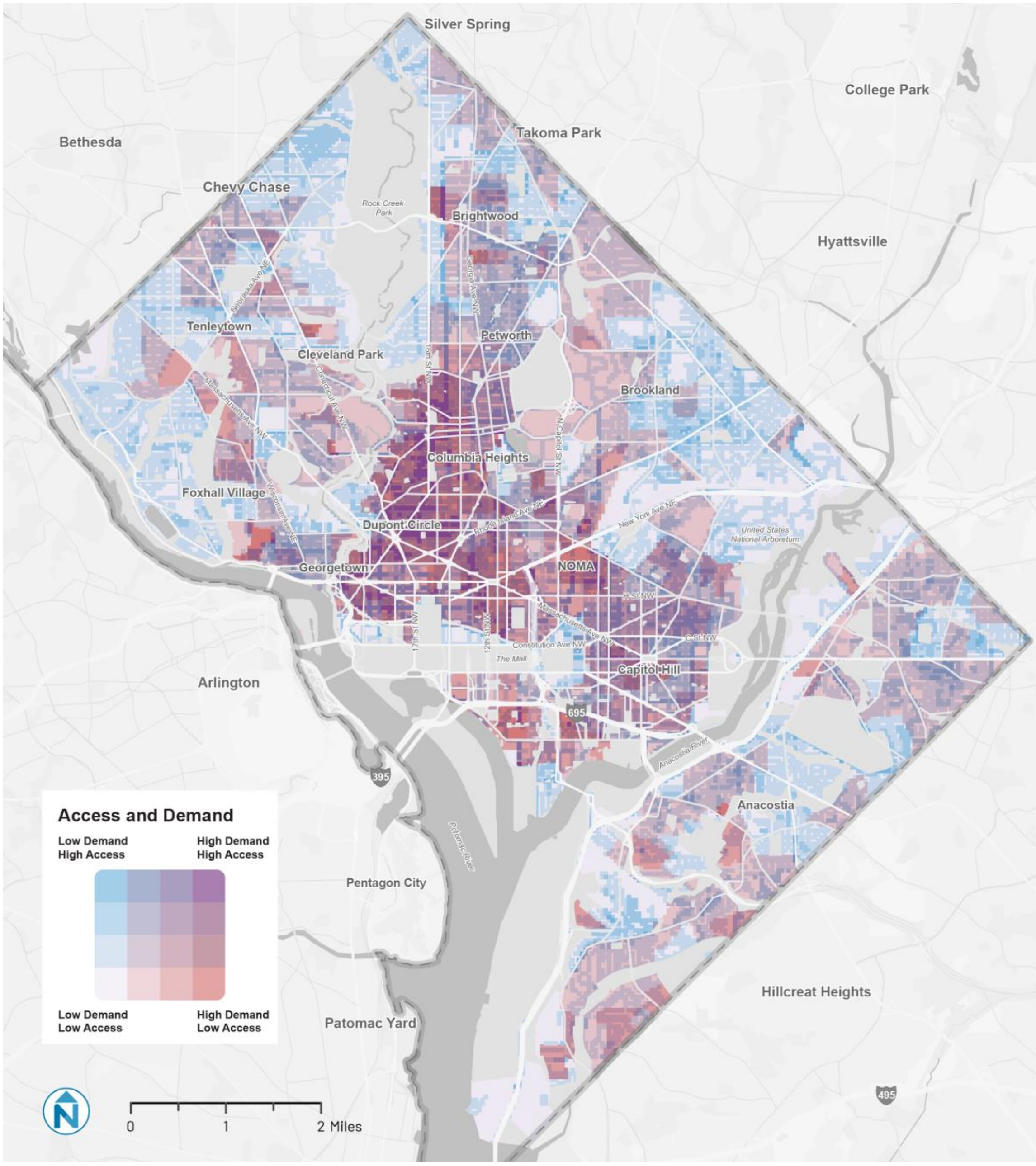
Delivery Access Analysis in the District of Columbia



The composite Delivery Access Analysis score estimates the ease of how deliveries could flow in and out of certain areas of the city. Because a microhub is meant to have an inflow of larger vehicles (trucks, vans, etc.) bringing parcels to the hub and an outflow of smaller vehicles (bicycles, pedestrians, electric carts, etc.) picking up the parcels at the hub and delivering them to their final destination, the hub must be located where it is both: A) convenient for trucks and large vehicles to drive, and B) safe and convenient for smaller vehicles to finish the delivery. Average roadway congestion displayed the areas of the city where traffic was highest, a Pedestrian Friendliness score created by MoveDC showed which areas of the District of Columbia were easiest and safest to walk as a pedestrian, and level of traffic stress gave a score to each roadway representing its bikeability.

The Delivery Access Analysis shows a much more even distribution of Access throughout the city as compared to the Delivery Demand Analysis, but still has a concentration in Georgetown, and Dupont Circle up 16th Street through Columbia Heights. Other high scoring areas include Capitol Hill and the Navy Yard neighborhood.

Composite Service Area Analysis in the District of Columbia



The composite Service Area Score combined both access and demand variables to show where the highest demand score corresponds with the highest access score (the areas shown in purple). The Composite Service Area Analysis shows the highest scores in the areas around

Foggy Bottom, Dupont Circle, Adams Morgan, and the northwestern side of Columbia Heights. Areas within NOMA and Capitol Hill also show high composite scores.

Step 2: Identify Potential Facility Locations within Neighborhood/Service Area of High Suitability

Based on the propensity for high delivery demand and service area access determined in Step 1, additional layers reflecting facility criteria will be evaluated to understand an appropriate location for a hub within a suitable service area. This analysis will identify potential facility locations within areas that have high propensity to support a microhub.

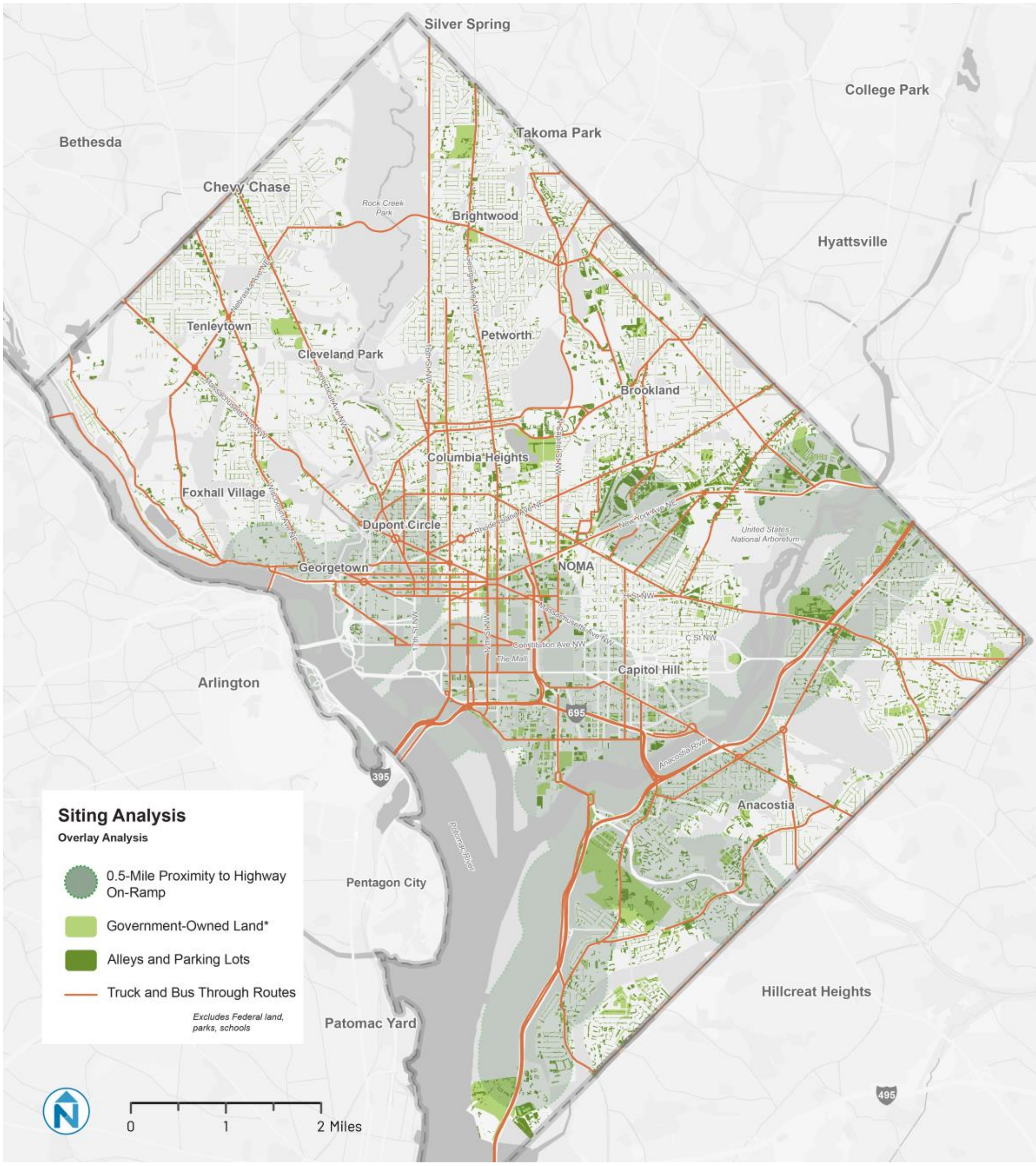
Table 9: Suitability Factors

Factor	Category	Description	Source for the District of Columbia Data
Half-mile Proximity to Highway Ramps	Facility Access	Closer access to highways means that trucks delivering sorted packages from a suburban distribution warehouse can more easily reach the microhub	▪ Open Data DC Roadway SubBlock
Quarter-Mile Buffer around Truck Routes	Facility Access	Closer access to truck routes means that trucks delivering sorted packages from a suburban distribution warehouse can more easily reach the microhub	▪ Open Data DC – Truck and Bus Through Route
Alleys and Parking Lot/Garage	Facility Access	Alleys and parking lots and/or garages are a potential option for a microhub. Many previous pilots have used an empty parking garage for a microhub.	▪ Open Data DC Alleys and Parking
District of Columbia Government Land	Facility Access	Land owned and operated/managed by the DC government may be easier to acquire or make small zoning changes to for a microhub.	▪ Open Data DC District Government Land (Owned, Operated, and or managed)

Compatible Existing Zoning Designation[9]	Facility Compatibility	Land already zoned for compatible zoning designations can make setting up a microhub easier. If land is already zoned for a microhub, there are fewer regulatory barriers. This also identifies land that may meet other factors, but needs to be rezoned to support a microhub.	▪ Open Data DC – Zoning to Property Lot Query Layer

[9] See Section 4 for information on compatible zoning designations.

More Suitable Facility Locations in the District of Columbia



The Potential Facility Location Analysis uses overlay data of 0.5 miles around highway ramps, alleys and parking lots, government-owned land (consisting of District of Columbia-owned land excluding schools and parks), and truck and bus through routes to provide a potential siting location for the microhub in the District of Columbia area. The areas with the highest overlay percentage are near the Navy Yard neighborhood, Anacostia, Brentwood, and Mount Vernon Square.

Step 3: Consider Equity Overlay in Choosing Among Facility Alternatives

This analysis creates an equity overlay for consideration in microhub siting. It attempts to ensure that the pilot hub site selection considers the needs of communities that currently experience high negative impacts from the transportation system while not receiving benefits like other communities in the District of Columbia.

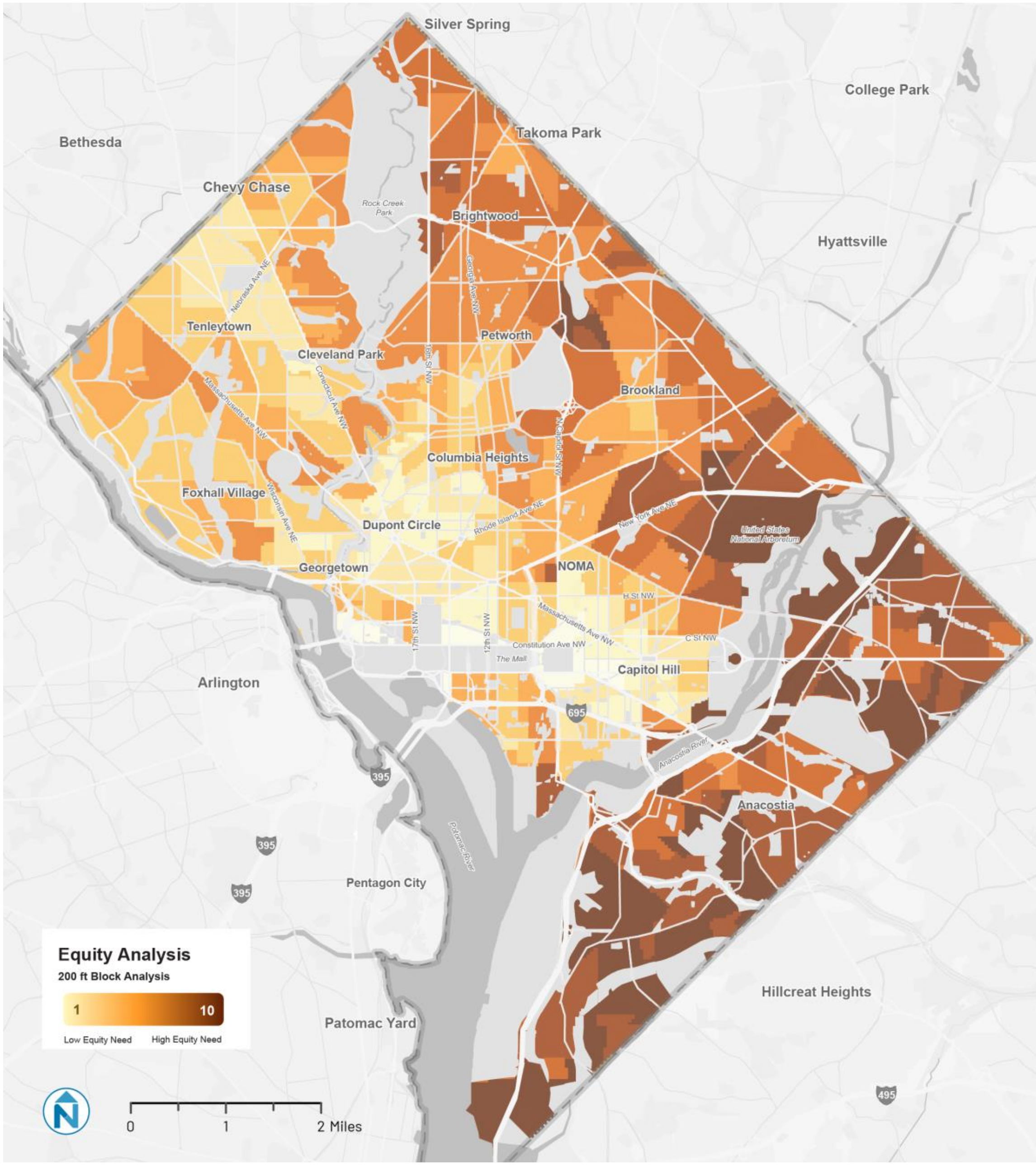
Table 10: Equity Factors

Criteria	Category	Weight	Description	Source for District of Columbia Data
moveDC Transportation Needs Index[10]	Equity	4	The moveDC Transportation Needs Index shows areas with high levels of transportation need. Areas with transportation needs can help to ensure that a microhub is sited equitably.	▪ Layer in this map package - https://dcgis.maps.arcgis.com/apps/mapviewer/index.html?panel=gallery&suggestField=true&layers=583151fe6c984855bfdbff72bb7d6213

[10] The moveDC Transportation Needs Index layer does not show transportation burdens (such as traffic noise and pollution). To capture broader equity concerns, it may need to be supplemented with other health data.

Asthma	Health	3	The CDC's PLACES dataset shows prevalence of asthma by census tract. Higher asthma numbers may indicate higher numbers of air pollution, some of which comes from trucks.	▪ CDC PLACES Data - https://chronicdata.cdc.gov/500-Cities-Places/PLACES-Census-Tract-Data-GIS-Friendly-Format-2022-/yjkw-uj5s
Diesel Particulate Matter	Health	3	Areas with high concentrations of diesel particulate matter in the air may increase health risks for community members and may indicate areas that are already truck burdened.	▪ EPA Environmental Justice Screen https://ejscreen.epa.gov/mapper/

Mobility Hub Equity Considerations in the District of Columbia



Expansive research of microhubs' effects on a community has yet to be conducted. This Equity Consideration Analysis shows areas of the city identified as high on the Transportation Needs Index by MoveDC, with high instances of Asthma, and with reportedly high concentrations of Diesel Particulate Matter. The areas with the highest Equity Consideration scores are east of the Anacostia River in Anacostia, Mayfair, and Langston. Other areas of Equity Consideration include Fort Totten, Brightwood, and Buzzard Point.

IMPLEMENTATION CONCEPT PLAN AND DECISION-MAKING FRAMEWORK

The decision-making framework for developing a delivery microhub pilot project generally follows a five-step process.[11] These five steps are:

1. Determine the Use Case for a Delivery Microhub
2. Identify Service Area(s) for a Successful and/or Feasible Delivery Microhub
3. Determine Location(s) and Design(s) for a Delivery Microhub Facility/Site
4. Identify and Coordinate with Area Partners
5. Develop a Delivery Microhub Operational Flow and Troubleshoot Potential Challenges

The pilot framework will begin to diverge with context-specific answers at Step 3, 4, and 5.

Step 1: Determine the Use Case for a Delivery Microhub

Key questions to ask to determine the use case include:

- What are your goals for a microhub?
  - What are the safety, congestion, emissions, equity, and other challenges surrounding delivery in your city? Which of those challenges are you looking to solve with a delivery microhub?
  - How can a microhub make delivery easier in your city?
- Which types of deliveries are most common in your area? Are delivery challenges more prevalent in residential areas, commercial areas, or mixed-use areas?
- Would the microhub address deliveries to homes, businesses, or both?
  - Are the deliveries made to homes primarily food deliveries or parcel deliveries?
- What vehicle type are you interested in deploying for delivery via use of a microhub?

[11] See Appendix 1 for a full list of questions

- How long are most deliveries expected to take? Are they time-sensitive?
- What is the average size of a delivery?

Chapter 4 describes these considerations in detail and a summary is included below. Understanding the key challenges in your city is the first step in setting up a microhub for success. Not every delivery use case works well with microhub operations, and a microhub may not be able to resolve some issues that cities see (such as stolen parcels from porches or blocked vehicle or bike lanes due to food delivery vehicles). However, an issue like box trucks double parking in travel lanes to make deliveries is a prime example of a problem that can be addressed through a microhub.

Established goals for a microhub (such as mitigating congestion or streamlining deliveries) can guide a city throughout the process of creating a microhub. The District of Columbia use case goals include:

- reduce delivery issues around traffic congestion on roadways and traffic safety caused by doubled-parked trucks or vehicles,
- mitigate traffic safety and environmental and health concerns around large trucks entering neighborhoods and travelling on neighborhood or local streets, and
- address concerns surrounding inequitable impacts of delivery truck travel to burdened neighborhoods.

Based on the desired use case for the District of Columbia scenario, the following determinations have been made:

- Microhubs work best for deliveries that are not time-sensitive or perishable, small in size and weight, and have a short last-mile delivery trip. As such, home and business parcel deliveries are the best candidates for microhub delivery.
- Urgent deliveries that may be time-sensitive or temperature controlled are not good options for a microhub delivery type.
- A microhub is less able to address delivery challenges of on-demand food delivery, whether meals or groceries because deliveries via a microhub are usually route-based, and a time-sensitive package or a perishable delivery may not be able to arrive within a set window.
- Parcel delivery to both residences and businesses are the best use case for a microhub in the District of Columbia environment.
- A microhub is often better suited to a smaller vehicle, like a cargo bike, or an on-foot delivery, such as a walker with a handcart. Cities need to decide what kind of last-mile vehicle is best suited to address the challenges that they wish to resolve, while operators need to consider what vehicle they think will allow the highest delivery efficiency and/or feasibility.

- Large operators may have more package deliveries and may have more opportunities to create additional operational efficiencies using a microhub.
  - In the District of Columbia, 95% of all packages between 2021 and 2022 were performed by four carriers: Amazon, USPS, UPS, and FedEx.
- Multi-round deliveries, where multiple destinations are served on one trip, are more efficient for a microhub when destinations are clustered in a small area.
  - Most delivery carriers in the District of Columbia market use multi-round delivery operations. In a multi-round delivery operation, carriers leave suburban warehouses (often in Maryland) and drive into the District of Columbia to make their deliveries before returning to a warehouse.
- Delivery companies must see potential benefits to themselves in order to participate in a delivery microhub. It is unlikely that operators will participate in a microhub if they do not see a way to make deliveries more efficient or cost-effective with a microhub.

Step 2: Assess Areas Where a Delivery Microhub Might Work

Chapter 5 describes a methodology for analyzing areas of a jurisdiction that might be well-suited for a delivery microhub service area and site and/or facility. This section captures the guiding questions at a high level that will help identify service areas that could support a microhub:

- Where are package deliveries concentrated?
- Where is it difficult to deliver parcels under traditional operational models today?
- Where are the neighborhoods that may safely support alternative delivery vehicles?

Based on the desired service area for the District of Columbia scenario, the following determinations have been made:

- Areas with higher residential unit density, higher population density, and higher employment density are likely to generate more delivery demand and activity. More residences typically means more deliveries, and density can result in more efficient deliveries which make a microhub more attractive to operators.
- In neighborhoods with high levels of roadway congestion, operators experience associated traffic delay resulting in higher labor costs, fuel costs, and traffic violation fees; adjusting business and operational models to a microhub in these areas may be economically beneficial.

- Areas with connected street grids, sidewalks, and intersections and blocks that are designed to be pedestrian friendly are better for e-cargo bike riders and delivery staff walking to destinations with handcarts.
- Microhubs should be sited within a half-mile of a highway, highway ramp, and/or truck route, and microhubs sited near convenient transit service to support employees working at a microhub.
- Focusing only on areas with high population and employment, mixes of uses, and supportive transportation infrastructure might leave out other areas that experience the negative impacts of delivery traffic.
  - In the District of Columbia context, many freight deliveries come in via highways that bisect low-income communities and BIPOC communities.
- Equity considerations also need to be made in the context of realistic operations. While cities and decision-makers may want to site a microhub in an area that would see significant equity benefits from a microhub, operators may have concerns about safety or infrastructure in those areas. This should be an ongoing conversation with the operators and should not exclude locations that would see an equity benefit because of operator concerns.

Step 3: Determine Location and Design for the Facility

Chapter 5 describes a methodology for siting a facility within a suitable service area. This section captures the guiding questions at a high level that will help identify an individual location and facility needs of the microhub itself:

- What land uses or building uses are easily converted to a microhub facility?
  - Is the facility publicly owned or privately owned?
- Is the hub meant to serve one operator or multiple operators?
- How much space does a microhub need?
- What technology is necessary for the microhub to succeed and be fully utilized?
- What amenities does the hub need for workers? (e.g., waiting area, vending machines, restrooms, etc.)?
- Which vehicles will be used at the microhub facility?
- Would an on-street (e.g., a converted parking space or loading zone) or off-street facility (e.g., a surface parking lot or garage or small building) be best-suited for a microhub?

The following determinations have been made in regard to a microhub in District of Columbia:

- A microhub requires about 10,000 - 12,500 square feet. An on-street microhub may require less space directly on the curb, but it would need accessory spaces for employee amenities and vehicle/cargo bike parking and battery charging.
- Microhubs are typically under mixed-use zoning or industrial zoning. In the District of Columbia , the Production, Distribution, and Repair zoning classification would also apply. If a suitable site does not have appropriate zoning, a zoning map amendment or temporary use could be requested for the site.
- Determination of on-street and off-street locations are based on available space and the preferences of the operator. An off-street microhub in the District of Columbia could be in a surface parking lot or alley or a structured parking facility on land owned by the District of Columbia government or a private property owner. An on-street microhub would be in a section of DDOT-managed curb lane.
- City ownership of a hub site may aid in streamlining property and use agreements. In the District of Columbia context, federal land is not considered an ideal publicly owned site: the contracting and permitting hurdles are too great without an explicit federal partner.
- Operators have indicated that they prefer not to share space.
  - In the District of Columbia context, a shared microhub would be considered if multiple operators were interested in sharing space in a microhub; but given known operator preferences this microhub pilot could likely only serve one operator.
- A surface-level lot will have easier, more straightforward access for both large trucks making deliveries to the site, as well as for smaller vehicles/last-mile modes that will use the site as a home base.
- The site should have curb cuts that at least meet, if not exceed, District of Columbia's standard for curb cuts and access (minimum of 12 feet wide). Ingress and egress points should be consolidated to a single curb cut, and the location of the curb cut should avoid conflict with high pedestrian and bicycle traffic areas. If possible, there should be a separate ingress and egress point for any handwalkers or bicycle delivery. This access point should be located along the street frontage with the most pedestrian activity and the nearest bike lane.
- Due to the site's location, security fencing may be required to secure materials and vehicles after hours.
- A below-ground or above-ground parking structure will have additional considerations, including the dimensions of access and clearance heights of garage

floors: trucks need to be able to get in and out of the garage, so the height of the ramp clearance is a key consideration. Determination of surface lot or structured parking (above and below ground) will be based on available space and the preferences of the operator.

- A microhub should be located within a half-mile of major arterials or truck routes that facilitate trucks coming in from suburban warehouse locations to the hub. It should not be sited in a location where trucks will need to drive through residential neighborhoods or streets that are too narrow or congested.
- At a minimum, a microhub requires an electric connection and WiFi or cellular service. Other technologies, such as last-mile delivery routing software or geofencing, may be used, but this would likely be at the discretion of the operator.
  - In initial conversations, operators indicated that they already had successful last-mile routing processes. Depending on the site and the vehicles chosen, the electric connection may need to be upgraded to withstand the power drain.
- The microhub should have some form of shelter, whether it is temporary or permanent for employee amenities, packages during the day, and vehicle storage overnight. Generally, operators need about 4,000 square feet of storage space for vehicle parking and battery charging and about 3,000 square feet for space for other vehicle repair or storage needs.
- Onsite employee amenities for District of Columbia will likely include a bathroom, locker room, kitchen area, rest area for delivery drivers (both first-mile and last-mile drivers), and desk or office space for a dispatcher or other administrative staff, but will be dependent on the needs of the operator and their staff. In general, operators use about 3,000 square feet for employee amenities and infrastructure.
- Time restrictions on the facility will depend on the specific site chosen.
  - A microhub in a District of Columbia -owned parking facility in a residential area will likely require different time restrictions than a microhub in a commercial area.
  - Time restrictions will be discussed with the community, including the Advisory Neighborhood Commission board, and any BID in the area. However, general hours are expected to be from 9:00 AM to 7:00 PM.

Table 11: Estimated Square Footage for a Microhub

Microhub Space Consideration	Square Footage
Total Microhub Square Footage	12,500 square feet
Loading and Unloading Space	2,500
Vehicle Parking and Battery Charging	4,000

Vehicle Repair and Other Storage Needs	3,000
Employee Amenities	3,000

Step 4: Identify and Coordinate with Partners

- Who will your **operational partners** be to support the microhub site and operations?
- Which **community partners** will be engaged?
- What public engagement is needed to support a delivery microhub?
- What data will be shared by the operational partner with the overseeing jurisdiction?

The following determinations have been made in regards to engagement for a microhub in the District of Columbia:

- The main partner is expected to be a large delivery operator.
- It is expected that the delivery operator will manage the site, but DDOT will provide support as necessary.
- Technology partners will be determined by the operator's needs.
- Community partners will depend on the microhub site chosen. Outreach to the BIDs has already begun, and the BID where the site will eventually be located will be a key partner. Once the number of sites has been narrowed down, outreach will be done to Advisory Neighborhood Comissions and other neighborhood stakeholders to understand community support and concerns for a microhub.

Step 5: Smooth Out Operational Considerations

- What is the **estimated cost of implementation and maintenance** of the microhub?
- Who will be responsible for microhub operations? What role can the city play to help support the site operator?
- What **incentives** are needed to entice the use of the microhub site for the community, site owner, and delivery companies?

The following operational determinations have been made in regards to a microhub in the District of Columbia:

- The delivery operator will be responsible for the majority of day-to-day microhub operations.
- Incentives will vary across microhub types, but are expected to include some combination of assistance with acquiring a site, any zoning or permitting changes

needed; real estate or facility cost subsidy (including rent subsidies); waivers or exemptions to the zoning or building code; rebates or subsidies for use or purchase of low/no-emission last-mile delivery vehicles; direct start-up subsidies; commercial electric vehicle or e-cargo bike procurement support; extended delivery windows; zone-based vehicle access restriction waivers; vehicle or bicycle size requirement waivers; and emissions fee waivers.

  – DDOT has received funding from the Carbon Neutral Cities Alliance for implementation, which includes a limited budget for incentives.

- Regulations will also vary across microhub types to some extent. Potential regulations include, but are not limited to, off-hour delivery mandates; low or zero-emission delivery zones; commercial operator licensing restrictions and fees; zone-based vehicle access restrictions; road access restrictions; and congestion pricing. Regulations can include flexibility from existing regulations, new regulations, and/or changes in enforcement.
- DDOT and operating partners will need to coordinate on initial outreach to communities and neighborhoods with potential microhub sites. After a site is selected, DDOT representatives, the consultant team, and operating partners will continue to outreach to community stakeholders to keep them informed about the pilot.
- Enforcement policies will be determined as part of the future operational framework and evaluation framework tasks. The consultant team will handle monitoring and will likely work with DDOT and other District of Columbia agencies on enforcement.

MICROHUB PILOT FRAMEWORKS

This section applies the decision-making framework (discussed above) to four potential microhub pilot types that were identified through the previous tasks and in collaboration with DDOT. The following sections describe how the implementation concept results in pilot frameworks for the follow types of microhubs:

- Microhub in a Publicly Owned Parking Lot
- Microhub in a Privately Owned Surface Lot
- Microhub in a Privately Owned Parking Structure
- Microhub in a DDOT-Managed Curb Lane

The first two sections of the framework, "1. Determine the Use Case for a Delivery Microhub" and "2. Assess Areas Where a Delivery Microhub Might Work" are sections that apply across all microhub pilot options in the District of Columbia and will not be evaluated on a case-by-case basis. The frameworks are briefly described below and then specific design and use considerations are laid out in the table following.

Framework 1: Microhub in a Publicly Owned Parking Lot

Framework 1 is a microhub in a publicly-owned parking lot. A publicly owned parking lot can be a surface parking lot or above or below-ground parking facility that is owned and managed by the District of Columbia government. There may be some opportunities for a publicly-owned parking lot to be a lot owned by the federal government but managed by DDOT, however, the team is not currently considering federally-owned sites as viable locations for a microhub pilot.

Framework 2: Microhub in a Privately Owned Surface Parking Lot

Framework 2 is a microhub in a privately-owned surface parking lot. Rather than a parking lot owned or managed by the District of Columbia, this would be a parking lot owned by a private property owner. This could be a stand-alone surface parking lot or part of another building parcel. This type of parking lot would be a surface lot, without a parking structure.

Framework 3: Microhub in a Privately Owned Parking Structure

Framework 3 is a microhub in a privately-owned structured parking garage. Rather than a parking lot owned or managed by the District of Columbia, this would be a parking facility owned by a private property owner. This could be a stand-alone parking garage (either above-ground or below-ground) or a parking structure attached to another development, such as an attached parking garage.

Framework 4: Microhub in a DDOT-Managed Curb Lane

Framework 4 is a microhub in a DDOT-managed curb lane. These microhubs provide temporary parking for large delivery trucks to unload and transfer their packages to smaller last-mile delivery modes. A curbside microhub can be at the curbside, demarcated by bollards or fencing, or can use some sort of pod, like an Oonee pod.[12]

Frameworks 1-4: Considerations for Location, Design, and Necessary Elements

Consideration	Publicly Owned Parking Lot	Privately Owned Parking Lot	Privately Owned Parking Garage	DDOT-Managed Curb Space
Foundational Questions				
Is the microhub on-street?				X
Is the microhub off-street?	X	X	X	
Is the microhub located in a parking lot?	X	X		
Is the microhub located in a structured parking facility?	X		X	
Is the microhub in a curb lane?				X
Location and Design				
A microhub should have curb cuts with a minimum of 12' in width	X	X	X	X

[12] https://www.ooneepod.com/.

Curb cuts should be consolidated into a single ingress and egress point	X	X	X	X
The microhub should be located on a truck or bus route and within 1/2 mile of a highway or major arterial	X	X	X	X
Microhub access points should have 8' or more height clearance and 54" door clearance for bikes and trailers	X	X	X	
Microhubs should have 16' vertical clearance between the floor and the ceiling of a parking garage or facility to allow trucks to access it.			X	
Microhubs should have at least one 15' by 40' parking space for large trucks to park.	X	X	X	X
Microhubs should have a separate ingress and egress point for handwalkers and bicycle delivery to separate them from truck traffic.	X	X	X	
The microhub site should be zoned as Production, Distribution, Repair; Industrial; Warehouse; or Mixed-Use	X	X	X	X
The site should be surrounded by land uses that will generate a suitable number of deliveries, including residential areas or commercial/office areas.	X	X	X	X
The site may require a temporary use permit if any zoning changes are needed.	X	X	X	X
The entrance to the microhub should be located on a minor arterial or local street, away from traffic congestion.				
The entrance to the microhub should be located in an alley or where a loading dock is.				
Facility Elements				
The microhub should have an adequate electric connection (240V) to charge e-bike batteries	X	X	X	X
The microhub should have a WiFi connection	X	X	X	X
The microhub should have some sort of temporary or permanent structure to protect drivers and parcels from elements	X	X		X

The microhub should have secure storage for parcels (approximately 2,500 sqft)	X	X	X	X
The microhub should have space to store the vehicles used for last-mile delivery and charge batteries (approximately 4,000 sqft)	X	X	X	X
The microhub should include employee amenities, including a driver break room with lockers, restrooms, and a kitchen	X	X	X	X
Key Partners and Engagement				
The microhub will be managed by the delivery operator, who will be a key partner.	X	X	X	X
The adjacent BID will be a key partner and engagement will happen with them throughout the pilot.	X	X	X	X
Engagement will happen with the adjacent Advisory Neighborhood Commission throughout the pilot.	X	X	X	X
Adjacent property owners will be engaged with throughout the pilot.	X	X	X	X
The property owner of the site will be a key partner and will be engaged with throughout the project.		X	X	
Engagement will happen during the planning process.	X	X	X	X
Engagement will happen during the implmentation and monitoring pilot.	X	X	X	X
Public Policy Supports				
Incentives will vary across microhub types, but are expected to include some combination of assistance with acquiring a site, any zoning or permitting changes needed; real estate or facility cost subsidy; rebates or subsidies for use or purchase of low/no-emission last-mile delivery vehicles; direct start-up subsidies; extended delivery windows; zone-based vehicle access restriction waivers; vehicle or bicycle size requirement waivers; and emissions fee waivers.	X	X	X	X

Regulations will also vary across microhub types to some extent. Potential regulations include, but are not limited to, off-hour delivery mandates; low or zero-emission delivery zones; commercial operator licensing restrictions and fees; zone-based vehicle access restrictions; road access restrictions; and congestion pricing. Regulations can include flexibility from existing regulations, new regulations, and/or changes in enforcement.	X	X	X	X
The microhub will need some sort of enforcement.	X	X	X	X
The project team will draft data sharing agreements.	X	X	X	X
The project team will draft MOUs for DDOT, the operating partners, and community partners.	X	X	X	X

APPENDIX: DECISION-MAKING FRAMEWORK QUESTIONS

Determining an Appropriate Use Case

- What are the safety, congestion, emissions, equity, etc. challenges surrounding delivery in your city?
  - Which of those challenges are you looking to solve with a delivery microhub?
- How can a microhub make delivery easier in your city?
- What are your goals for a microhub? Examples include mitigating congestion, noise, and pollution.
- Which **vehicle types** are of interest in addressing these challenges?
  - The range of types is changing quickly, but currently includes e-cargo-bikes of various formats, electric handcarts to accompany walking deliveries, and other small vehicles.
  - This may be answered differently depending on the city's considerations and the operators' choices. Cities may be more interested in e-cargo bike delivery than handwalkers and vice versa.
- Which types of deliveries are most common in your area? Are delivery challenges more prevalent in residential areas, commercial areas, or mixed-use areas? Would the microhub address deliveries to **homes, businesses, or both**?
  - Home Delivery
    - Are deliveries (and challenges) more common in low-density single-family residential areas or higher-density urban areas with high-rise buildings?
    - Are the deliveries made to homes primarily **food** deliveries or **parcel** deliveries?
    - If food delivery, is it groceries or meals? If groceries, is it on-demand like GoPuff, or scheduled like Giant PeaPod?
    - If parcel delivery, is it small parcels or large parcels?
    - FedEx and UPS define small parcels as packages less than 150 pounds and packages smaller than 108 inches in length and 165 inches in width. Large parcels exceed those limits and may need to be shipped via freight shipping, which is separate from small parcels. Large

    - parcels are often too large for last-mile delivery vehicles and are not a good option for a microhub.
  - Business Delivery
    - Deliveries to businesses include the same kinds of deliveries that come to homes—small and large parcels, meals and other perishables—often from the same shipping companies.
    - However, businesses also receive lots of deliveries from other businesses (called B2B), Are B2B deliveries in your area usually sent directly between businesses, or are via a third-party carrier?
- How long are most deliveries expected to take? Are they urgent?
  - Are challenges related to **on-demand** delivery versus less urgent deliveries scheduled to take **2 days to several weeks?**
  - Are most deliveries perishable? Do most deliveries have sensitive timelines? If most deliveries are perishable, a microhub may increase the delivery time and not be a conducive option. Additionally perishable deliveries would require temperature control and/or refrigeration at the hub and on the last-mile delivery mode.
- Which **providers** carry out most of the delivery operations?
  - Are these large providers (e.g., USPS, UPS, FedEx, Amazon, DHL, etc.) or small providers?
    - Small providers may have more specialized and/or dedicated markets and service areas with limited opportunities to make deliveries more efficient through a microhub.
    - Large operators may have more package deliveries and may have more opportunities to create additional operational efficiencies using a microhub. Large operators are typically more common to be interested in participating in delivery microhub approaches.
- What type of **delivery operation** is used by carriers?
  - You may need to contact the carrier(s) directly to understand how they operate.
  - Are deliveries made using a **multi-round** delivery (multiple stops along a route) operation or a **single-round** delivery (point to point) operation?
  - What **type of vehicles** are typically used for deliveries?
    - What is the typical size of vehicles used (e.g., vans, small delivery trucks, personal passenger vehicles, bikes, Postal Service vehicles, delivery vans, refrigerated trucks)?

    - Are some deliveries made using a mode of transportation other than a truck or car (e.g., bicycle)?
  - What is the **average size** of a delivery?
    - Are the deliveries made usually smaller, more compact items (e.g., household goods, home office supplies) or larger more cumbersome items (e.g., furniture, bulk items)?
  - Do delivery companies see potential benefits to themselves from participating in a delivery microhub?

Assess Areas Where a Delivery Microhub Might Work

Chapter 5 describes a methodology for analyzing areas of a jurisdiction that might be good candidates for a delivery microhub. This section captures the guiding questions at a high level.

- Where are package deliveries concentrated?
  - What areas have the highest residential unit density? More residences typically means more deliveries, and density can result in more efficient deliveries which make a microhub more attractive to operators.
  - What areas have the highest population density? Including this adds weight to places where the number of residences doesn't fully capture density, for examples places with larger family sizes, multiple roommates, etc.
  - What areas have the highest employment density? More employees, on its own and as a proxy for more businesses, leads to more delivery demand.
  - Is there overlap between areas of high population density, high residential unit density, and high employment density? This overlap can help identify areas with the highest number of package deliveries throughout the day.
- Where are areas that could support a microhub?
  - Where are high levels of roadway congestion? Moving standard trucks through these areas is more challenging, so a microhub might provide more benefits.
  - Where are areas with connected street grids, sidewalks, and intersections and blocks that are designed to be pedestrian friendly? These neighborhoods provide direct, safe routes for deliveries on bikes and on foot.

- Where is the connected bicycle network in the area? A better network that includes protected lanes, paths, and other features can make delivery by bike more attractive.

- Equity Considerations. Focusing only on areas with high employment and mixes of uses might leave out other areas that experience the negative impacts of delivery traffic. DDOT defines areas of transportation need using a combination of factors.
  - What areas are/are not concentrated around frequent transit?
  - What areas have higher or lower access to jobs and destinations?
  - Where are high-stress and/or low-comfort cycling routes?
  - Where are sidewalk gaps?
  - Where are high crash corridors or locations?

  In addition, we look at the key indicators of environmental impacts of vehicle traffic.
  - Where are asthma rates highest?
  - What areas have high concentrations of diesel particulate matter?
- Do candidate service areas have the right characteristics to site a facility? (see next section for more detail)
  - How would large distribution trucks access the site. Where are highway ramps? Where are truck routes?
  - What places are available to locate a site? Where are alleys, parking lots, garages, warehouses, and other supportive land uses and zoning classifications?
  - Where is city-owned land? City ownership should make the process easier by limiting the number of required partners.

Determine Location and Design for the Facility

- What type of microhub would best benefit the area based on **current types of deliveries?**
  - Is the hub meant to serve one operator or multiple operators? Do multiple operators have large amounts of package deliveries in the area?
  - If a multi-carrier or shared facility is used, will each carrier have their own section, or will carriers need to reserve shared space in a microhub?
  - In general, operators have indicated that they prefer not to share space. They have security concerns about their parcels.

- Would an **on-street** (e.g., a converted parking space or loading zone) or **off-street** facility (e.g., a surface parking lot or garage or small building) work?
  - If the facility is **on-street**, is it in the curb lane, taking up a parking space, or replacing an existing loading zone?
  - If the facility is **off-street**, is it a parking facility or a retail or warehouse space?
    - If a parking facility, is it at the surface level, below ground, or above ground?
    - If it's a building (other than a parking garage), what type of land use is the current space?
    - Is the facility publicly owned or privately owned?
- How will vehicles **access the site** (e.g., ingress and egress routes, traffic considerations, etc.)?
  - This consideration should include both delivery trucks coming to the microhub and last-mile delivery modes coming to and from the hub.
  - Is the site near arterials or major roads that allow trucks?
  - Is the site near the connected bicycle network or pedestrian-friendly streets that are supportive of e-cargo bikes, cargo-bikes, handcarts/walkers, or other sustainable modes?
  - If the facility is in a structured parking garage or other enclosed location, what access does the site have? What is the vertical clearance in both entry and exit and height clearance between levels (if applicable)?
    - Operators have indicated in other pilots that building access requirements on the ground level include eight feet or more height clearance and 54 inch or wider door width for bikes and trailers. For raised structures, operators prefer docks with space for a fifty-three-foot tractor-trailer, high doors with dock leveler; drive-in ramp; entrance location in a non-congested area (vs. on a main arterial) for easy vehicle access; ramps for bike/trailer access to building.
- What are the existing **zoning and use restrictions** for the facility site?
  - Microhubs are most commonly allowed under industrial or warehousing zoning classifications and some commercial and mixed-use zoning classifications. A parking lot/garage or warehouse may be more likely to have a supportive zoning classification, rather than a retail site.
  - If the site is not currently zoned with microhub operations as a by-right use or allowed by special or temporary use permit, can the parcel get a variance or be rezoned?

        - What is the process required to get a regulatory change?
        - How much influence/control does the city agency/department implementing a microhub have over zoning? Does it need to go to a council (for the District of Columbia, the Council of the District of Columbia) or other board?
    - If the facility is in an unused retail space, how long is the site available for?
- What **technology** is necessary for the microhub to succeed and be fully utilized?
    - Does the site have an existing electric connection?
    - Would the site need electric utilities or grid upgrades?
    - Would the potential operator(s) have last-mile delivery routing software?
        - Does the site have good cell service or WiFi coverage to support last-mile delivery software?
- Does the facility have **shelter** for delivery workers and/or deliveries?
    - Is the shelter a physical building, or temporary building (shipping container, etc.)?
    - This may only be a consideration for microhubs built in parking garages and surface parking lots.
- Does the facility have **secure storage** for deliveries and vehicles?
    - Does the facility have secure storage for packages during the day? In general, operators are unlikely to leave parcels in a microhub overnight.
    - Does the facility have secure storage for vehicles overnight or while batteries are charging? Delivery operators are unlikely to want to bring last-mile vehicles to and from the facility each day.
    - Does the facility have sufficient space for safe **charging**?
- What delivery **worker amenities** does the hub have (e.g., waiting area, vending machines, restrooms, etc.)? This may vary based upon what the specific operator requests.
- Which **vehicles** will be used at the microhub facility?
    - What type(s) of sustainable delivery modes or vehicles will be used?
    - What type(s) of vehicles will be used **to transport goods from large facilities outside the city to the microhub**? This will likely be some sort of large truck.
    - If the facility will primarily use electric vehicles, what are their specific **charging requirements** do vehicles need?
- Will the use of the microhub facility have **time restrictions?**

   - Community members may push back against a microhub that has significant noise levels overnight.

Identify and Coordinate with Partners

- Who will your **operational partners** be to support the microhub site and operations?
   - Which **delivery operators will** use the site? What will the partnership include? Typically a memorandum of understanding will be required even if no financial transaction is involved.
   - What **technology partners** are needed?
      - Are last-mile delivery routing software partners necessary?
      - Are partners who manage smart loading zones or geofencing necessary for site operations?
   - What **types of agreements** are necessary for a successful partnership site?
- Which **community partners** will be engaged?
   - Which communities need to be consulted and included in the planning and operations design? At what stage do they want to be involved?
   - Will historically underserved communities or low-income communities receive monetary compensation for participating in community engagement?
- What public engagement is needed to support a delivery microhub?
   - What are the key points for engagement while the microhub is being developed, before launch?
   - How will delivery operators be involved in the pre-launch engagement?
   - What post-launch engagement needed from the city, community partners, or the delivery operator?
   - How will community members be able to communicate any issues or complaints about the microhub?

Smooth Out Operational Considerations

- What is the **estimated cost of implementation and maintenance** of the microhub?
- Who will be responsible for microhub operations? What role can the city play to help support the site operator?
- What **incentives** are needed to entice the use of the microhub site for the community, site owner, and delivery companies?
   - Incentives can include, but are not limited to: assistance with acquiring a site, any zoning or permitting changes needed; real estate or facility cost subsidy

(including rent subsidies); waivers or exemptions to the zoning or building code; rebates or subsidies for use or purchase of low/no-emission last-mile delivery vehicles; direct start-up subsidies; commercial electric vehicle or e-cargo bike procurement support; extended delivery windows; zone-based vehicle access restriction waivers; vehicle or bicycle size requirement waivers; and emissions fee waivers.

  - What is the cost to provide incentives for delivery companies to utilize the site?
    - Who bears the cost of the incentive, the city or the site operator?
    - Does the city have budget set aside for incentives?
  - What funds exist to create incentives?
- What **regulations** are needed to help an operator participate in a microhub?
  - These include, but are not limited to: off-hour delivery mandates; low or zero-emission delivery zones; commercial operator licensing restrictions and fees; zone-based vehicle access restrictions; road access restrictions; and congestion pricing.
  - They can include flexibility from existing regulations, new regulations, and/or changes in enforcement.
- What **coordination** is necessary between the city, operating partners, and community stakeholders to create and operate a successful microhub?
  - Coordination can include organizational support; data sharing and reporting agreements; and draft MOU agreements between the jurisdiction, operating partners, community stakeholders, and other partners
- How will **enforcement** of facility policy be handled?
  - What type of enforcement is needed to ensure proper use of the facility?
  - Do enforcement tactics and needs differ if the pilot is in an on-street facility or an off-street facility?

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