

Logistics Architecture as Urban and Social Infrastructure

NICOLAS FUERTES LA-ROTTA
The City College of New York

CATHERINE BRIZO
The City College of New York

HECTOR TARRIDO-PICART
The City College of New York

SHAWN L. RICKENBACKER
The City College of New York

JOEL CARDENAS
The City College of New York

SHYANNE SONNENBERG
The City College of New York

JULIO SALCEDO
The City College of New York

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New York City (NYC) must innovatively respond to the socio-spatial challenges of accelerating e-commerce growth. The city’s constrained urban grid faces substantial truck freight induced traffic congestion and pollution—a dangerous set of externalities that undermine NYC’s quality of life and economic development potential. This paper posits that the establishment of a Harlem based Multi-Sided-Platform (MSP) that supports public community alliances with the logistics sector can help NYC: (1) catalyze economic development, (2) foster sustainability, and (3) improve quality of life. Two underutilized segments of NYC’s infrastructure can be symbiotically leveraged to foster this alliance: the Metropolitan Transportation Authority (MTA) and the New York City Housing Authority (NYCHA). A licensing agreement between 3rd-party logistics (3PL) providers and the MTA can permit relatively unobtrusive nightly freight transport through the subway in exchange for right-of-use fees. Additionally, public-private partnerships between the logistics industry and NYCHA can enable the development of disaggregated and Hyper-Local Community Distribution hubs (HCDH) throughout its reportedly underutilized land. The newly formed network of HCDHs can scale across NYCHA and link to accessible MTA subway lines to receive and consolidate small-package freight within close proximity of its destination. A private 3PL provider can operate these HCDHs and complete “The Last Mile” of delivery cheaply and ecologically by deploying e-bike and on-foot couriers. Furthermore, the proposed logistics network can serve as a vital piece of NYC urban infrastructure that doubles as a mechanism for community level socio-economic revitalization. In other words, not only can this proposed network help address NYC logistics and public health challenges but it can also provide significant local economic development opportunities on and around NYCHA sites in the form of: new revenue streams, improved public amenities, and employment.

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SECTION I: IDENTIFYING THE PROBLEMS

Problem Statement I: Congestion in NYC is a pressing issue of: public health, environmental sustainability, economic development, and quality of life.

In 2019 the NYC Department of Transportation reported that NYC’s roadways are more congested than ever before. Today, of the 365 million tons of freight that enter, leave, or pass through NYC each year, 89% are carried by a delivery truck. Delivery trucks face inadequate parking and loading facilities, and are forced to awkwardly double-park, inefficiently using busy streets and obstructing sidewalks.¹ These makeshift delivery conditions significantly reduce the flow of traffic, further exacerbating already intense urban congestion.² If e-commerce trends continue to accelerate, it is estimated that by 2045 delivery tonnage will grow by a staggering 68%.³ Without plans to accommodate such e-commerce growth, congestion will pose significant health and economic challenge for NYC.

Respiratory Risk: Worsening congestion is accompanied by worsening air quality. NYC Health data reveals that asthma related health complications spike in areas predominantly serviced by diesel-fueled trucks. A 2011 NYC Health Department report estimates that each year particulate matter pollution in New York City causes more than 3,000 deaths, 2,000 hospital admissions for lung and heart conditions, and approximately 6,000 emergency department visits for

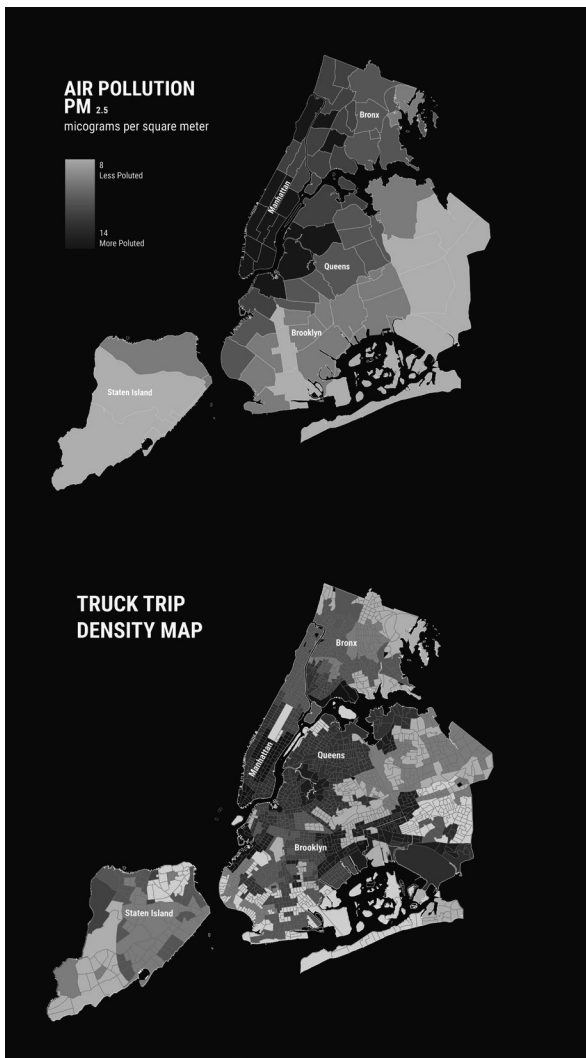


Figure 1. Maps comparing NYC's air pollution and truck density.

asthma in children and adults.⁴ Asthma is now the leading cause of emergency room visits, hospitalizations, and missed school days in New York City's poorest neighborhoods.⁵

Collision Risk: Trucks themselves pose a serious risk to pedestrian traffic.⁶ In New York City, about 10,000 truck accidents take place every year. A report from the Accidents and Prevention Journal explains that because light trucks are "heavier, stiffer, and geometrically more blunt than passenger cars", they pose a dramatically different type of threat to pedestrians. The report also reveals that the probability of serious head and thoracic injury is substantially greater when being struck by a truck than by a passenger vehicle.⁷

Climate Risk: Burning fossil fuels such as gasoline and diesel negatively alter the chemistry atmosphere and help contribute to increasingly more extreme climate events.⁸ According to the EPA, between 1990 and 2018, greenhouse gas emissions (GHG) from the burning of fossil fuel by the transportation sector

increased in absolute terms more than in any other sector of the economy.⁹ In NYC alone approximately 1.8 million tons of carbon dioxide were emitted by delivery trucks in 2019.¹⁰ If trends of e-commerce induced truck activity continue to rise, then NYC will find itself contributing to climate change at ever increasing rates.¹¹

Psychological Risk: Studies have also shown that congestion produces negative mental health outcomes in commuters; namely, psychological frustration and mental fatigue.¹² A report titled *The Commuting Paradox* concludes that longer congestion-induced commuting time systematically lowers subjective well-being. The report states that the burden of congestion is associated with raised blood pressure, musculoskeletal disorders, lowered frustration tolerance and increased anxiety and hostility, bad mood, increased lateness, absenteeism and turnover at work, as well as adverse effects on cognitive performance.¹³

Productivity Loss: Gridlock represents a large waste of resources that diminishes productivity. A 2018 report from the Partnership for New York City asserts that between 2018 and 2023, traffic congestion will cost New York City approximately \$100 billion in economic growth. It also estimates over 111 millions productive hours are lost annually as a result of bumper-to-bumper traffic.¹⁴ The data analytics company INRIX asserts that New York City was the most heavily congested city in the US, causing drivers to lose an estimated 100 productivity hours per year stuck in traffic in 2020 and costing them \$1,486 annually.¹⁵

Infrastructure Deterioration: Accelerating demand for e-commerce and intensification of truck freight places increased strain on NYC's road and tunnel infrastructure. Every day thousands of trucks enter the city to complete over 1 million deliveries. Engineering experts agree that the presence of overweight trucks can cause sections of roads to become structurally unsafe and unable to carry existing levels of traffic.¹⁶ The presence of trucks and their impact on NYC roadways has been so alarming that in 2020 Governor Cuomo announced that the state's budget would include new measures for increasing bridge fines and penalties for overweight trucks to up to \$10,000.¹⁷ Similarly, in 2020 NYC mayor DeBlasio signed an executive order to increase overweight truck enforcement of the Brooklyn-Queen Expressway.¹⁸

Problem Statement II: "Last Mile" of delivery within NYC is notoriously costly for the logistics industry.

Scarcity of Space: As the demand for e-commerce has surged in the last couple of years, so has the demand for warehousing space.¹⁹ In fact, while various other sectors floundered in the face of the COVID-19 pandemic, the industrial sector continued to see accelerating demand. Despite the logistics sector's desire for warehousing space, both the prohibitively high cost of land and accompanying zoning restrictions have impeded developers from addressing scarcity. Without the necessary space to establish operations close to

consumers, distributors face increasingly high delivery costs.

Costly Operating Expenses: Logistics industry currently suffers from disproportionately high ‘last mile’ delivery costs. While the dollar/mile efficiency of transporting freight across interstate boundaries is relatively high, the efficiency of moving freight through the last mile of the delivery is exceedingly low. Reports indicate that between 28-50% of total delivery expenses are due to last mile costs.^{20,21} In urban areas, the costs are particularly high as congestion induced idling consumes fuel at a faster rate. Furthermore, poor off-loading procedures, improper consolidation routes, and inefficient streetscapes contribute to greater fuel consumption and higher parking fee costs.²²

SECTION II: CRAFTING A SOLUTIONS FRAMEWORK

Both of the outlined problem statements are deeply entangled, with one giving rise to the other, ultimately forming a vicious cycle. This paper attempts to help address this entanglement; it posits that by addressing Problem Statement II (PS-II), NYC can begin to solve Problem Statement I (PS-I). In other words, by solving for the high operational expense troubles of private industry NYC can address the slew of congestion related public health and financial problems. The paper goes further and posits that not only can the above-mentioned problems be addressed, but that other local objectives such as community resilience, social empowerment, and economic development can be achieved.

This paper recognizes that the range of issues that arise from PS-I and PS-II cannot be solved by the free-market or government alone since market solutions are bound by affordability constraints and government solutions are bound by technological specialization constraints.²³ For this reason this paper proposes the development of a multi-sided platform (MSP). MIT’s Sloan Management Review defines MSPs as systems that create value by enabling direct interactions between participant groups. To solve for PS-II, and ultimately for PS-I, a MSP must exist so that a value-oriented collaboration and alliance between public and private participants can occur.²⁴ This paper’s approach seeks to develop a MSP that leverages private-sided logistics specialization and public-sided infrastructure. The proposed MSP manifests itself in the form of logistics architecture—a distinct form of architecture that operates as both urban and social infrastructure.

Private-Side Relationship to Problem Statement II: Last-Mile experts recognize that delivery costliness is a function of two distinct components in the logistics calculus: namely, weak site distribution density and expensive transportation. Therefore, logistics operators can reduce costs if: (A) distribution site density is optimized, and (B) cost of transportation is reduced.

- A) **Distribution Site Density Optimization:** Geo-spatial mapping of Manhattan and logistics literature suggests that optimized multi-echelon distribution networks

are an effective strategy to combat the Last-Mile problem.^{25,26} An optimized multi-echelon system is defined as a disaggregated form of inventory that spans across multiple layers of distribution. Such a system accounts for complex interdependencies between supply nodes as well as variables that lead to oversupply, undersupply, uncertainty, or volatility in inventory.²⁷ To achieve optimization, logistics experts suggest that: (1) operators distribute urban freight consolidation sites by using geospatial modeling to maximize operational cost reductions and (2) that they deploy data-driven algorithms to achieve accurate inventory demand projections.²⁸ The successful deployment of a multi-echelon distribution network results in satellite consolidation nodes existing at closer proximity to customer locations. At these consolidation nodes, freight can be cross-docked onto lighter vehicles such as e-bikes, or e-vans or on-foot-couriers, to perform the final leg of delivery.²⁹

- B) **Cost of transportation Reduction:** Logistics experts suggest that an urban freight light rail system is a cost effective strategy to reduce the cost of truck based freight transportation.^{30,31,32} The implied decrease in congestion, dedicated delivery routes, easy access to existing infrastructure, and environmental benefits of rail have been well investigated. In fact, successful prototypes have already been deployed in various cities across the world including: Dresden, Thailand, and Amsterdam.³³ In 2020, a NYSERDA commissioned a report on the viability of urban rail in NYC concluded that: “urban rail intermodal freight systems are both technically and economically feasible.”³⁴

While these twin solutions remain promising, there exist few market-based tools to help crystalize their implementation. Land remains prohibitively costly, denying logistic operators from optimizing urban distribution site density. And truck transportation remains the default means of transport. Due to the market’s limitations, government must enter the discussion and collaborate with private actors in developing a Multi-sided platform that can best tackle PS-II.

Public-Side Relationship to Problem Statement II: City officials can collaborate with logistics companies by leveraging existing NYC infrastructure in the service of: (A) distribution site density optimization, and (B) transportation cost reduction.

- A) can be accomplished if government accommodates the spatial requirements needed for logistics operators to establish multi-echelon distribution. NYC can support this effort by enabling private access to underutilized land.

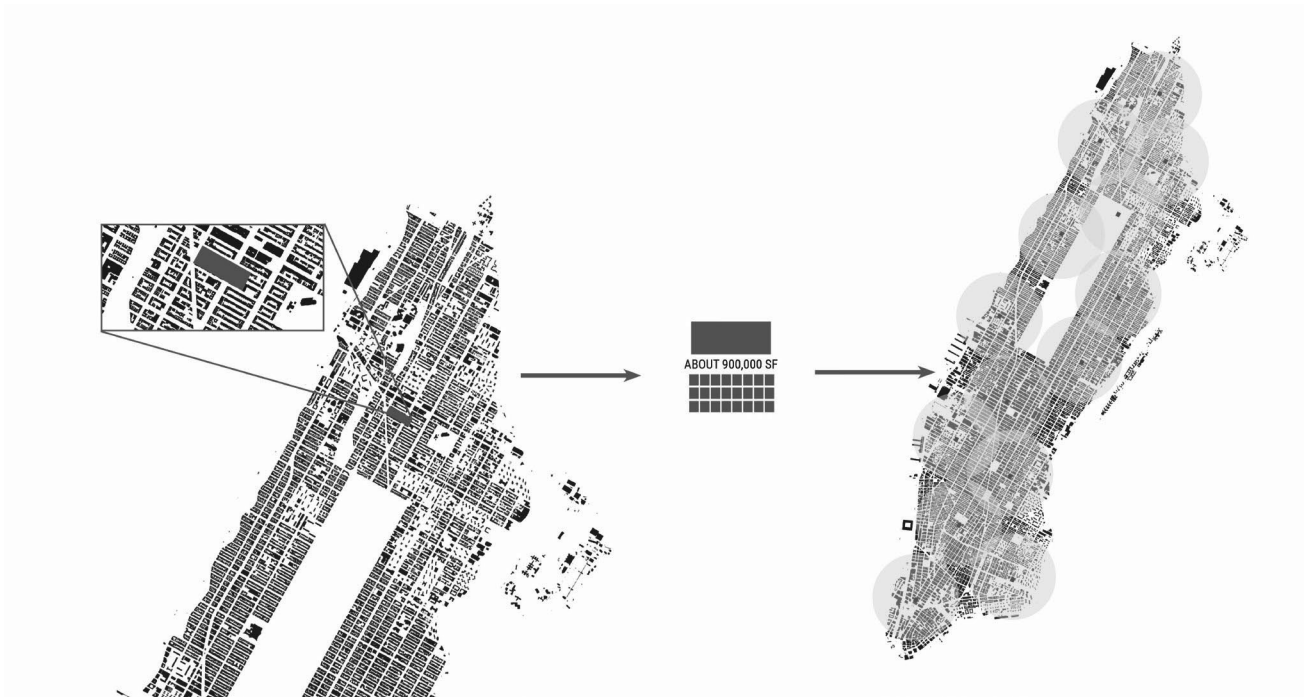


Figure 2. Diagram depicting disaggregated site density optimization.

- B) can be accomplished if government offers an alternative mode of freight transportation. NYC can support this effort by enabling the private use of existing rail infrastructure.

It is obvious that access to public land and rail infrastructure cannot be awarded to industry at no cost. It is not enough to claim that PS-I alone can be addressed by solving for PS-II. Whatever PPP scheme is developed must be proven to be both beneficial to NYC at a large (PS I) and beneficial to local community stakeholders as well, that it does not gift industry with public assets but that it helps generate a significant net social and economic benefit at the city and neighborhood level.

Underutilized Land: As previously discussed PS-II can be resolved by enabling the multi-echelon disaggregation of distribution hubs. The public side of the platform can collaborate with private actors to provide the off-market land required for the logistics industry's distribution network to scale. Public land for these efforts must be readily accessible, demonstrably underutilized, close to the urban core, and under the authority of singular government entities. This paper advances NYCHA land as a noteworthy candidate for this collaboration.

Both the Bloomberg and DeBlasio administration recognize the spatial underutilization of NYCHA's 2.5 million square feet of non-commercial land and have proposed various "shovel-ready" projects to capture said unrealized value.^{35,36} In 2015, the DeBlasio Administration produced a comprehensive plan, NextGen, to guide NYCHA's uncertain future. Billions in

underfunding by all levels of government, archaic management models, and rapidly deteriorating conditions have severely weakened NYCHA.³⁷ Today, it is burdened by 17 billion dollars in unmet capital needs across its entire portfolio. At the same time, NYCHA struggles with a significant structural operating deficit of tens of millions of dollars each year.³⁸ The NextGen report concludes that "aggressive action" is necessary to sustain the ailing NYCHA developments in the long-term.

The basis for an Urban Logistics Architecture with an expressed focus on the provision of sustained social and economic benefits is in line with two distinct NextGen strategies; namely, Strategy #3: "Maximizing revenue and use of ground floor spaces," and Strategy #15 "Connecting residents to quality workforce opportunities."³⁹ A logistics company could contribute to Strategy #3 by operating under a lease agreement on a NYCHA-owned distribution hub; this way NYCHA could maximize revenue from unused ground area and achieve short-term financial stability.⁴⁰ Furthermore, the Mayor's report explains, NYCHA is subject to a federal policy from the HUD Act of 1968 that "helps foster local economic development, neighborhood, economic improvement, and individual self-sufficiency." The act requires that recipients of financial assistance provide job training, employment, and contracting opportunities for low-income residents in connection with projects in their neighborhoods.⁴¹ This paper contends that a logistics company could contribute to strategy #15 by serving as powerful employment generators for the local community.

Underperforming Transportation Infrastructure: As previously discussed PS-II can be resolved by offering rail freight alternatives to the logistics industry. The public side of the platform can collaborate with private businesses to share its underperforming transportation infrastructure. The public rail options offered for these efforts must be: readily accessible, demonstrably underutilized, able to meet capacity, and reliable. This paper advances the MTA's subway network as a noteworthy candidate for this collaboration.

The MTA's financial and management struggles are also well documented. A 2021 MTA report escalated the level of urgency and claimed that the organization is facing the greatest challenge in its history.⁴² Two distinct trends outline the dire situation it faces: reduced revenue trends and increased expenditure trends. Federal contributions and ridership are decreasing, with 16% reduction in revenue expected in 2021, or 11.8 billion dollars in revenue loss. Meanwhile, maintenance and payroll spending have increased, with a 4% annual increase in baseline expenditures and 10% increase in debt service obligations.⁴³ This paper contends that a licensing agreement between logistics providers and the MTA can permit relatively unobtrusive nightly freight transport through the subway in exchange for right-of-use fees.

The next sections will better detail how these distribution hubs and rail networks as a new urban spatial logistics network can resolve PS I challenges while: generating revenue for NYCHA and the MTA, and improving social and economic conditions for local communities.

SECTION III: PROPOSED NETWORK SOLUTION

A "SWIFT" (Subway with Intermodal Freight Transfer) system will leverage existing MTA subway infrastructure.⁴⁴ A licensing agreement between 3rd-party logistics (3PL) providers and the MTA will permit relatively unobtrusive nightly use of SWIFT in exchange for right-of-use fees. Additionally, public-private partnerships between the logistics industry and NYCHA will enable the development of disaggregated and hyper-local community distribution hubs (HCDH) throughout its reportedly underutilized land. The newly formed network HCDHs will scale across NYCHA and link to accessible MTA subway lines to receive and consolidate small-package freight within close proximity of its destination. A private 3PL provider will operate these HCDHs and complete "The Last Mile" of delivery cheaply and ecologically by deploying e-bike and on-foot couriers. Such a network will address PS-I and PS-II and demonstrably (1) catalyze economic development, (2) foster sustainability, and (3) improve quality of life for city residents.

This network focuses on Harlem NYCHA sites as a test case that meet the criteria for the development of a HCDH: Polo Grounds, Kings Towers, and Manhattanville Housing. This section offers a brief outline of the necessary nodes that compose the proposed freight distribution network.

A: Drop-off Portals: Are the first nodes within the proposed network, these portals will accept incoming small-package freight and transfer it onto existing NYC-bound trains. There are a few criteria that qualify the viability of a portal:⁴⁵ Location along arterial interstate truck routes, location in relation to NYC-bound rail transportation, physical connection to NYC-bound rail transportation, proximity to freight originating warehouses, train availability and reliability, dwell time, and freight intake capacity.

Truck freight from New Jersey (NJ) warehouses will be conveniently dropped-off at night at viable portals locations so as to minimally hinder the operation of NJ trains. (While not considered in this paper, other outlining warehouse sites within Staten Island, Long Island, and Westchester have rail corridors as well as river corridors for consideration.) Incoming small-package freight must be previously sorted and it must enter these portals on storage containers, or pods, for increased convenience and maneuverability through the entire delivery journey.

B: Transfer Nodes: Major connection nodes, 34th Street-Penn Station, 42nd Street-Grand Central and Fulton Street, will transfer freight from NJ rail to NYC rail. These stations will utilize the speed and flexibility of mobile robot units to interchange freight from one form of rail to the other cheaply and reliably. Presently, Kiva systems, autonomous robots can handle up to 3,000 lbs of weight and move up speeds of 5 mph.⁴⁶ These robots and future iterations will be used reliably to transfer small-package freight onto Pod units. Retrofits can be done in these stations to accommodate for necessary mechanical armature that aid the Kiva robots.

C: Train Modifications: Freight-carrying subway cars will be produced with a few simple alterations to existing cart stock. Alterations will be made to 6 out of 11 cars. Alterations will include the removal of seats, installation of fastening mechanisms, and addition of overhead access openings. The MTA has previously investigated seatless trains on the subway in an effort to combat overcrowding.⁴⁷ The remaining modifications are estimated to have marginal impact on ridership. Each car will accept and dispense pods organized and transferred via optimized sorting algorithms and algorithm-driven Kiva robots. Based on the capacity of a R-142 Rail Car, each subway car will transport up to 24 pods, or 144 pods per train.⁴⁸ These cars will receive and deliver freight on an Off-Peak service schedule to remove potential friction between passengers. Operating between late night hours of midnight and 6:30 A.M. ensures that minimal amount of contact is made between civilians and Kiva's.⁴⁹

D: Community Distribution Hubs: Currently, delivery demand is met through rented and private delivery vehicles that offload packages onto sidewalks and streets, complicating the patterns of public space. Hyper Local Community Distribution Hubs (HCDH) will reimagine this dynamic by accepting packages arriving from the subway via Kiva robots into dedicated drop-off zones.

Assuming that the Polo Ground HCDH serves a 1.5 miles radius, and captures fifty percent (50%) of the small-package freight delivery market, it can accept approximately 37,302 cubic feet of freight every day. Twenty-five (25) subway cars, or four (4) full capacity trains, could meet the daily small-package freight demand of roughly all of Manhattan community district 10. The packages that arrive will be immediately placed on cargo e-bikes and on-foot-couriers for final delivery. A report from McKinsey & Company, explains that bike couriers are likely to be the best delivery form for instant delivery in urban areas.⁵⁰

E: Offloading Pads: Cargo e-bikes represent the final leg of delivery. This proposed offloading pad requires relatively sizable off-loading space to be carved out to park in-transit e-bikes. Once parked, the courier will deliver small-packages on foot in the same way it is presently done. Retractable dollies and other wheeled platforms can be used to facilitate maneuvering. A report by RethinkX think tank claims that the future of city transportation is a network of communal, autonomous electric cars owned by ride-share companies. The report also estimates that by 2030 only 20% of Americans will own private cars.⁵¹ Such changes will force cities to rethink how much parking is needed in the city and will open city officials to reconsider space for new land uses, such as the one presented.

SECTION IV: PROPOSED DISTRIBUTION HUB

This paper rejects the conventional warehouse and offers the design of a new urban typology—one composed of both urban and social infrastructure elements and which ultimately manifests itself in the form of a new urban architecture. This paper proposes a Hyper-Local Community Distribution Hub (HCDH) that not only advances solutions for Problem State I and II (PS-I and PS-II) but also catalyzes economic development for the associated NYCHA communities. For this to be accomplished, the proposed HCDC's architecture and cross programming must operate similarly to the multi-sided platform previously discussed. However, in this case, the idea of the 'platform' operates quite literally. The platform, or HCDH, enables both logistics-side design components and social-side components to interact and generate an entirely new synergetic whole. Without this multi-sidedness, the proposed HCDH would merely become as inert as standard warehouses of the past.

1. Logistics-side Infrastructure: The proposed network of distribution sites is well positioned to capture large quantities of incoming freight. Arriving deliveries will be transported through Kivas to two distinct destinations within the hub: immediate fulfillment or storage. Same day delivery items will be offloaded from the train and be directed to sorting stations; in these spaces out-going parcels will be packed onto e-bikes for immediate delivery. Longer-term items will be stored away onto mechanized shelving, or high capacity mobile racking systems.

Algorithm-driven Order Fulfilment: To further increase the efficiency of the last mile challenge the HCDH will use cloud-based

machine learning technology to analyze consumer preference data-sets and to help predict the demand for constantly recurring purchases within the community. This practice is currently in use today and has proven to increase efficiency as the warehousing of these items closer to the destination invariably reduces the delivery time, distance traveled, and costs of operation.

Disaggregated Urban Freight Consolidation: Each HCDH is estimated to service a 1.5 mile delivery radius, this allows the packages to be consolidated within close proximity of neighborhoods. This short radius shortens the distance between consumers and their packages, allowing for deliveries to be made via foot or bike. One report concluded that distribution systems are greatly optimized if disaggregated, allowing a final cost reduction of about 16%.⁵⁴ Other research has extensively analyzed and reported the many other benefits hyper-local distribution has on suppliers' efficiency and reliability; and the impact it has on congestion reduction and pollution mitigation.^{55,56,57,58}

Consumer Lockers: Consumers will benefit from the convenience of local delivery lockers available within the HCDH. Such amenity will contribute to the sustainable ambitions of the project as it is proven to lessen the CO2 emissions from failed home deliveries and inefficient return processes. Research generally suggests the use of collection delivery points aid in the reduction of costly lost prevention and are a more environmentally-friendly alternative to redelivery and collection from non-urban depots.^{59,60}

Environmental Sustainability Features: NYC and Federal authorities have considered East Harlem to be particularly vulnerable to extreme weather conditions and combined sewage overflow. The Mayor's Office of Sustainability has developed a resilience plan that calls for the redevelopment of public spaces; it concludes that inaction will cost Harlem approximately \$3.2 Billion dollars over the next 50 years.⁶¹ For this reason a proposed systematized lightweight modular skeletal structure and skin of the proposed intervention increases water permeability, drainage and retention on the site.

Beautification through Biophilic Design: Biophilic design has the potential to improve human well-being. Some research claims that it can serve as a form of restorative mental therapy for populations deprived of green space.⁶² Other research suggests that forms of augmented natural landscapes may improve cognitive functions, reduce stress, and provide mental peace.⁶³ The proposed HCDC aims at achieving such levels of qualitative control over the psychology of NYCHA residents and passerby. The HCDC modularity enables for the possibility of overhanging plants, large planters, interior gardens, rooftop pastures, and other elements of biophilic materiality that would augment the city's ongoing efforts to green the city.

2. Social-side Community Infrastructure: The proposed HCDC is designed to foster community development and catalyze



Figure 3. Diagram of underground rail distribution system. Warehousing locations (top left), subway network and nodes into NYC (top right), Polo Grounds HCDC site location (bottom left), on-foot/e-bike distribution network (bottom right).

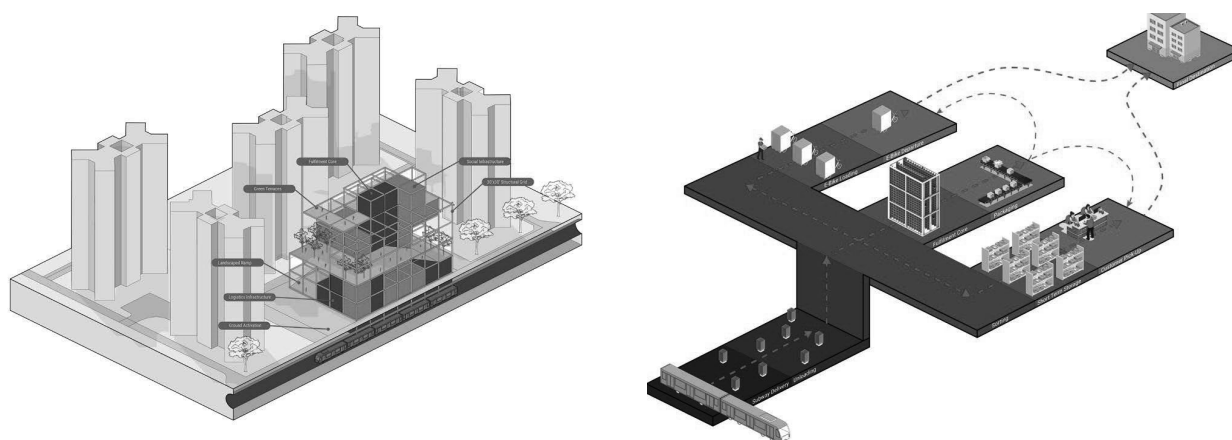


Figure 4. Diagrams of logistics-side infrastructure programming.

economic growth. Our proposed spaces serve as locales for community resilience infrastructure, places where NYCHA residents can work, learn, live, and play. To account for NYCHA resident's present needs and future expectations, a survey was sent to Manhattan community boards 9 and 10 leadership. Responses from the community will be integrated into the design process. Spaces this proposal could potentially accommodate include: Employment and B2B incubation, Upcycling Center⁶⁴ Prioritized Flex Courier Employment, Collective MOOC Hubs, Vocational Centers, Clinic, Daycare Center, and a Library. Furthermore, the modular construction system allows for more convenient growth as e-commerce continues to expand. The proposed intervention does not deny the development of future housing stock. In fact, its modular design welcomes the attachment and growth of housing as the substructure may be over-designed to handle future loads.

3. Operations: Operation will be carried out by a 3rd party logistics (3PL) company which leases the government owned HCDH. The 3PL enters a long-term lease with the landlord, and will agree to distribute 10% of yearly earnings to NYCHA. The rest of the HCDH is to be managed by an institutional-grade property management company.

4. Funding: The proposed intervention sits squarely with the current federal administration's commitment to infrastructure spending. The president's \$2 trillion dollar infrastructure plan titled, The American Jobs Plan, advances two specific ambitions that sit squarely within the framework of this proposal:

1) Creating a national network of small business incubators and innovation hubs: "President Biden is calling on Congress to invest \$31 billion in programs that give to small businesses. The proposal includes funding for community-based small business incubators and innovation hubs to support the growth of entrepreneurship in communities of color and underserved communities."

2) Redressing historic inequities and building the future of transportation infrastructure: "The President's plan for transportation is not just ambitious in scale, it is designed with equity in mind and to set up America for the future. The President's plan includes \$20 billion for a new program that will reconnect neighborhoods cut off by historic investments and ensure new projects increase opportunity, advance racial equity and environmental justice, and promote affordable access."⁶⁵

SECTION V: METRICS AND CALCULATIONS

The capacity calculations below offer a schematic representation of the type of analysis required to generate the architectural design of the hyper-local community distribution hubs (HCDH). Other calculations used to estimate node capacity, carbon reduction potential, and demand were replicated based on the 2010 Urban Rail report for NYSEDA.⁶⁶

Capacity of Transport Pods:

Width: 39 inches
Length: 39 inches
Height: 72 inches
Volume per Pod: 63.37 cubic feet

Capacity of Rail Cars

Pod pers subway car: 24⁶⁷
Pods per train: 144
Volume per Car: 1,521 cubic feet
Volume per Train: 9,126 cubic feet
Volume per Day: 1,031,238 cubic feet⁶⁸

Analysis of Demand

Radius serviced by Polo Ground HCDH:	1.5 miles
Residential Household Serviced:	144,942 ⁶⁹
Avg. Residents per NYC Households:	2.42
Total Resident Serviced:	350,760
Packages Received per Day:	1,500,000
NYC Population:	8,230,290
Packages Received per Resident Per Day:	.182
Est. Amount of Packages Received per Day:	63,927
Average Small Package Volume	1.167 cu. ft.
Vol. of Packages site must Accept Every Day	74,603 cu. ft.

Capacity Requirement for Distributions Hub

Volume Requirement per Day :	37,302 cu. ft. ⁷⁰
Day of short term storage Capacity:	30
30-day Volume Requirement	1,119,046 cu. ft.
e-Bike Volume	144 cu. ft.
Amount of E-bikes:	102
e-Bike Volume:	14,628 cu. ft.
Total Logistic Vol. Requirement	1,133,674 cu. ft.
Adjusted Logistics Vol. Requirement	1,417,092 cu. ft. ⁷¹

Dimensions of Proposed (HCDH):

Bounding Box to meet Vol. Requirement :	112.32' (F,L,W)
Fragmentation into Modules:	~30 feet.
Modules needed to meet Vol. Req.	64
Square Feet per Module:	900 SF
Estimated Logistics SF:	57,600
Adjusted Logistics Space:	69,120 ⁷²



Figure 5. Rendering of architectural proposal manifesting as both logistics hub (top) and community hub (bottom).

Community Modules at Opening:	20 (30' x 30')
Estimated Community Space:	18,000 SF
Total HCDH SF:	87,120 SF

Delivery Truck Capacity:	
Max Volume for 16 foot truck :	900 cu. ft. ⁷³
Max Weight Load Capacity:	4 tons
Adjusted Volume per Truck:	630 cu. ft. ⁷⁴
Item Capacity per Truck	539 packages ⁷⁵

e-Bike Capacity:	
Height:	6 ft.
Length:	6 ft.
Width:	4 ft.
Max Load Capacity:	144 cu. ft.
Adjusted Volume per e-bike:	122.4 cu. ft. ⁷⁶
Packages per e-Bike	105 packages

Analysis of Truck Displacement via Rail and e-Bike delivery:

Trucks needed to meet current demand:	59 Trucks
Train Cars need to meet current demand:	25 Cars
Full Trains need to meet current demand:	4 Trains ⁷⁷
e-Bikes needed to meet demand:	102 ⁷⁸

Analysis of Carbon Mitigation (Polo Grounds):

Distance Freight Traveled by Truck:	60 miles
Weight of Truck (MT55):	11.5 Tons
Ton Miles:	690 Ton-Miles
Grams of CO2 per Ton-Mile:	161.8 grams ⁷⁹
Total CO2 per truck:	0.11 tons
Amount of Delivery Trucks in Transit per Day	59 trucks
Tons of CO2 Removed per Day:	6.61 tons
Tons of CO2 Removed per Year:	2,413 tons

SECTION VI: SPECULATIONS OF ECONOMIC VIABILITY

Economic and Viability of HCDH construction: According to discussions with consulting Structural Engineers (A. Nelson, from STVInc Engineering), there are no advanced or novel construction technologies required for the construction of the proposed HCDH. According to this professional opinion, the NYC construction industry is well equipped to develop a project of this scale. Costs were estimated to be around \$380/SF, making the total hard construction costs approximately \$33,105,600. Additional MTA subway connection and soft costs are estimated to be approximately \$5,000,000, and \$8,276,400, respectively, making the grand total for the proposed Polo Grounds intervention \$46,382,000.

Economic Viability of Hub operations and revenue structure: A preliminary pro-forma statement estimates that the HCDH hub can produce revenue based on rent proceeds from the Logistics Operator. Based on \$55/SF rental income, NYCHA can expect approximately \$4,038,448 in revenue every year.⁸⁰

Economic Viability of 3PL operator Business Plan: A preliminary profit and loss statement estimates that logistic operators at Polo Grounds stand to receive \$2,649,248 a year in net operating income. Based on NYSERDA report calculations it estimates that it can generate \$29,237,433 in net services revenue. Notable operating expenses include \$8,771,230 for MTA License Agreement Fees, \$3,801,6000 in Lease Agreement expenses, \$8,645,000 in wage expenses. Estimated Return on Equity for logistics operators is approximately 26.5%.⁸¹

Proceeds were based on the cost of shipping 180 cubic feet of freight weighing 50 lbs: \$456. Assuming Polo Ground processes 37,302 cubic feet of freight, it could charge \$661,480 per week, or \$34,396,980 per year to distributors. For the Polo Ground 3rd Party Logistics operator to remain competitive and entice distributors it could offer its services for a 15% reduction, or \$29,237,433.

Comparative Analysis of Job Creation Relative to Other Large infrastructure Projects: The Barclay's Development reportedly created 2,000 jobs through it Brooklyn Stadium project which cost \$1B⁸² to construct, making job creation cost approximately \$500,000 per job.⁸³ The Hudson Yard Development group reportedly created 55,752 jobs through its Manhattan mixed-used project which cost \$25B to construct, making job creation cost approximately \$448,414 per job.⁸⁴ This proposed project can generate jobs much more efficiently as it can create an estimated 180 high paying jobs with an estimated \$46M infrastructure investment, making job creation cost approximately \$257,678 per job.

SECTION VII: BENEFITS TO STAKEHOLDERS

Response to Problem Statement I:

- Reduced Pollution: Approximately 2,413 tons of CO2 can be removed from the Harlem every year by each proposed site operating at 50% capacity.
- Reduced Congestion: An estimated 59 delivery trucks can be removed off the road every day, alleviating congestion into Harlem.
- Improved water capture capacity for Harlem: Cistern and permeable areas help combat combined sewage overflow.
- Improved bike infrastructure for Harlem in the form of off-loading pads and improved lanes

Response to Problem Statement II:

- Reduced delivery cost by approximately 15%, or \$5,159,547 per year.
- Improved business reliability, redundancy, and speed.

Additional Economic Stimulus to the Local Community:

- Approximately 180 jobs, averaging a salary of \$59,989 can be created per Harlem site.
- Local workforce development and the reduction of employee's home–work commuting distances.

Revenue for NYCHA:

- Approximately \$4,038,448 in yearly lease agreement revenue, or \$40,384,480 in the next 10-years.
- Approximately \$294,361 in yearly 3PL profit distributions, or \$2,943,610 in the next 10-years.
- Total of approximately \$4,332,809 per year or \$43,338,090 in the next 10-years.

New Amenities for NYCHA:

- Employment and B2B incubation spaces, upcycling center, prioritized flex courier employment, collective MOOC hubs⁸⁵, vocational centers, clinic, daycare center, library, ground-floor retail, and biophilic environments.

Revenue for MTA:

- Approximately \$8,771,230 in yearly licensing fees, or \$87,712,300 in the next 10-years.

Revenue for Local 3PL:

- Approximately \$2,649,248 in yearly net operating income, or \$26,492,480 in the next 10-years.

SECTION VIII: CONCLUSION

Despite extensive research regarding the Last Mile, few site-specific proposals have been investigated in the context of New York City. This paper presents an original minimally viable proposition (MVP) that advances both a new architectural typology and a speculative network for urban freight distributions in Harlem and beyond. Based on the review of existing logistics literature, the architectural and spatial prototype(s) presented, and their economic implications, this paper suggests that the establishment of a multi-sided-platform (MSP) that supports public community alliances with the logistics sector can help NYC: (1) catalyze economic development, (2) foster sustainability, and (3) improve quality of life. Furthermore, the paper suggests that the proposed network can provide significant local economic development opportunities for both Harlem and NYCHA residents in the form of: new revenue streams, improved public amenities, and employment.

Admittedly, this proposal is composed of provisional assumption sets and elementary methodology. Further study of the economic viability, capacity, and policy implications associated with this proposal are very well justified. Still, the results of this present work are non-trivial. This proposal is a template from which to further study and develop: MSP models, urban rail networks, and disaggregated distribution typologies for NYC. This paper offers a forward-thinking vision of NYC that hopes to engage

future discussions on how architecture can help build a greener, healthier, and more prosperous city.

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