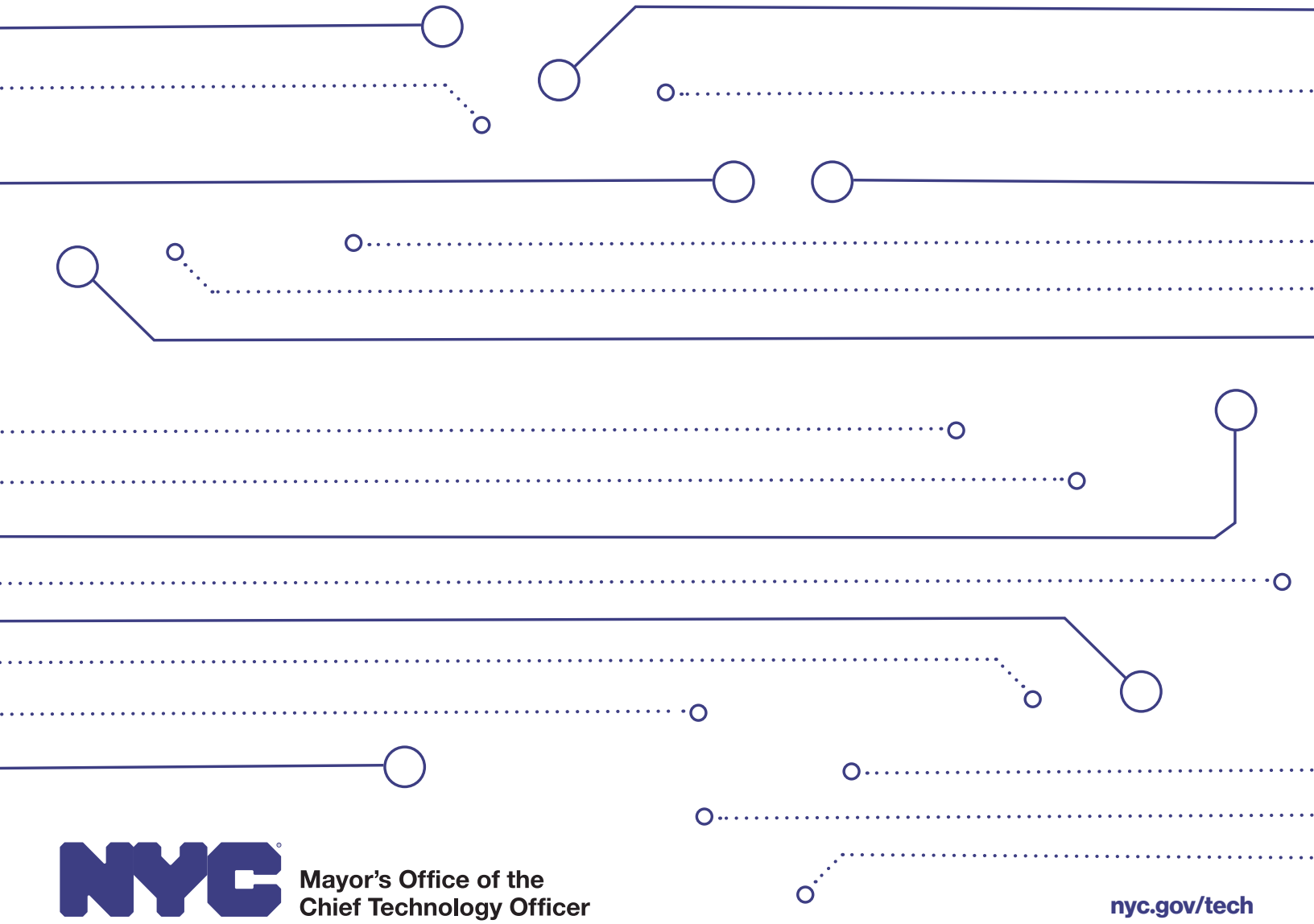
THE NEW YORK CITY INTERNET MASTER PLAN



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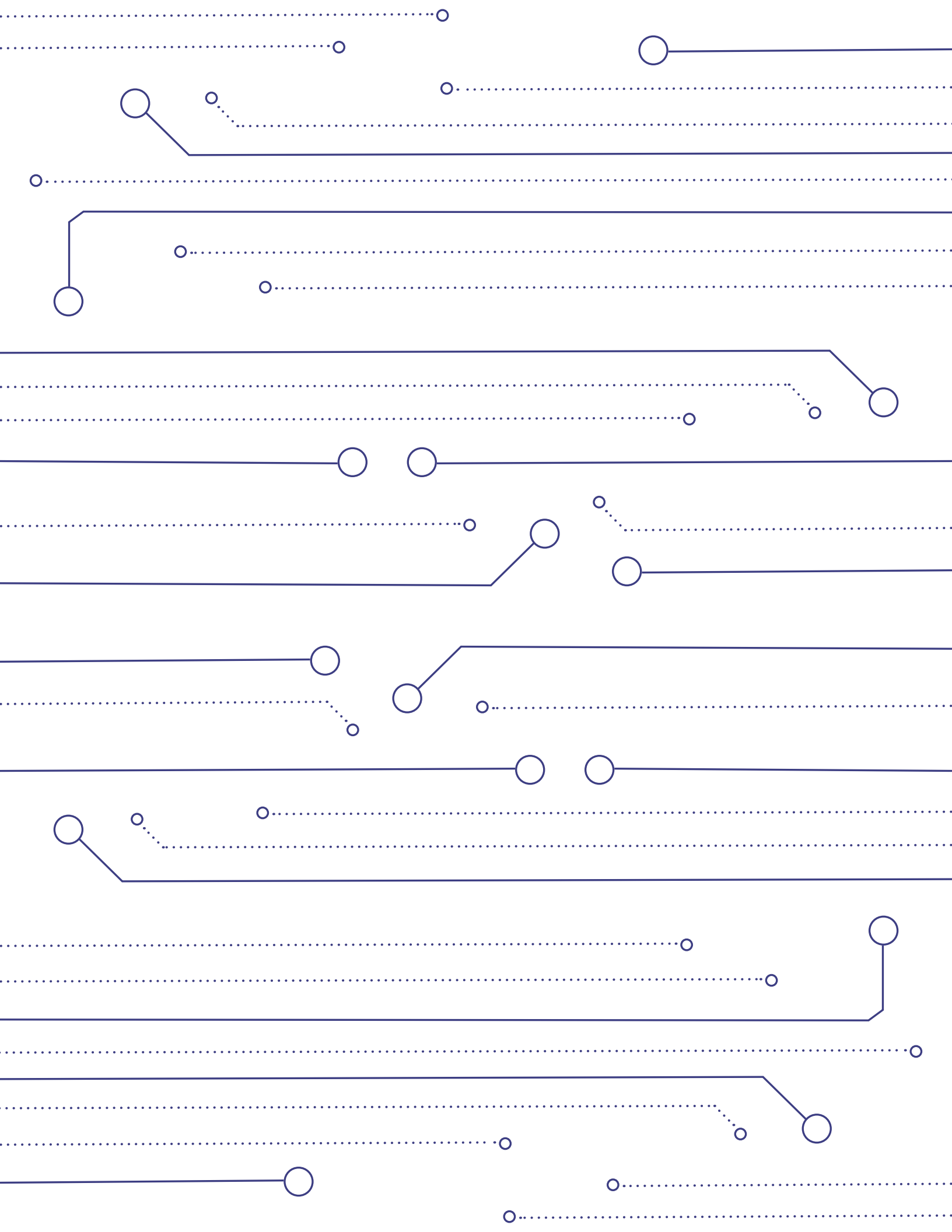

A Message From Our Mayor

Every New Yorker deserves access to affordable, high-speed internet.

However, the private market solution to broadband service continues to leave out too many New Yorkers. While a majority of New Yorkers do have access to broadband, more than 1.5 million residents still have neither a connection at home nor on a mobile device. Millions more have limited broadband service because they cannot afford the basic necessity of online access to education, employment, banking, healthcare, and government services. The quality of service is inconsistent from neighborhood to neighborhood, and the lack of choice impedes economic opportunity in many parts of our city.

This digital divide, like so many other aspects of life in New York City, leaves a significant part of our population at a major disadvantage. The New York City Internet Master Plan lays out a new vision for the City's role in shaping this essential infrastructure, one that is oriented toward making broadband a truly universal service for all our citizens.

This plan will build on work our Administration has already done in the area of internet equality. In the past five years, we have brought free internet service to over 50,000 households through our Department of Education, New York City Housing Authority, local libraries, and internet service providers.

We have more than tripled the number of free public Wi-Fi hotspots in public spaces. We launched CS4All to bring Computer Science education to every elementary, middle, and high school by 2025, and we provide the most robust citywide digital literacy education program of any city in the country through a network of over 500 public computer centers. We have been a leader for online privacy and cybersecurity through initiatives like Library Privacy Week and NYC Secure.

This new Master Plan will redouble our efforts to extend broadband internet service to all New Yorkers, regardless of income or zip code. We will work with the private sector to make sure it is available across the five boroughs, close the digital divide, and make sure all New Yorkers have equal access to the economic, social, and civic power of the internet.

Thank you,

Bill de Blasio, Mayor of the City of New York

Acknowledgments

The Mayor's Office of the Chief Technology Officer prepared the New York City Internet Master Plan with support from the Department of Information Technology and Telecommunications, the NYC Economic Development Corporation, and the members of the Broadband City Asset Task Force. The report draws on research and analysis conducted by a master planning team led by HR&A Advisors, with CTC Energy and Technology, Hunter Roberts Construction Group, Stantec, Baller & Lide, and The New School Digital Equity Lab. The City would also like to acknowledge the diverse range of stakeholders who shared their expertise and perspectives.

NOTE

The Internet Master Plan is subject to applicable laws, rules, and regulations, including City procurement rules and processes. The City reserves all rights, including rights to postpone, cancel, or amend this Master Plan at any time. The City shall not be liable for any costs incurred in connection with the Master Plan.

JANUARY 2020

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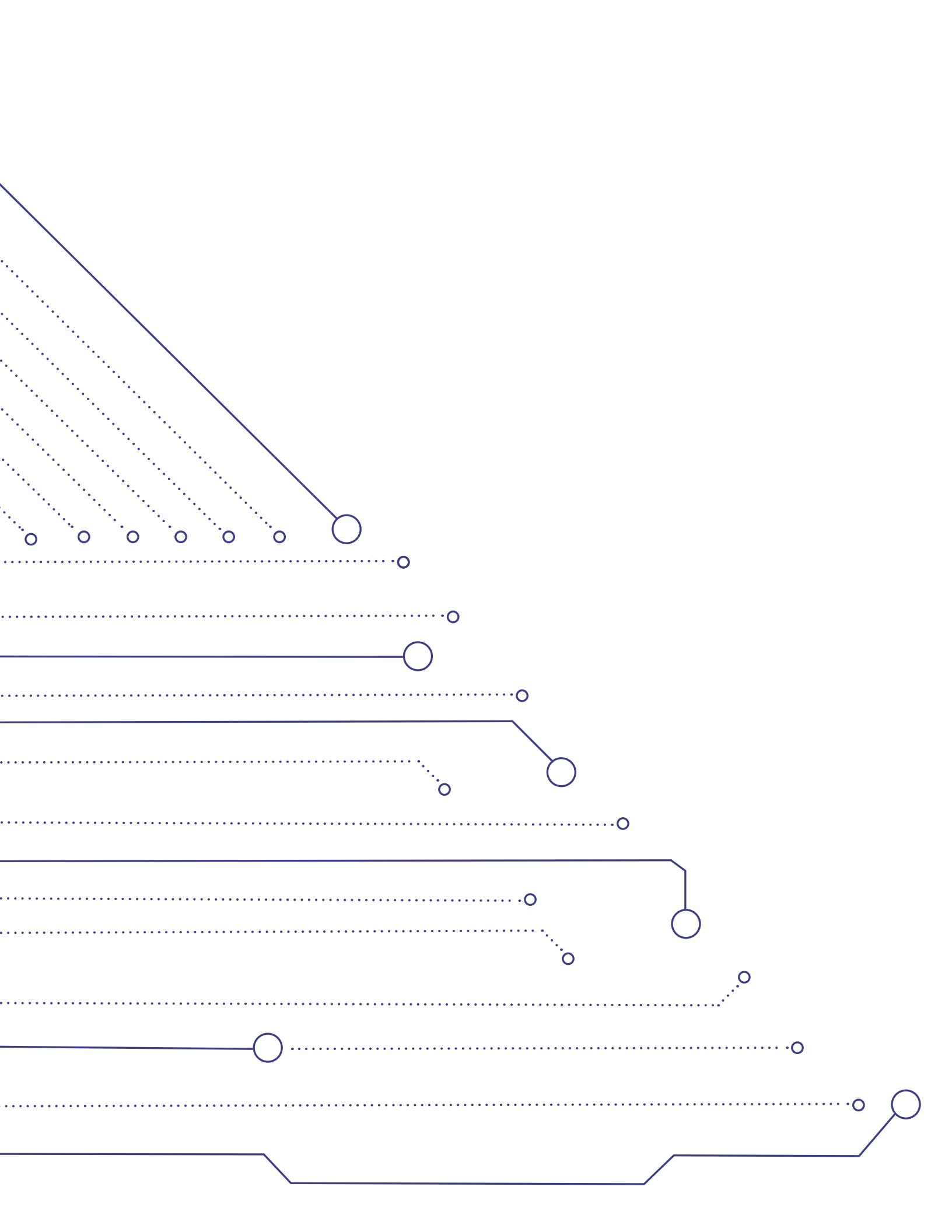


Executive Summary

The internet is essential. As daily life in our city increasingly requires broadband connectivity, every New Yorker must be able to access and use the internet to its full potential.

New York City thrives on the flow and exchange of information throughout its five boroughs. However, internet service options vary throughout the city, both in terms of quality and pricing. This inequity reflects underlying disparities in infrastructure and market competition, impeding full economic and social inclusion.

People and businesses too often encounter an unaffordable cost of service, which is the biggest barrier to internet adoption in New York City. Achieving universal broadband will require lower-cost options for home and mobile service as well as no-cost access at computer centers, in public spaces, and through wireless corridors. No New Yorker should have to choose between a mobile phone bill and a monthly food bill.

The Internet Master Plan is a bold, far-reaching vision for broadband infrastructure and service in New York City. It frames the challenges of achieving universal connectivity, clearly states the City's goals for the next generation of internet service, and outlines the actions the City will take to help all service providers contribute to those goals. It is both comprehensive in its view of the city and tailored to each neighborhood's unique conditions. The Master Plan presents public and private actors with the opportunity to address major, persistent gaps in infrastructure; deliver higher-performing connectivity for residents and businesses; and set a course for eliminating the digital divide in New York City.

VISION AND PRINCIPLES

The City of New York envisions an internet for all New Yorkers that is founded upon five principles – equity, performance, affordability, privacy, and choice. These principles will serve as measures for success and as design parameters for the City's approach to broadband infrastructure and services. The five principles are:

Equity — No one will face a barrier based on who they are or where they live.

Performance — The internet should be fast and reliable, and the quality should improve over time as uses of the internet continue to evolve.

Affordability — Cost should not be a barrier for any New Yorker who wants to connect to the internet.

Privacy — New Yorkers must be able to determine how their data is or is not used.

Choice — There should be sufficient competition among providers and diversity of technological solutions to sustain the other principles.

The Challenge

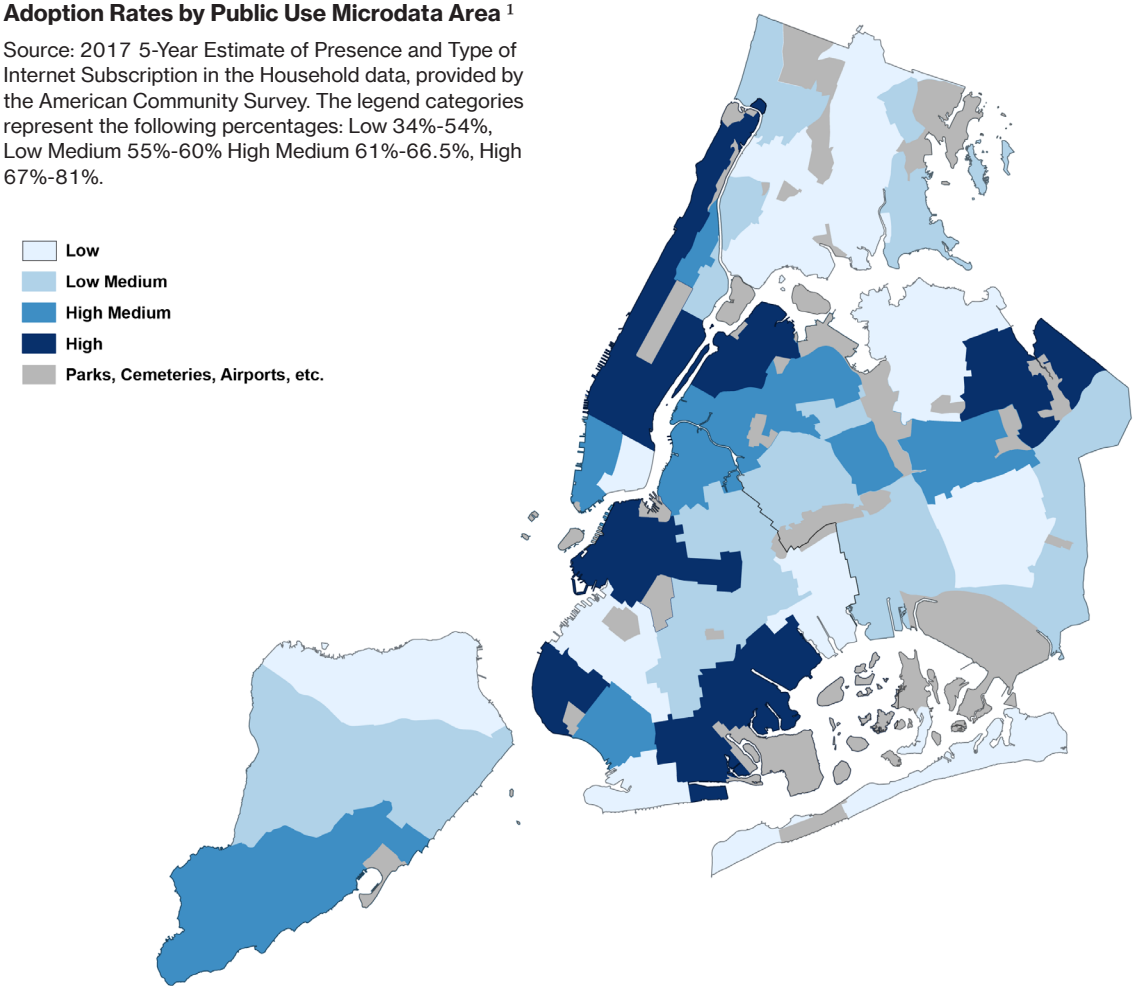
Today, there is a large digital divide in New York City.

The majority of New Yorkers use a mobile connection and a home connection, and they increasingly need both to make full use of the internet. Mobile connectivity is especially critical for people who commute to service jobs or for those with unstable housing, while a connection at home is essential for doing homework or applying for a job. However, 40% of New York City households do not have this level of comprehensive connectivity, which means that 3.4 million residents are excluded, entirely or in part, from digital life.

40% of New York City households lack the combination of home and mobile broadband, including 18% of residents – more than 1.5 million people – who lack both.

Map 1: Combined Home and Mobile Broadband Adoption Rates by Public Use Microdata Area [1]

Source: 2017 5-Year Estimate of Presence and Type of Internet Subscription in the Household data, provided by the American Community Survey. The legend categories represent the following percentages: Low 34%-54%, Low Medium 55%-60% High Medium 61%-66.5%, High 67%-81%.



DISPARITIES IN SERVICE

The private market has failed to deliver the internet in a way that works for all New Yorkers. Citywide, 29% of households do not have a broadband subscription at home. The same percentage of households are without a mobile broadband connection. The substantial overlap between these under-connected populations means that 18% of residents – more than 1.5 million New Yorkers – have neither a mobile connection nor a home broadband connection. This significant portion of the city's residents face barriers to education, employment, banking, healthcare, social networks, and government services in ways that other residents do not.

The millions of underconnected New Yorkers tend to have lower household incomes compared to more digitally-connected households. 46% of New York City households living in poverty do not have broadband at home. A map of internet service rates in New York City bears a striking resemblance to a map of poverty rates.

Internet use is foundational to economic mobility, but current broadband subscription costs can impose a considerable burden on the budgets of low-income families. New York City households living in poverty might need to spend as much as 10% of their monthly budget to have a home broadband connection and a single mobile connection.[2] These expenses further strain households already struggling to pay rent, access healthcare, and buy food.

Today in New York City, competitive residential broadband markets exist almost exclusively in high-density neighborhoods with high-income households. Areas with three or more residential broadband providers have an average household income 50% greater than households in areas with only two providers. A choice among several service providers can lead to greater affordability and improved service, as companies differentiate their products and compete for customers.

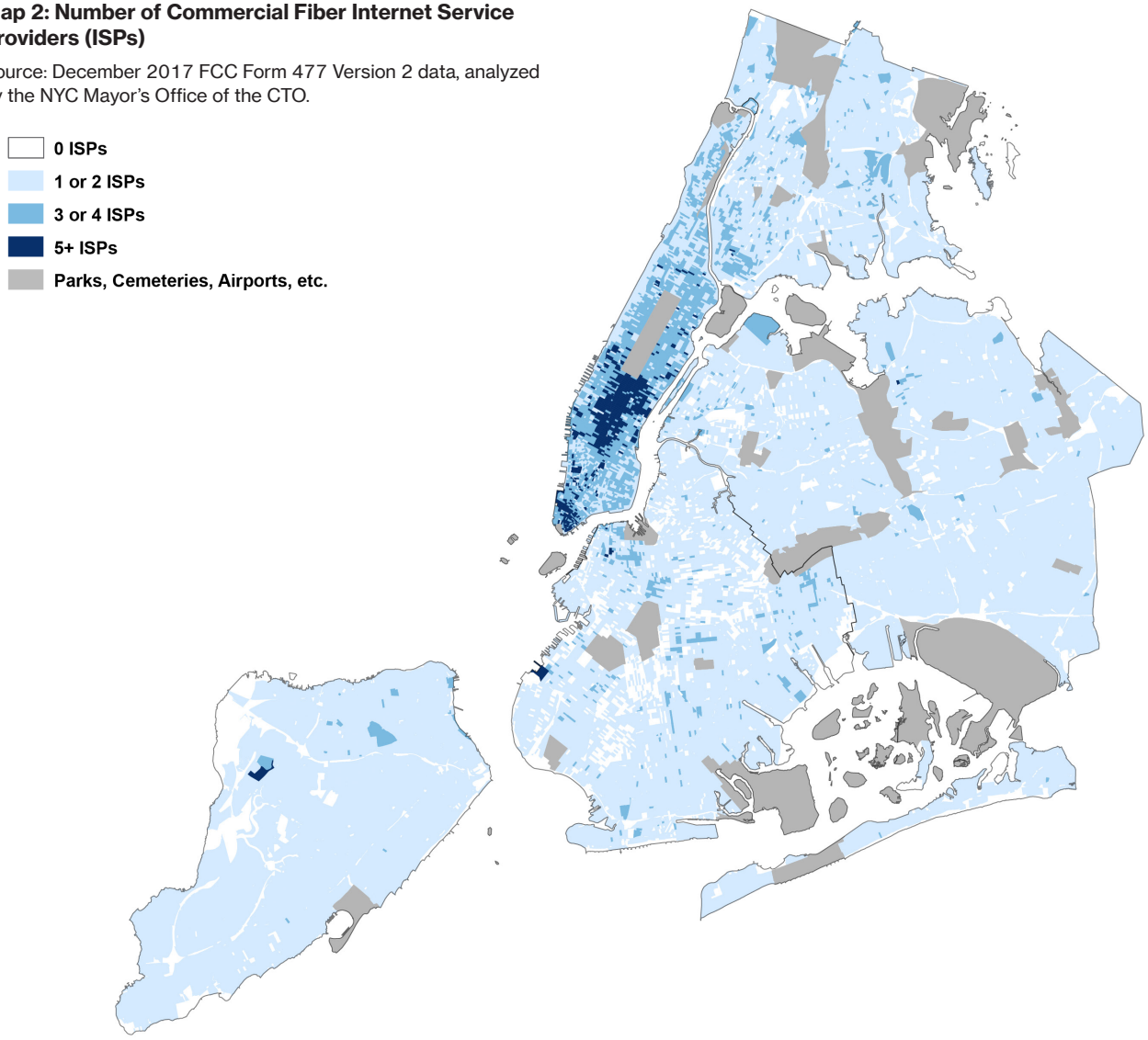
GAPS IN INFRASTRUCTURE

New York City suffers from disparities in the presence of fiber optic infrastructure, which is the basic building block of internet connectivity and a critical driver of economic development. Lower Manhattan has more options for commercial broadband service than perhaps anywhere else in the country. However, fiber optic infrastructure is relatively sparse throughout the rest of the city. The most sizable gaps are in areas of Brooklyn and Queens where a lack of accessible conduit or utility poles limits opportunities for new services.

New Yorkers who live in these neighborhoods have fewer service options, which may be of lower quality. Gaps in fiber optic infrastructure can limit the types of businesses that take root in a neighborhood or the potential for small businesses already there to grow and adopt new technologies. Residents in these neighborhoods are less likely to experience the benefits of future technologies that rely on this infrastructure. Over time, without broadband as a foundational resource, neighborhood economies risk losing ground in the face of regional, national, and international competition. The digital divide in New York City is a serious barrier to economic opportunity for residents and small businesses and a threat to long-term economic growth.

Map 2: Number of Commercial Fiber Internet Service Providers (ISPs)

Source: December 2017 FCC Form 477 Version 2 data, analyzed by the NYC Mayor's Office of the CTO.



Students at P.S.188, The Island School in 2015
Source: Michael Appleton/NYC Mayoral Photography Office

The Plan

The City of New York will take advantage of a once-in-a-generation opportunity to dramatically reshape its role in enabling affordable, reliable broadband service for all. In addition to the urgent need to address disparities in infrastructure and service, the City is entering what may be the most pivotal period for its communications infrastructure since the dawn of the internet. The franchise agreements that establish the basic framework for broadband deployment in New York City are approaching key milestones. Simultaneously, emerging wireless technologies are accelerating private-sector demand for public assets while also lowering the barriers for new providers to enter the markets for both home and mobile broadband service.

NETWORK EXPANSION

Universal broadband throughout the five boroughs will require a network of multiple operators using a range of technologies. This network will support multi-modal use of the internet: constant, seamless mobile service with robust, reliable service at home and at other fixed locations. It will prioritize and optimize "open access" or "neutral host" infrastructure, which can be shared by multiple operators to lower costs, increase competition, minimize physical disruption to the city, and incentivize private-sector investments to reach and serve customers.

Based on the data and analyses contained in this Master Plan, the City has determined that universal broadband calls for an open access fiber optic infrastructure built out to nearly every street intersection with an aggregation point in every neighborhood. Leveraging City real estate assets[3] and public rights-of-way will allow network operators to extend fiber optic infrastructure from the intersection to a pole or building and deliver service using any of a number of potential technologies. This new infrastructure will support the rapid and equitable deployment of multiple choices for service.

The planned infrastructure, were it to be built entirely new throughout the whole city and rely on the open access conduit system in Manhattan and in the Bronx, is estimated to cost $2.1 billion. The Master Plan prioritizes

infrastructure development for neighborhoods that have low levels of commercial fiber service and where new construction opens the way for new providers and services.

This fiber network will be overlaid with a neutral radio access network capable of providing mobile wireless service throughout every neighborhood. This wireless network will use shared spectrum to support multiple operators. The mobile network will enable efficient deployment of licensed spectrum by commercial operators to provide the most advanced mobile telecommunications services possible. The Master Plan prioritizes mobile wireless infrastructure in low-income areas where New Yorkers are most dependent on mobile service, as well as in areas where commercial broadband deployment is already placing the greatest burden on City assets. Determinations will be made on a neighborhood-by-neighborhood basis and will be adjusted as new information is assessed.

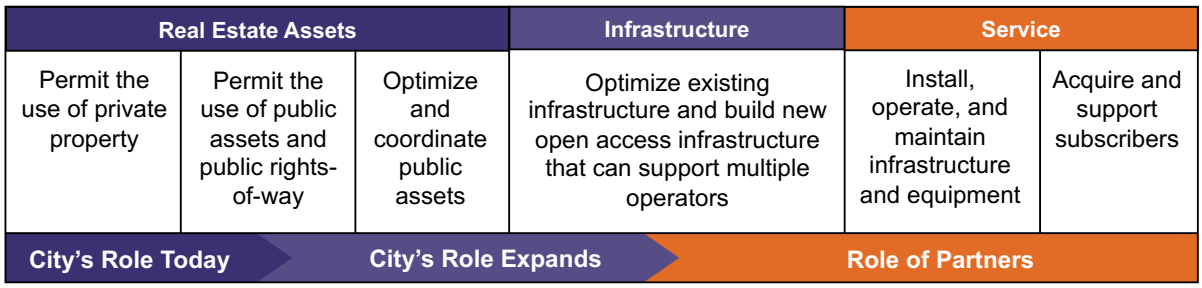
Broadband may be as important to New York City in the 21st century as the subway or electricity was in the 20th century.

A worker installs mobile wireless equipment on a City lightpole
Source: NYC Mayor's Office of the CTO

New York City's digital divide is a barrier to economic opportunity and a threat to long-term economic growth.

- Nearly a third of New York City households do not have a broadband connection at home.
- More than 1.5 million New Yorkers have neither a mobile connection nor a home broadband connection.
- New Yorkers without home or mobile connections have lower household incomes compared to more connected households.
- Neighborhoods with competitive residential broadband markets have higher household incomes than areas without the same level of choice.
- The Bronx has the lowest broadband adoption rates of any borough and the disparities are even more pronounced at the neighborhood level.
- Gaps in fiber optic infrastructure are most stark in areas of Brooklyn and Queens.

Figure 1: An Expanded Role for the City in Broadband Delivery



IMPLEMENTATION

This Internet Master Plan marks the beginning of a new era for the City in the delivery of broadband infrastructure and services. Specifically, the City will:

Coordinate City Processes

The City will build on the interagency contributions to this Master Plan to maintain the consistency and clarity of City policies as broadband deployment increases.

Optimize Public Assets

The City will invite proposals for the coordinated use of public real estate assets through a new Universal Solicitation for Broadband (USB). For the purposes of this Master Plan, "City assets" refers to those assets that are owned, operated, or otherwise controlled by the City, or available for City use. Private operators will be able to respond with requests for assets from multiple City agencies. The City will prioritize approaches that enable multiple operators to share in the use of an asset. The City will review responses to the USB for feasibility of implementation and potential impacts on City resources.

Partner on Infrastructure

The City will invest in new infrastructure that can be shared by multiple broadband operators. In addition to its own seed investments, the City will leverage public-private partnerships to install, operate, and maintain the infrastructure.

Enable Service Delivery

The City will support and promote the use of new, shared infrastructure by broadband operators to reach more areas with more services. New Yorkers will benefit from reliable and affordable broadband options that meet the City's principles.

The Impact

Universal broadband that is in line with the City's principles will produce transformative and widespread economic benefits. Broadband may be as important to New York City in the 21st century as the subway or electricity was in the 20th century. The means by which broadband is delivered will shape the future of neighborhoods, local industries, and the daily lives of millions of New Yorkers.

Broadband has already unlocked new forces in the local economy, from the delivery of internet service, to the development of websites and computer systems, to the growth of tech companies that have become mainstays of the city's employment landscape. The larger tech sector accounts for over 240,000 jobs in New York City, and the growth in tech jobs was three times faster than general private sector jobs from 2010-2016.[4] This technology-driven economic development has occurred so far with barely 60% of residents being fully connected and many neighborhoods facing gaps in service.

The economic and fiscal impacts of realizing this vision will have a transformational impact on New York City's economy, residents' quality of life, and the City's ability to operate more efficiently. Based on an analysis of potential economic impacts of universal broadband, getting all New Yorkers connected and establishing equitable infrastructure citywide could, in the best-case scenario, result in up to 165,000 new jobs, up to a $49 billion increase in personal income, and up to $142 billion in incremental Gross City Product by 2045. These economic impacts cannot be fully realized under the current conditions of the internet in the city.

Benefits will be most dramatic for those who are currently excluded from full participation in the digital economy. A competitive service market that includes options for low-income New Yorkers will provide newly affordable services for 1.2 million households.[5]

Figure 2: Potential Economic Impacts of Universal Broadband

Consumer price reductions and broadband-enabled gains in labor productivity will create a more prosperous city economy. With universal broadband, New York City could gain, in the best-case scenario, up to $142 billion in incremental Gross City Product, up to 165,000 new jobs, and up to a $49 billion increase in personal income.

$142B
increase in Gross City Product, a **9.0% increase** over baseline projections

165K Jobs
newly created, a **2.3% increase** over baseline projections

$49B
increase in personal income, a **4.1% increase** over baseline projections

With universal broadband and a strong digital inclusion strategy, all New Yorkers will experience quality of life improvements. More children will be equipped to succeed in school with online resources. More adults will be able to participate in the media and technology sectors of the local economy. More seniors will be able to access health information and care. All New Yorkers will be more connected to each other in a City where they are protected online.

The City of New York is open to all potential partners that agree with the principles of equity, performance, affordability, privacy, and choice and that want to contribute to the realization of the New York City Internet Master Plan. Ideas, feedback, and suggestions in response to this Master Plan are welcome via email at:

InternetMasterPlan@cto.nyc.gov.

Endnotes

1. These geographic areas that combine multiple neighborhoods are Public Use Microdata Areas (PUMAs), which approximate New York City's Community Districts and are the smallest unit of measure for combining American Community Survey data on home broadband and mobile data subscriptions. Predominantly throughout the Internet Master Plan, the unit of measure is Neighborhood Tabulation Areas (NTAs), which approximate a single neighborhood. For more information on these units see https://www1.nyc.gov/site/planning.
2. Assuming a rate of $50 per month for each service. The U.S. poverty threshold is $24,858 for a family of four (source: U.S. Bureau of the Census). Approximately 50% of New York City households in poverty have a home broadband subscription. The median household income for households in poverty with broadband is $10,415, for which a $100 monthly expense for broadband would be 10%.
3. City assets may include those that the are owned, leased, or otherwise controlled by the City, or available for City use.
4. Office of the State Deputy Comptroller for the City of New York, "The Technology Sector in New York City," Office of the New York State Comptroller (2017) at https://www.osc.state.ny.us/osdc/rpt4-2018.pdf.
5. Affordability assumptions based on the number of households that could newly subscribe to broadband service based on household income levels. Analysis compares economic impact study assumptions of new service pricing to 2016 American Community Survey data. Analysis assumes that universal broadband includes a more competitive service market and low-cost options for low-income New Yorkers.

Figure 3: The Impact of Universal Broadband

Universal broadband that embodies the City's principles will drive significant economic growth benefiting all New Yorkers. The economic and fiscal benefits will result from three expansive transformations: closing the digital divide, catalyzing economic expansion, and improving public service delivery.

Close the Digital Divide

- **Create ubiquitous access** to high-speed internet for all New Yorkers
- **Lower consumer prices for internet services** and increase disposable incomes among low-income New Yorkers

Catalyze Economic Expansion

- **Improve matches between employers and workers** via new opportunities for skills development
- **Make regional firms more competitive** via enhanced labor and capital efficiency

Improve Public Services

- **Improve delivery of services** online and offline through personalization and more efficient reinvestment of cost savings
- **Expand the local tax base** through increased economic activity

Mayor Bill de Blasio delivers free, connected tablets to families in the Bronx
Source: U.S. Department of Housing and Urban Development

01

INTRODUCTION

THIS SECTION INTRODUCES THE INTERNET MASTER PLAN AND THE VISION, PRINCIPLES, AND PROCESS THAT SHAPED IT.

What Is The Internet Master Plan for New York City?

The New York City Internet Master Plan is a comprehensive framework for the infrastructure and services that provide connectivity to New York City residents and businesses. This Master Plan will guide City actions and public-private partnerships to transform New Yorkers' access to this essential infrastructure for generations to come.

It is the first such master plan by any big city in America. It is also just the beginning in an anticipated decades-long focus on a more equitable and economically productive internet to benefit all New Yorkers.

The Master Plan is presented in four sections founded on distinct areas of study:

- The Economic Impact of Universal Broadband

  This section presents the number of jobs, increase in personal income, and economic growth in the overall economy that the City expects from universal broadband.

- New York City's Internet Today

  This section presents the current rates of broadband adoption and conditions of broadband infrastructure in New York City.

- The Network for Universal Broadband

  This section describes the public assets, infrastructure, and range of technologies that will deliver universal broadband in New York City.

- The Phases of Implementation

  This section establishes the overall strategy and priority actions that the City will take to implement the Internet Master Plan through a new approach to City assets and a new Universal Solicitation for Broadband.

This Master Plan addresses the varied conditions in existing infrastructure across New York City. It includes data on these conditions that inform proposed solutions that are specific to the neighborhood level or, in some cases, to the census block level. A Master Plan is not a precise prescription, but a long-term path toward a desired outcome to steer future public and private investments in infrastructure.

This Master Plan uses certain dollar amounts and timeframes to inform calculations and to present options, but it does not prescribe what New Yorkers should be paying for internet service, what the City will invest, or which company will deliver that service. It does not specify a timeframe for achieving universal broadband – not least because the private sector will play an important role. The Master Plan aligns the City and potential partners from private industry on mutual goals to shape the way broadband networks develop in the decades to come.

The Vision of Universal Broadband

The City of New York first outlined a vision for universal broadband access in *One New York: The Plan for a Strong and Just City* (*OneNYC*), released in April 2015. OneNYC set a goal for universal connectivity.[1] Acknowledging that access to high-speed internet is not a luxury, but an essential service that New Yorkers depend on to communicate, make a living, and access essential goods and services, OneNYC included five initiatives to achieve ubiquitous connectivity:

- Promote competition in the residential and commercial broadband markets.
- Provide high-speed, residential internet service for low-income communities without internet service.
- Increase investment in broadband corridors to reach high-growth business districts, with a focus on emerging outer borough hubs.
- Upgrade and expand public broadband to create high-speed citywide access.
- Invest in innovative ways to provide high-speed internet to homes, businesses, and the public.

The City renewed this commitment in *OneNYC 2050: Building a Strong and Fair City*, released in April 2019, which emphasized the City's pledge to improve digital infrastructure to meet the needs of the 21st Century.[2]

Broadband Principles

The City has established five principles to guide City actions and partnerships with private internet service providers and related companies: **equity**, **performance**, **affordability**, **privacy**, and **choice**. As shown in the chart below, the City has previously applied these principles to internet service broadly, but they are equally applicable as a guide for broadband infrastructure development in particular. These principles serve as both an evaluative tool and an aspiration for the infrastructure, service, and governance initiatives of the Master Plan. They are intended to structure the next era of City broadband policy.

How New Yorkers Shaped This Master Plan

The strategies in this plan have been shaped by the voices, writings, research, and analysis of a diverse range of stakeholders. Numerous City agencies; internet service providers; companies that build the infrastructure and equipment for broadband service; advocates for worker rights, consumer rights, and digital inclusion; and a wide array of other subject matter experts have provided input for this Internet Master Plan.

Broadband City Assets Task Force

As New York City enters an era of exponential increase in private sector demand for the use of public rights-of-way and City property for broadband infrastructure and equipment, it is more important than ever that the City maintain a coordinated and standardized approach to managing its City assets and related procedures. For the purposes of this Master Plan, "City assets" refers to those assets that are owned, leased, or otherwise controlled by the City, or available for City use.

In August 2018, the City established the Broadband City Assets Task Force (BCATF), an internal team to coordinate the use of City assets for broadband infrastructure deployment. The BCATF is comprised of representatives from seventeen City agencies that collectively control approximately 11,000 City facilities and other potential broadband-related infrastructure assets across the city.[3]

NYC Connected Request for Information

In 2017, the City issued a Request for Information (RFI), in concert with the development of this Internet Master Plan, to solicit ideas for potential strategies and partnerships to achieve universal broadband connectivity in New York City.[4] The NYC Connected RFI garnered over fifty responses, representing a wide range of stakeholders from the private and non-profit sectors, as well as a wide array of other subject matter experts. Among other information, the responses provided information on potential network architecture and emerging technologies, use of City assets, approaches to network construction, business parameters, and collaboration opportunities.

Over a dozen internet service providers operating in the city responded to the RFI, including both large service providers active in most neighborhoods across the city and niche or startup providers who wish to expand their service in New York.

Figure 4: NYC Principles for Internet Service and Infrastructure

PRINCIPLE	WHAT THE PRINCIPLE MEANS FOR:	
	Internet Service	Internet Infrastructure
Equity	No one will face a barrier based on who they are or where they live.	The infrastructure has capabilities throughout the city, able to reach all residents and businesses everywhere, outdoors and indoors.
Performance	The internet should be fast and reliable, and the quality should improve over time as uses of the internet continue to evolve.	The infrastructure supports both fixed and mobile service. It is capable of at least gigabit-per-second service to all fixed locations, with substantial additional capacity for future demand and supporting rapid deployment of new technologies. The infrastructure is reliable and resilient, designed to withstand equipment failures, power outages, natural disasters, or manmade disasters.
Affordability	Cost should not be a barrier for any New Yorker who wants to connect to the internet.	The design minimizes capital and operating costs, has a long useful lifespan, and provides low-cost upgrade paths to meet future demands or accommodate new technologies.
Privacy	New Yorkers must be able to determine how their data is or is not used.	The infrastructure reaches residences and other safe locations. The network's components are secure against physical and cyber threats. The infrastructure supports private physical and virtual networks that ensure data integrity and the privacy of user data.
Choice	There should be sufficient competition among providers and diversity of technological solutions to sustain the other principles.	The infrastructure is designed to be shared by multiple service providers, and competition is never curtailed due to network capacity, physical space in network hub locations, or technology choices.

Digital Access, Digital Literacy, and Development Research

In 2018, the City conducted interviews and focus groups with individuals from twenty-eight organizations and City agencies that provide digital inclusion services and related trainings. In addition to highlighting how essential those services and trainings are for achieving universal broadband, this research explored the contours of residents' practices, concerns, and barriers when using the internet, focused on those who are not served well by the broadband market today. This perspective has critically informed this Master Plan in its focus on neighborhood-scale intervention with a combination of mobile and fixed broadband service.

A Pivotal Moment for Broadband in New York City

The next generation of wireless technology is the first to arrive in the mobile-first era. The deployment of such technologies will define a whole range of urban applications that rely on connectivity, from sensor data usage to virtual reality, and will shape how New Yorkers move through the city, connect to each other, and interact with local government.

This is a potential turning point in the history of internet infrastructure and governance. Without meaningful and focused governmental action, private investment alone will determine how these technologies shape connectivity in the city. Allowing industry to dictate connectivity will reinforce the current distribution of access and undermine the equitable allocation of new services.

The Internet Master Plan establishes a decision-making framework for the City of New York to guide a major digital transformation, harnessing connectivity to advance economic, social, and infrastructure development. The City will play a more active role in ensuring that all New Yorkers share in the benefits of internet connectivity.

Endnotes

1. The City of New York, "One New York: The Plan for a Strong and Just City," (April 2015) at http://www.nyc.gov/ html/onenyc/downloads/ pdf/publications/OneNYC.pdf.
2. The City of New York, "OneNYC 2050: Building a Strong and Fair City: Modern Infrastructure," (April 2019) at http://onenyc.cityofnewyork.us/strategies/modern-infrastructure/.
3. Information on City facilities can be found in the Facilities Database maintained by the New York City Department of City Planning, available at https://www1.nyc.gov/site/planning/data-maps/open-data/dwn-selfac.page.
4. New York City Mayor's Office of the Chief Technology Officer, "NYC Connected Request for Information," (November 14, 2017) at https://tech.cityofnewyork.us/wp-content/ uploads/2018/11/NYC-Connected-RFI.pdf.

Patrons use the Shelby White and Leon Levy Information Commons at the Brooklyn Public Library
Source: Gregg Richards/Brooklyn Public Library

02

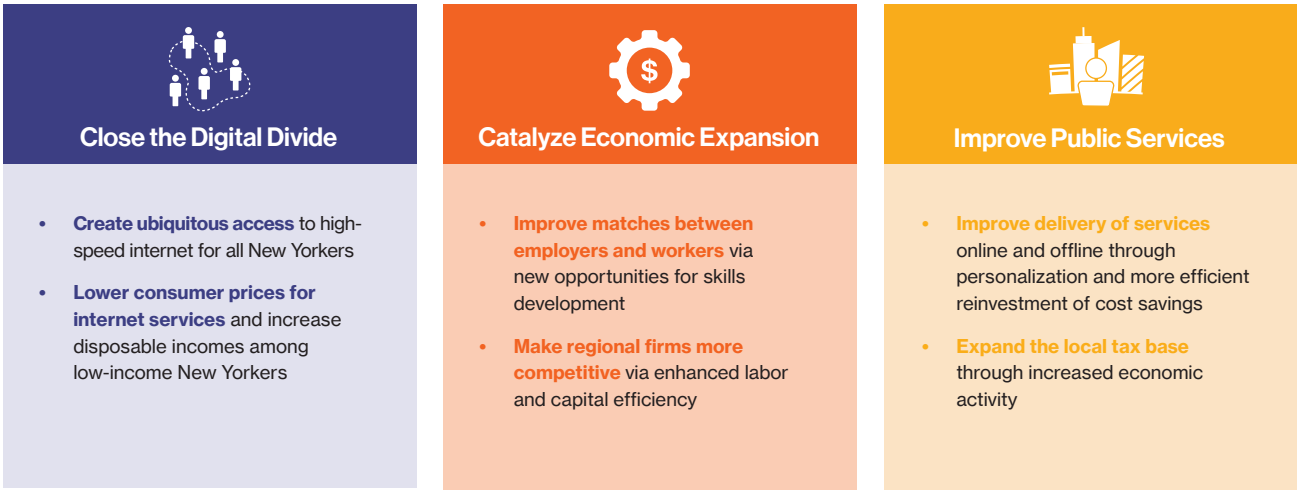
THE ECONOMIC IMPACT OF UNIVERSAL BROADBAND

THIS SECTION PRESENTS THE NUMBER OF JOBS, INCREASE IN PERSONAL INCOME, AND GROWTH IN THE OVERALL ECONOMY THAT THE CITY EXPECTS COULD BE ACHIEVED THROUGH UNIVERSAL BROADBAND.

Introduction

Universal broadband is essential for economic inclusion and will lead to widespread benefits. The economic and fiscal benefits will result from three broad transformations: closing the digital divide, catalyzing economic expansion, and improving public service delivery. Consumer price reductions and broadband-enabled gains in labor productivity will create a more prosperous New York City. With universal internet access, New York City could gain, in the best-case scenario, up to $142 billion in incremental Gross City Product, up to 165,000 new jobs, and up to a $49 billion increase in personal income. In contrast to current conditions, New Yorkers will have increased disposable income, achieved through reduced consumer prices, and will be positioned to benefit from quality of life improvements stemming from the ability to afford high-quality internet. Universal broadband will result in greater economic efficiencies, enhancing labor productivity, lowering production costs, and accelerating regional competitiveness for local firms. It will facilitate lifelong learning to promote a more agile workforce that is primed for the economy of the future.

Figure 5: Categories of Economic Benefits from Universal Broadband



Ubiquitous connectivity will allow businesses to locate anywhere in the city, not just where there is access to secure fiber connections today, which will increase new commercial development outside the current commercial cores.

Finally, having all New Yorkers online will improve municipal service delivery. The City will have more affordable broadband service for its own needs and greater ability to deliver services to residents online. A future with universal broadband could bring about significant public cost savings, which could then be reinvested to reduce the City's fiscal burden.

The individual and citywide impacts of universal broadband are linked. This economic impact analysis draws on a combination of econometric modeling techniques, qualitative indicators, and narrative case studies to analyze the benefits of comprehensive connectivity for New York City's economy as a whole. It shows the magnitude of possible benefit over time and provides an indication of the breadth of impacts that come from connecting all New Yorkers with affordable, reliable broadband service. The entire city would benefit, but the greatest impacts would be with the people and neighborhoods that today are unserved or only marginally connected to the internet.

The full benefits of universal broadband come by pairing infrastructure and economic improvements – the focus of this Master Plan – with programs that support New Yorkers to acquire the resources and skills to live, learn, and access opportunity in a digital age, particularly among users with limited prior exposure to the internet. This economic impact analysis assumes these programs are sufficiently in place to support the adoption of affordable broadband by all households.

With universal internet access, New York City stands to gain up to $142 billion in incremental Gross City Product, up to 165,000 new jobs, and up to a $49 billion increase in personal income.

Figure 6: Potential Economic Impacts of Universal Broadband

Consumer price reductions and broadband-enabled gains in labor productivity will create a more prosperous city economy. With universal broadband, New York City could gain, in the best-case scenario, up to $142 billion in incremental Gross City Product, up to 165,000 new jobs, and up to a $49 billion increase in personal income.

$142B
increase in Gross City Product, a **9.0% increase** over baseline projections

165K Jobs
newly created, a **2.3% increase** over baseline projections

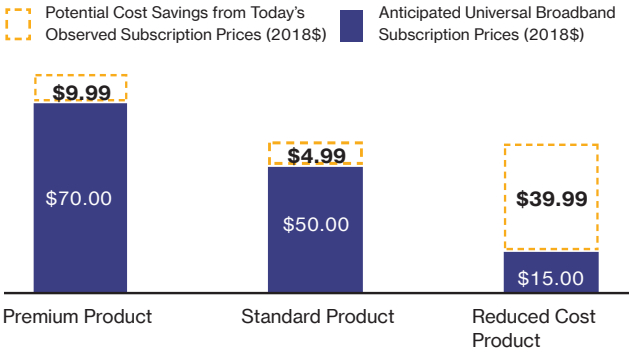
$49B
increase in personal income, a **4.1% increase** over baseline projections

This analysis is almost certainly the first of its kind by any big city in the United States. It relies on extensions of the tangible impacts already attributed to widespread broadband use. This analysis uses the REMI Policy Insight Model (PI+)[1] to dynamically measure the impacts of universal broadband by comparing it to baseline projections for New York City's economy absent universal broadband. Other studies have treated broadband as simply another commodity rather than as a catalyst for transformation and a fundamental need for participation in modern economic, civic, and social activity.

The analysis assumes that all components required for universal broadband are in place. Rather than only measuring the benefits of particular actions in the short-term, the Master Plan assumes that all complementary investments, policies, and programs have been enacted to ensure the optimal outcome over time. Therefore, the estimates of economic impact represent a best-case scenario.

For the purpose of this analysis, the time span for implementation is presumed to occur over more than two decades, with the impacts of universal broadband first fully accruing in the year 2045. The measures described in Section 5 of this Master Plan (The Phases of Implementation) – and the level of response from the private sector – will shape the actual rate of progress towards universal broadband in New York City. This economic benefits analysis is agnostic to the source of capital investment, the ownership model, and the particular technology deployed, as long as the assumed cost savings materialize. It is not tied to any particular set of actions, only the end state of universal broadband service that meets the City's requirements and principles. The analysis does not take into account the costs associated with achieving the desired outcomes.

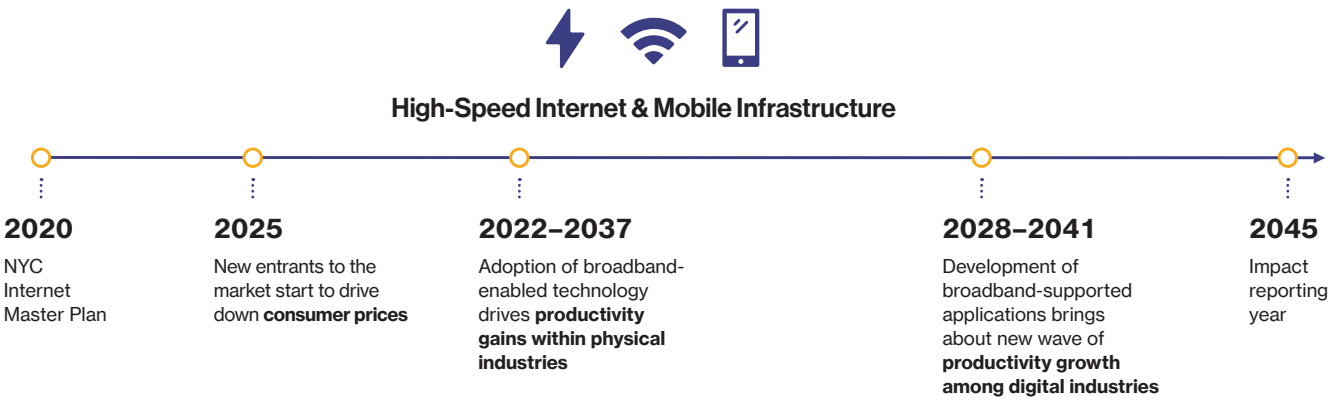
Figure 7: Anticipated Universal Broadband Consumer Internet Prices[2]



Closing the Digital Divide

The universal broadband envisioned by this Master Plan will drive down prices for internet service, bringing more New Yorkers online and saving other households money on their monthly bills. Based on global pricing for gigabit speed connectivity and general observations related to

Figure 8: Assumed Timing of Broadband Network Investments for Economic Impact



the elasticity of internet products (i.e., demand changes as more providers become active in the marketplace), this Master Plan projects that enhanced competition and new affordability thresholds will reduce the costs for three potential tranches of service.[3]

Universal broadband service that fosters a more competitive service market and provides options for low-income New Yorkers will provide newly affordable at-home access for up to 1.2 million households. The savings for a household are projected to range from $4.99 to $39.99 per month.[4] By eliminating the barrier of cost, this plan is projected to meaningfully increase broadband adoption among an many as 650,000 non-subscriber households without affordable service and benefit up to 600,000 existing household subscribers who are paying unaffordable rates.

Catalyzing Economic Expansion

Broadband has become a near-essential service for businesses operating in the 21st century economy. Broadband infrastructure is a prerequisite for New York City to compete with other global cities. With broadband as a ubiquitous, foundational resource, New York City can maintain its competitive advantages over other U.S. and international cities.

Broadband service enhances competitiveness of businesses via increased efficiency, and by creating better matches between employers and workers via increased labor force access. For example, high-quality video streaming is positioned to benefit the city's economy through emerging media distribution platforms that can continue to support New York City's status as a global media center. Robust citywide broadband infrastructure allows firms to locate in any neighborhood and contribute to this sector.

The three general ways broadband contributes to growth are through increased business activity, increased labor force access, and increased commercial and residential development.

Increased Business Activity

Based on past trends in technology-enabled booms in labor productivity, universal broadband could grow the local economy by up to $142 billion in Gross City Product, a 9% increase over baseline projections.[5]

Historically, the adoption of technological innovations has allowed workers to do their jobs faster and more effectively, driving increased labor productivity. Going forward, capital investments in new broadband-enabled technologies are similarly expected to drive efficiency gains, as they did during the dot-com technology boom period from 1995-2004, lowering the costs of production and attracting new businesses.

Open manhole with fiber optic splice cases
Source: NYC Mayor's Office of the CTO

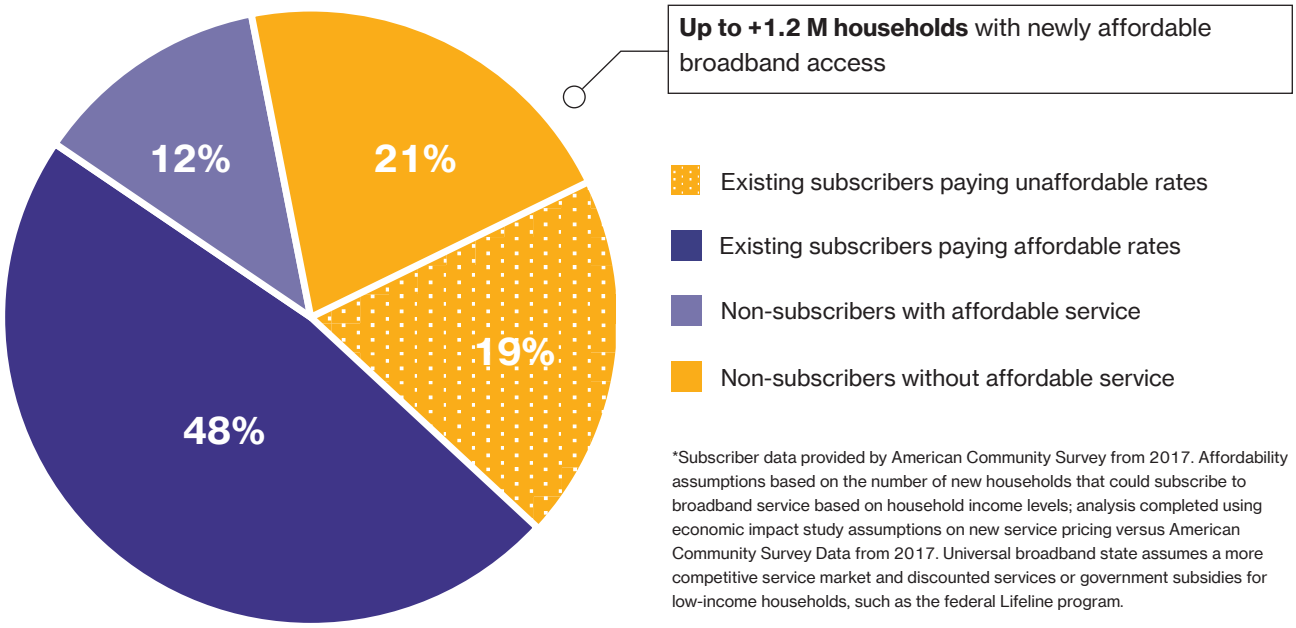
Universal broadband will bring more New Yorkers online and save others money on their monthly bills. Savings may be felt most strongly by current subscribers who are paying unaffordable rates today.

Increased Labor Force Access

Universal broadband could create up to 165,000 new jobs across all sectors, with better matches between employers and workers. This sum represents a 2.3% increase over the baseline.

About half of all incremental growth in labor productivity can be attributed to investment in the adoption of new technologies. Already, the local talent pipeline is challenged to keep pace with the needs of a modern labor market. In New York City, there is a significant gap between the average annual number of openings for middle-skilled jobs with living-wages and the number of graduates from relevant local degree-granting programs, which suggests opportunities for new forms of training and education to expand matches between local talent and employment opportunities. Between 2008 and 2017, the average annual gap in New York City was 350,000 jobs.[6] Future technology shifts can change how ever-growing demand for skills training and talent development is met.

Figure 9: New Affordable Service with Universal Broadband



*Subscriber data provided by American Community Survey from 2017. Affordability assumptions based on the number of new households that could subscribe to broadband service based on household income levels; analysis completed using economic impact study assumptions on new service pricing versus American Community Survey Data from 2017. Universal broadband state assumes a more competitive service market and discounted services or government subsidies for low-income households, such as the federal Lifeline program.

Increased Commercial and Residential Development

Expanding broadband infrastructure across the city may unlock commercial development potential in underinvested areas outside of the Manhattan core. New infrastructure is estimated to spur up to 45 million square feet of occupied commercial space.[7] This could provide New Yorkers with new opportunities for employment in neighborhoods closer to where they live.[8] Enhanced productivity in physical sectors such as construction may increase the capacity to address critical citywide challenges.[9]

Improving Public Service Delivery

Citywide economic expansion supported by universal broadband will create a larger tax base, generating new revenue streams to support City operations and services.

Universal broadband is positioned to help the City reduce cost as a barrier to municipal Internet of Things deployments, prepare for increasing demand for services, and limit the financial burden from a potential exponential growth in municipal internet needs. "Smart City" technologies can reduce local government expenditures by as much as 5%, based on industry-wide projections.[10] Telehealth – the ability to manage one's health and health care services though digital information and communication – has the potential to reduce emergency room visits by expanding access to regular preventative care and providing remote consultation services. Telehealth can reduce costs to elderly patients and caretakers alike, including those associated with travel, hospitalization, home health aides, and lost wages. These savings will be similar to the significant cost difference in providing New Yorkers with 311 information services through a website or smartphone app compared to a live phone call.

Overall, the potential cost savings for New York City from universal broadband could reach as much as $4.3 billion, driven by anticipated improvements in workflows, the ability to negotiate lower municipal rates for broadband services, and efficiencies in contract service management.[11] This assumes individual expenditures will continue to be evaluated based on the benefits of the specific program.

These economic impacts from closing the digital divide, catalyzing economic expansion and improving public service delivery cannot be fully realized based on the conditions of the internet in the city today. While all New Yorkers will benefit from universal broadband, these impacts will be most dramatic for those who are currently excluded from full participation in the digital economy or who rely most heavily on City services. A detailed assessment of the gaps in access, connectivity, and the underlying infrastructure makes clear which residents and neighborhoods stand to benefit most from closing the digital divide.

Figure 10: Historic Labor Productivity Growth, United States[12]

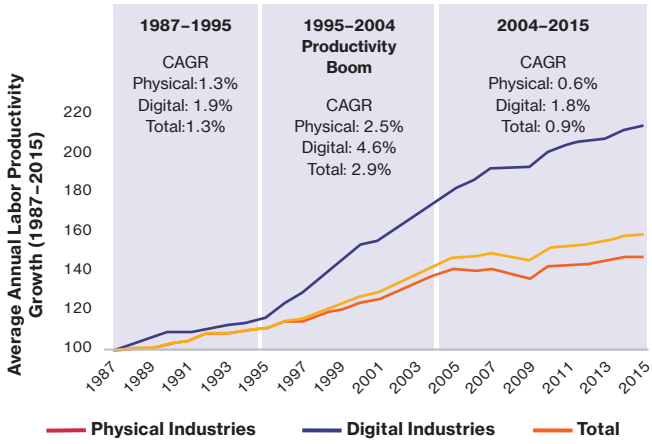
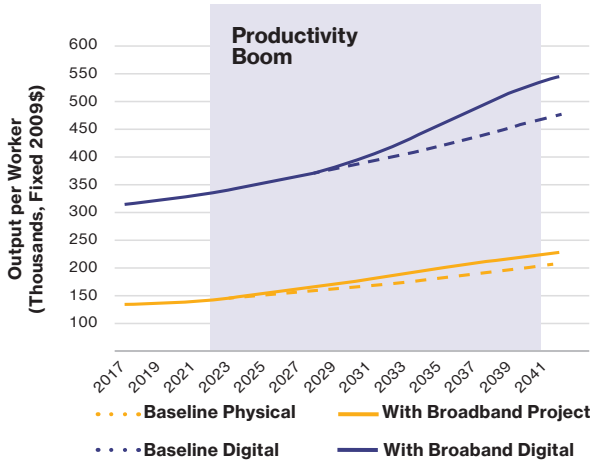


Figure 11: Projected Labor Productivity Growth under the NYC Internet Master Plan[13]



Endnotes

1. This analysis used the REMI Policy Insight Model (PI+) to estimate the impacts of universal broadband on all aspects of the local economy between 2020 and 2045. PI+, developed by Regional Economic Models, Inc. is frequently employed by local governments, economic development and transportation authorities, to measure the impacts of regional economic changes. PI+ is particularly adept at measuring the long-term impacts of infrastructure investments that fundamentally alter underlying economic relationships between economic output, factors of production, prices, and demographic factors.

2. Cost savings are based on 25% blended cost savings rate across speed offerings and affordability thresholds and HR&A analysis of service fees. See "Residential Pricing Information from the Four Largest ISPs Serving New York City" Appendix in NYC Mayor's Office of the Chief Technology Officer, "Truth in Broadband: Access and Connectivity in New York City," (April 2018) at https://tech.cityofnewyork.us/wp-content/uploads/2018/04/NYC-Connected-Broadband-Report-2018.pdf.

3. This analysis assumes that internet service providers will meet this threshold with means-tested reduced-cost products or government will subsidize broadband service for the lowest income New Yorkers who are unable to afford broadband service at market rates, for example with a program along the lines of the federal Lifeline consumer subsidy.

4. For more detailed comparisons, see the price chart in NYC Mayor's Office of the Chief Technology Officer, "Truth in Broadband: Access and Connectivity in New York City," (April 2018) at https://tech.cityofnewyork.us/wp-content/uploads/2018/04/NYC-Connected-Broadband-Report-2018.pdf.

5. Figures based on HR&A analysis of REMI regional forecasts for NYC. For this Internet Master Plan, HR&A collaborated with CTC Technology and Energy, the Digital Equity Laboratory at The New School, Baller Stokes & Lide, Hunter Roberts Construction Group, and Stantec.

6. HR&A analysis of existing skills gap; middle-skill defined as high-school to bachelor's degree; living wage is average hourly wage of $15.21 or higher per the MIT living wage calculator. Center for an Urban Future, "New York Works: Creating Good Jobs, City of New York," (2017). Conservative estimate of future employment trends based on literature review of: World Economic Forum, "The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution," (2016) at http://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf; OECD, "Getting Skills Right: Assessing and Anticipating Changing Skill Needs," (2016) at https://www.oecd.org/education/getting-skills-right-assessing-and-anticipating-changing-skill-needs-9789264252073-en.htm; The Institute for the Future and Dell Corporation, "The Next Era of Human-Machine Partnerships," (2017) at http://www.iftf.org/humanmachinepartnerships/. Estimate applied to American Community Survey 5-Year Estimates, 2012 – 2016, New York City, Age and Sex Tables, 2017 Estimates.

7. This figure is calculated using current industry standards for job density applied against incremental new employment attributable to universal broadband. The analysis assumes broadband will unlock office districts in the outer boroughs, compared to Manhattan which is already developed and significantly more space-constrained. The projected broadband-related increase in general office space is about 3% of the citywide total office stock.

8. HR&A analysis of new commercial development demand supported by broadband-generated job growth (per the findings of this study); assumes a 10-15% commercial vacancy rate in non-core districts.

9. HR&A analysis using American Community Survey, 2016 data, informed by REMI model output for construction industry labor productivity.

10. HR&A analysis; assumes a conservative estimate of 5% efficiencies across all cost categories owing to enhanced performance, efficiency, and management of resources. Literature reviews performed by HR&A indicate that potential cost savings could be in the order of 10 - 40% across certain categories. Literature reviewed includes: Deloitte Center for Government Insights, "Funding and Financing Smart Cities," (2017); McKinsey Global Institute, "AI Frontier Discussion," 2017; ABI Research, "Smart Cities and Cost Savings," 2017.

11. For the purposes of analysis, this plan projects that the amount of investments to improve public service delivery and support future growth are equal to the amount of cost savings.

12. Bureau of Labor Statistics, "KLEMS Combined Sector and NIPA-Level Manufacturing and Non-Manufacturing Multifactor Productivity Tables by Measure," (1987-2017), available at https://www.bls.gov/mfp/mprdload.htm.

13. Projections are outputs of the REMI model. HR&A methodology was informed by a literature review, including: National Bureau of Economic Research (NBER), "Is U.S. Economic Growth Over? Faltering Innovation Confronts the Six Headwinds," (2012); NBER, "Recent Manufacturing Employment Growth: The Exception That Proves the Rule," (2017); The Brookings Institution, "Why is US Productivity and Growth So Slow?," (2016); The Brookings Institution, "Capital, Labor, and Productivity," (1999); NBER, "Challenges to Mismeasurement Explanations for the U.S. Productivity Slowdown," (2016); McKinsey Global Institute, "The Productivity Puzzle: A Closer Look at the United States," (2017).

03

NEW YORK CITY'S INTERNET TODAY

THIS SECTION PRESENTS THE CURRENT RATES OF BROADBAND ADOPTION AND CONDITIONS OF BROADBAND INFRASTRUCTURE IN NEW YORK CITY.

Introduction

The internet is a fundamental part of life in New York City. Yet, today, there is inequity in broadband quality and pricing across the five boroughs of the City.

The internet holds the potential to make the City more connected – across neighborhoods, across language barriers, across racial and ethnic lines, and among all ages and household types. A close analysis of the internet in New York City today, however, shows that it reinforces systemic divisions. The portion of the City that has the internet at home or in their pocket – and especially those who have both – is not representative of the city as a whole.

There is a clear geographic component to the digital divide in New York City. The greatest disparities between New Yorkers that have and don't have broadband service correspond with gaps in broadband infrastructure. Identifying these gaps is necessary to understand the barriers to increasing use of the internet in certain areas of the city.

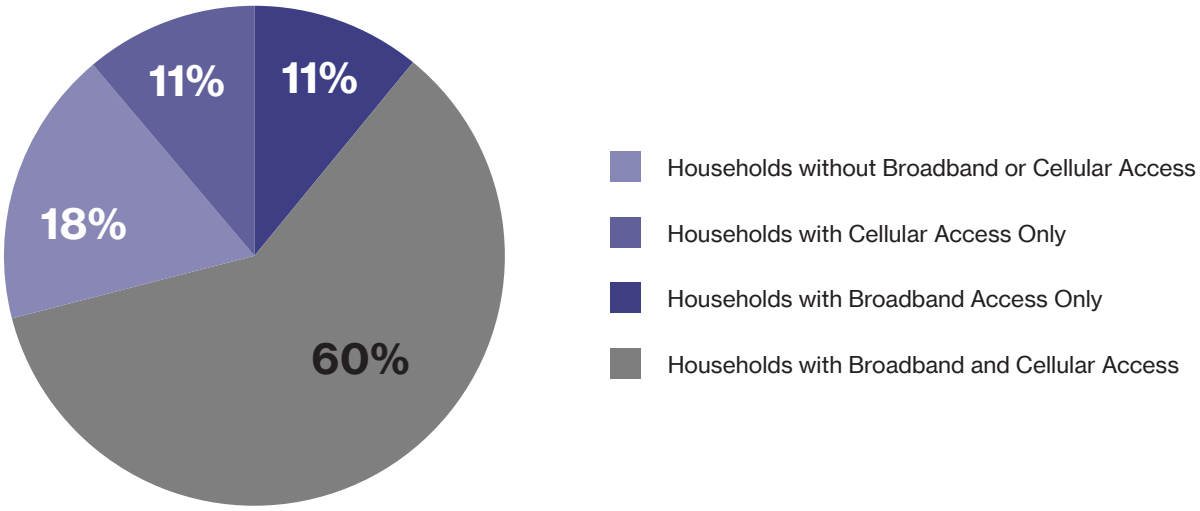
Universal Broadband Includes Both Home and Mobile Connections

Full connectivity in New York City requires more than merely a connection at home. It also means staying connected with mobile broadband service as one moves through the city. While the same percentage of households in New York City have a mobile broadband connection (71%) as have a home broadband connection (71%), the percentage of households that have both is far lower at only 60%.[1]

It is vitally important to see different modes of connectivity as additive rather than seeking to replace one mode with another. In other words, achieving universal broadband so all New Yorkers can stay connected wherever they go will require solutions that work for at least three categories of households: one for the 11% with a home broadband connection but no mobile connection; another for the 11% with a mobile connection but no home connection; and another still for the 18% that have neither mobile nor home broadband. Even within these important categories, there is tremendous geographic and demographic diversity. Additionally, many households that have both modes of service still struggle with affordability, service quality, and other barriers to equitable use.

Full connectivity in New York City requires more than a connection at home. It also means staying connected with mobile broadband service as one moves through the city.

Figure 12: Households in New York City with Home Broadband or Mobile Broadband



Broadband Access and Connectivity in New York City Today

STATE OF CONNECTIVITY

Nearly one third (29%) of New York City households do not have broadband at home. When the City measures comprehensive connectivity, meaning both at home and mobile broadband, the number of disconnected and underconnected New Yorkers rises to 40%. This equates to approximately 3.4 million residents excluded partially or entirely from the digital life of New York City. More than 1.5 million New Yorkers have neither a mobile connection nor a home broadband connection. This disconnected and underconnected population within New York City is itself larger than every other city in the country besides Los Angeles.

HOUSEHOLD-LEVEL DISPARITIES

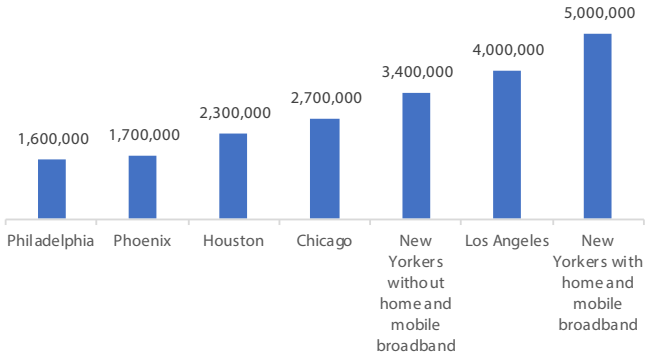
The New Yorkers who live at the digital margins are also living at the economic and social margins of the city in many respects. Over 40% of the households without broadband live below the poverty line. As more of daily life happens online – from applying for a job to scheduling a doctor's visit, from managing a bank account to checking in with friends and family – it can become harder to even see the neighbors who cannot afford a digital connection. Scholar Dr. Nicol Turner Lee calls this phenomenon "the digitally invisible."[2]

The millions of New Yorkers without home or mobile connections tend to have lower household incomes compared to digitally-connected households. Nearly half – 46% – of New York City households living in poverty do not have broadband at home. Overall, the median household income for those with broadband is two and a half times the level for those without broadband. A map of internet service rates in New York City bears a striking resemblance to a map of poverty rates, with high rates of adoption concentrated in wealthier areas and households without broadband concentrated in persistently low-income areas. The Bronx is the borough with the highest percentage of residents without home broadband, at almost 38%.

Internet use is foundational to economic mobility, but current broadband subscription costs can impose a considerable burden on the budgets of low-income families. New York City households living in poverty might need to spend as much as 10% of their monthly budget to have a home broadband connection and a single mobile connection.[3] These expenses strain households struggling to pay rent, access health care, and buy food. Only half of New York City households that have reported using supplemental nutrition benefits in the last year had a home broadband connection.

Figure 13: New York City's Digital Divide Relative to Other Cities' Total Populations

Source: HR&A Advisors

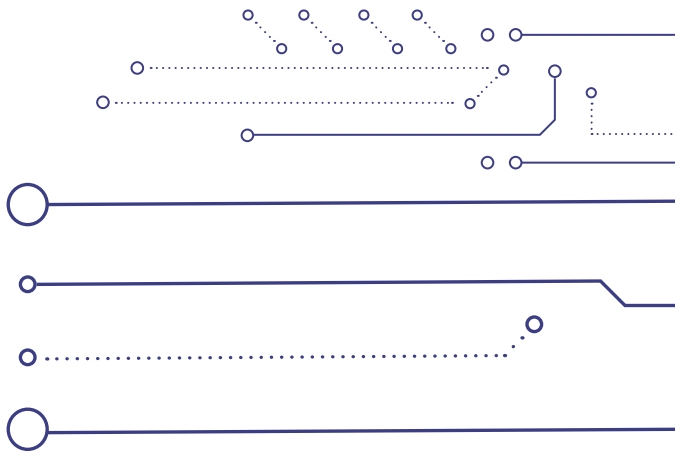


The digital divide in New York City highlights and contributes to disparities in formal educational attainment. Seven in ten teachers nationwide assign homework that requires web access after hours.[4] Yet more than one in five households with school-aged children in New York City do not have broadband at home, contributing to educational disparities relative to their peers with home access.

New York City is a majority-minority city, but that is not the case for access to the digital life of the city. 51% of city residents are Black/African American or of Hispanic origin, yet less than half of the households with broadband are in those categories.

The lack of a broadband connection can compound the challenge of social isolation. For New Yorkers who are over 65 years old and living alone, only 40% have a broadband connection at home. Fully two-thirds of people with disabilities living alone do not have a broadband connection at home.

Broadband subscription prices range from $50 to more than $125 per month for the most widely available services. Lower-priced options exist but are limited geographically or by eligibility criteria.



DIGITAL DIVIDES IN NEW YORK CITY

Figure 14: Home Broadband Adoption: All NYC Households

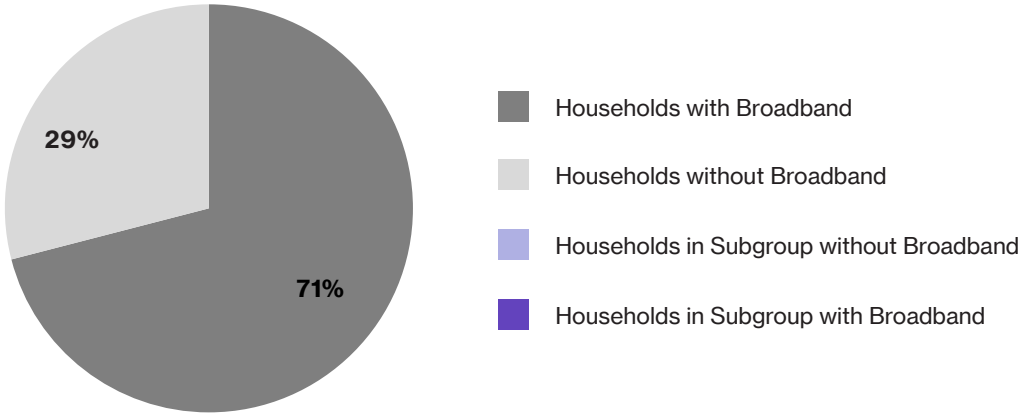
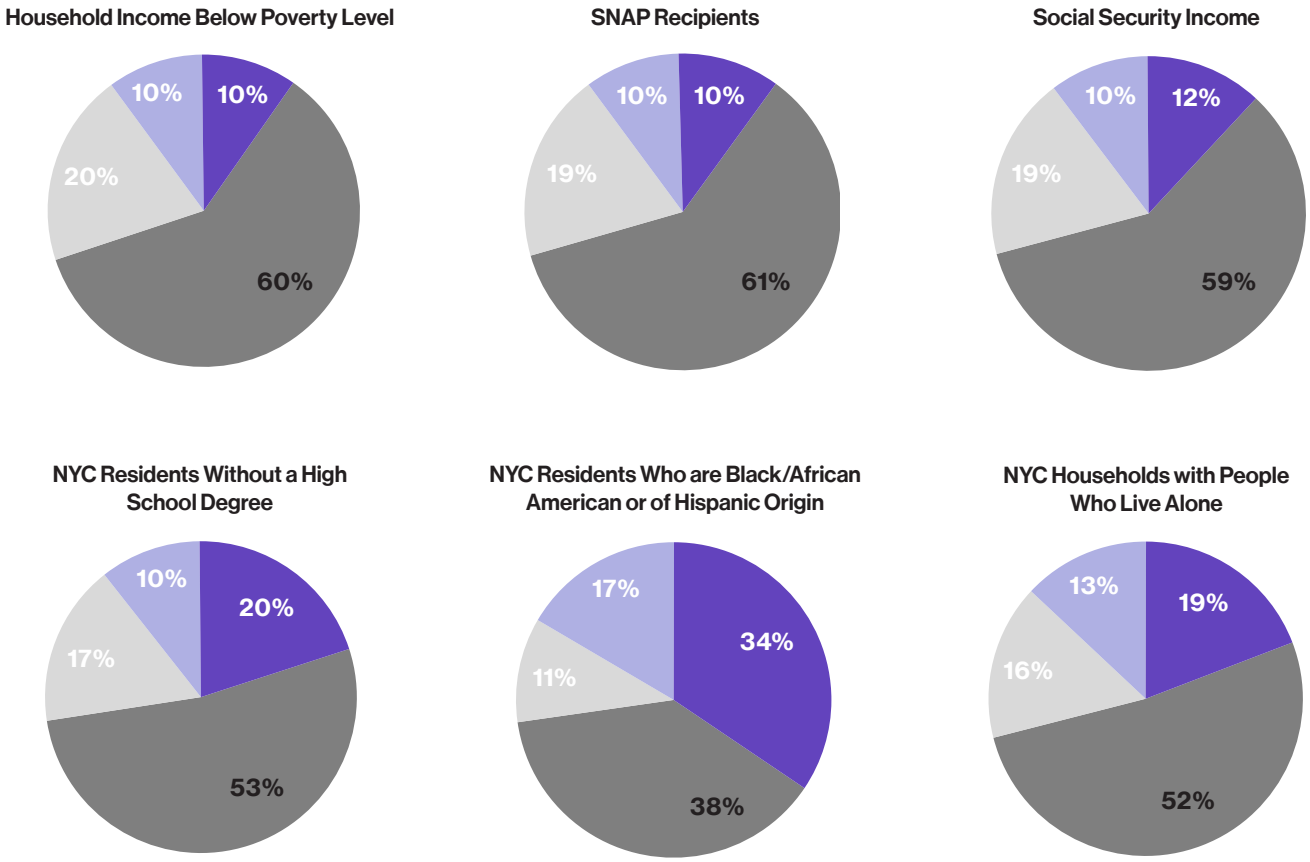


Figure 15: Home Broadband Adoption: Various Types of NYC Households



BROADBAND PRICES AND AVAILABILITY

Figure 16: Residential Broadband Prices and Products

Source: ISP pricing in 2019

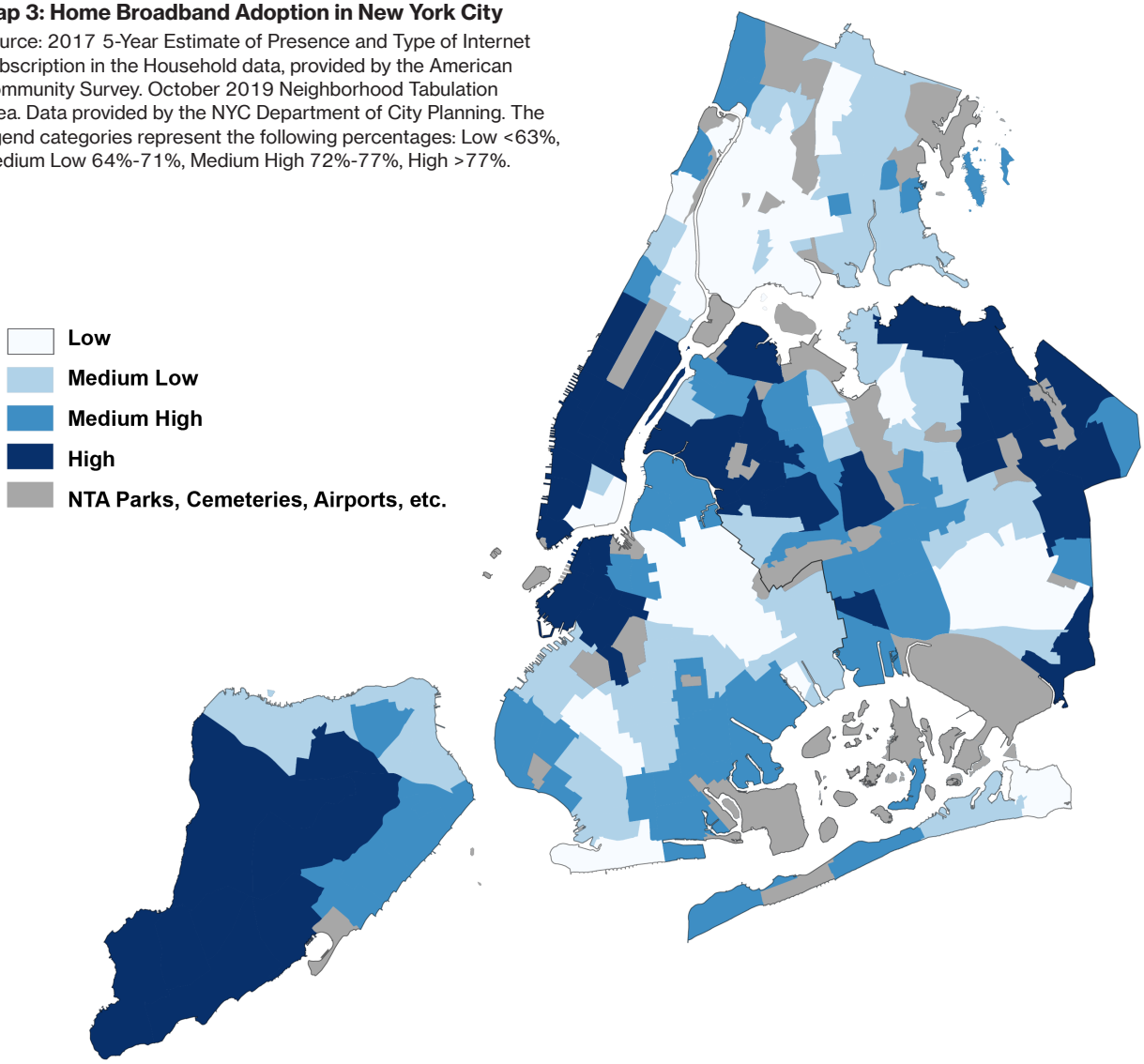
INTERNET SERVICE PROVIDER	PRODUCT NAME	DOWNLOAD SPEEDS / UPLOAD SPEEDS (IF SPECIFIED) - UP TO OR HIGHER	MONTHLY RATE	MONTHLY WI-FI FEE	MONTHLY EQUIP. CHARGE	EST. TOTAL MONTHLY COST	OFFER TERMS	% OF CITY W/ SERVICE AVAIL.
ALTICE (OPTIMUM)	Advantage Internet	30 Mbps	$14.99	$0	$10	$24.99	For eligible customers	32%
	Optimum 200	200 Mbps	$44.99	$0	$10	$54.99	1 - Year	
	Optimum 300	300 Mbps	$54.99	$0	$10	$64.99	1 - Year	
	Optimum 400	400 Mbps	$64.99	$0	$10	$74.99	1 - Year	
BKFIBER	Basic	20 Mbps/10 Mbps	$75.00	Not Listed	Not Listed	$75.00	Monthly	<1%
	Speed	30 Mbps/20 Mbps	$100.00	Not Listed	Not Listed	$100.00	Monthly	
	Pro	50 Mbps/25 Mbps	$215.00	Not Listed	Not Listed	$215.00	Monthly	
CHARTER (SPECTRUM)	Spectrum Internet Assist 30/4	30 Mbps/4 Mbps	$14.99	$5	$0	$19.99	Monthly - For eligible customers	66%
	Spectrum Internet 200/10	200 Mbps/10 Mbps	$65.99	$5	$0	$70.99	Monthly	
	Spectrum Internet Ultra 400/20	400 Mbps/20 Mbps	$90.99	$0	$0	$90.99	Monthly	
	Spectrum Internet Gig	940 Mbps/35 Mbps	$125.99	$0	$0	$125.99	Monthly	
HONEST		980 Mbps	$50.00	Not Listed	$5	$55.00	Monthly	No data
NYC MESH	Mesh Internet	Speeds vary. NYC Mesh uses best efforts for speed and support.	$20-50 *sliding scale*	Not Listed	$0	$0.00	Monthly	No data
RCN	High Speed Internet	25 Mbps/4 Kbps	$82.00	$5.50	$10.50	$98.00	Monthly	14%
	High Speed Internet	50 Mbps/10 Mbps	$99.99	$5.50	$10.50	$115.99	Monthly	
	High Speed Internet	Downloads 75 Mbps/110 Mbps/155 Mbps Upload 15 Mbps	$149.99	$5.50	$10.50	$165.99	Monthly	
	High Speed Internet	330 Mbps/20 Mbps	$249.99	$5.50	$10.50	$265.99	Monthly	
	500 Mbps	500 Mbps	$89.99	$5.50	$10.50	$105.99	Monthly	
	1 Gig	1 Gig	$149.99	$5.50	$15	$170.49	Monthly	
STARRY		200 Mbps	$50	$0	$0	$50.00	Monthly	No data
VERIZON (FIOS)	200 Mbps	200 Mbps/200 Mbps	$39.99	Not Listed	$12	$51.99	1 - Year	74%
	400 Mbps	400 Mbps/400 Mbps	$59.99	Not Listed	$12	$71.99	1 - Year	
	FiOS Gigabit Connection	940 Mbps/880 Mbps	$79.99	Not Listed	$0	$79.99	1 - Year	

GEOGRAPHIC DISPARITIES IN HOME AND MOBILE BROADBAND

The millions of New Yorkers without home or mobile connections are not spread evenly throughout the city but are generally concentrated in certain areas: the south Bronx and upper Manhattan, eastern Queens, and central Brooklyn. The Bronx has the highest percentage of residents without home broadband of any borough at almost 38%. At the neighborhood level, the percentage of households without home broadband ranges from below 60% in Borough Park and Bushwick in Brooklyn, Flushing in Queens, Highbridge in the Bronx, and the Lower East Side of Manhattan, to a high of over 85% in Battery Park City-Lower Manhattan and Park Slope-Gowanus in Brooklyn.

Map 3: Home Broadband Adoption in New York City

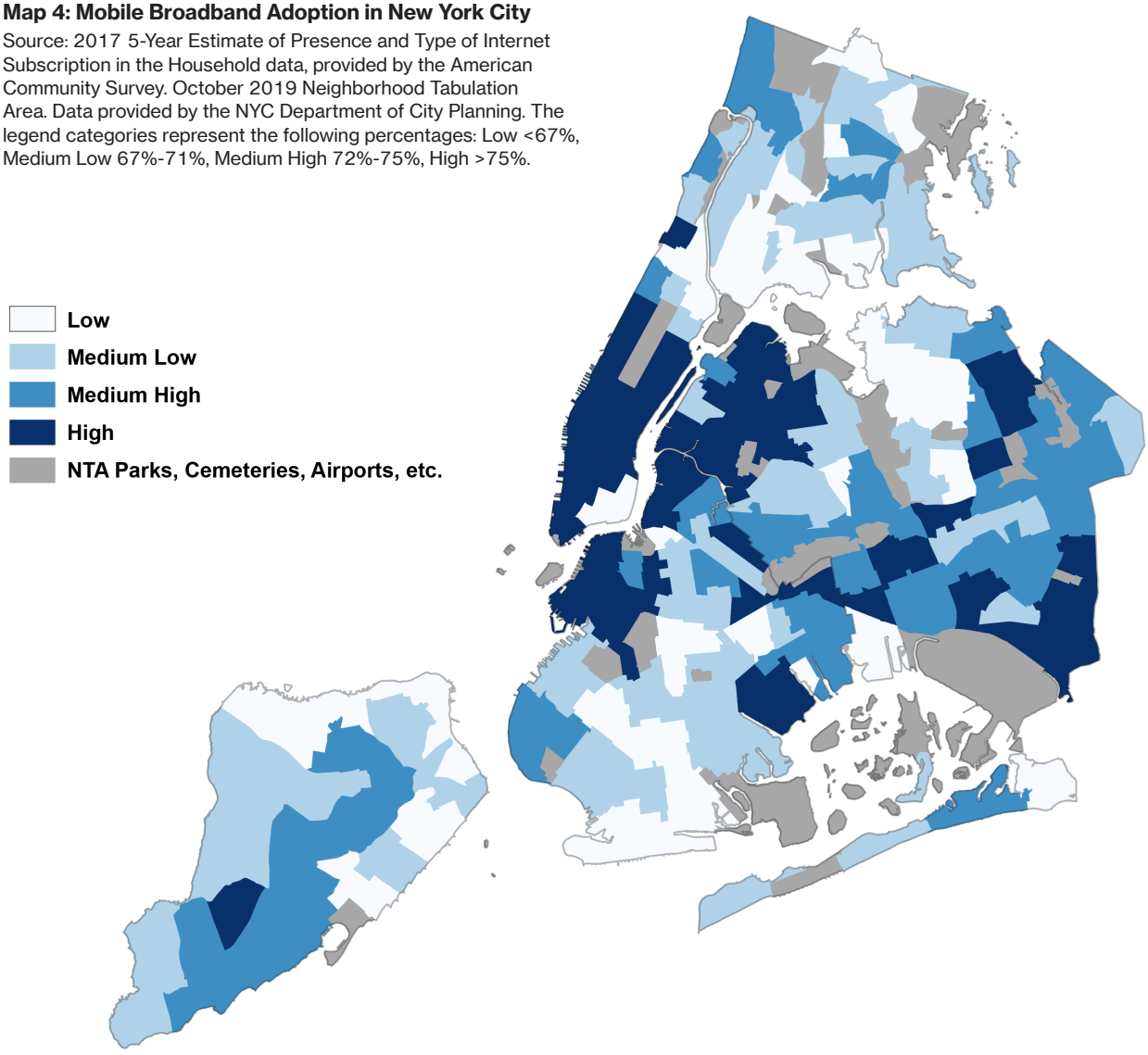
Source: 2017 5-Year Estimate of Presence and Type of Internet Subscription in the Household data, provided by the American Community Survey. October 2019 Neighborhood Tabulation Area. Data provided by the NYC Department of City Planning. The legend categories represent the following percentages: Low <63%, Medium Low 64%-71%, Medium High 72%-77%, High >77%.



The geographic distribution of mobile broadband adoption throughout the city is not as uneven as home broadband adoption. Still, nearly all of the neighborhoods with the highest rates of home broadband adoption also have above-average rates of mobile adoption. The reverse is also true for the neighborhoods with the lowest rates of home broadband. Some neighborhoods have significant variation between the two measures: Bushwick North and Ocean Hill in Brooklyn and Baisley Park in Queens, for example, have rates of home broadband adoption lower than 60% and mobile broadband higher than 75%. In the other direction, Middle Village, Maspeth, and Whitestone in Queens and New Springville-Bloomfield-Travis in Staten Island have rates of home broadband adoption at 78% or above and mobile broadband rates at 70% or below.

Map 4: Mobile Broadband Adoption in New York City

Source: 2017 5-Year Estimate of Presence and Type of Internet Subscription in the Household data, provided by the American Community Survey. October 2019 Neighborhood Tabulation Area. Data provided by the NYC Department of City Planning. The legend categories represent the following percentages: Low <67%, Medium Low 67%-71%, Medium High 72%-75%, High >75%.



WHY IS A GIGABIT IMPORTANT?

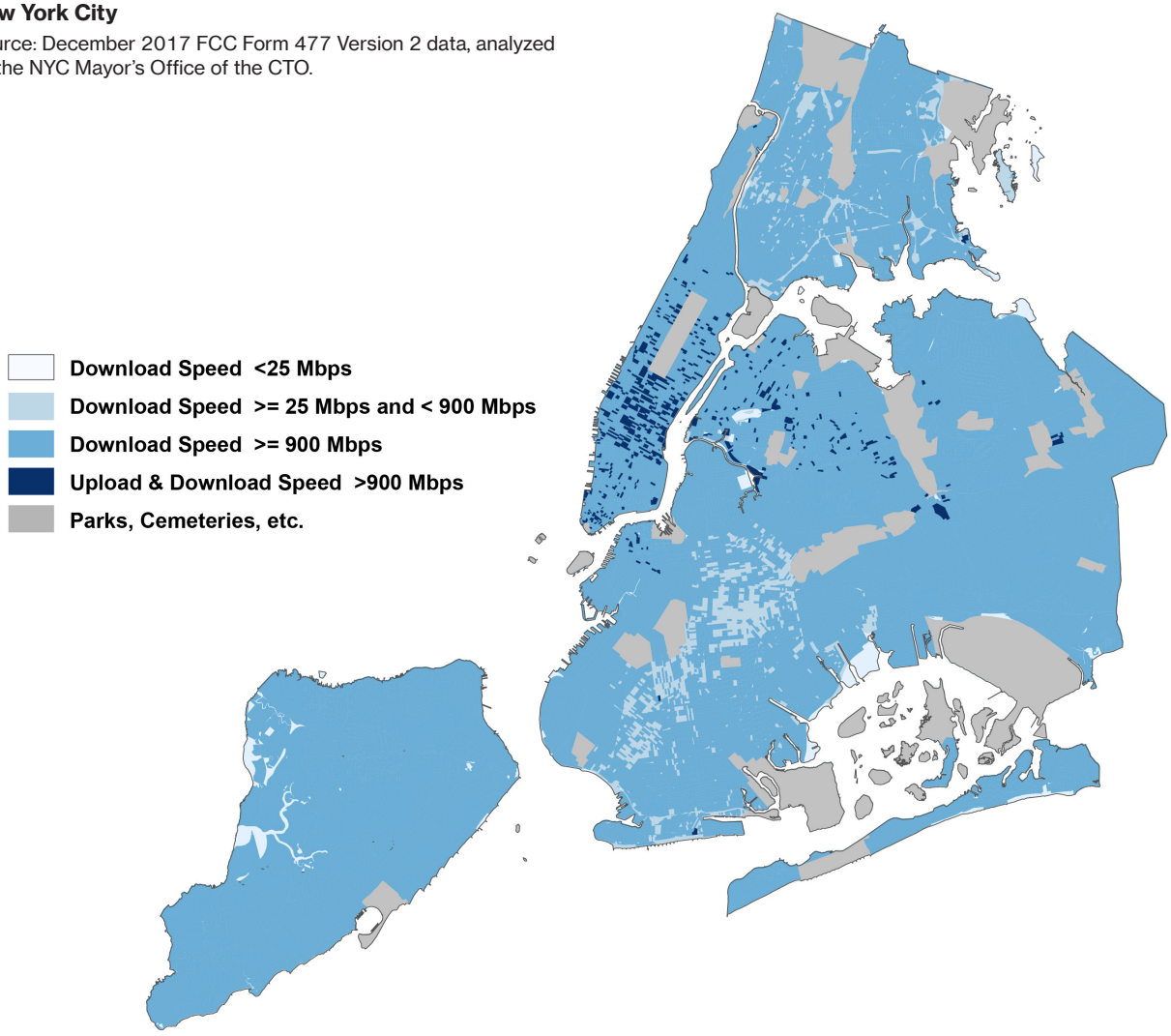
A "Gigabit" is a connection to the internet that is 1,000 megabits per second (Mbps) for both download and upload. That speed is beyond what most households need to use the internet today, but is useful as a benchmark for overall network performance to meet future needs. The availability of higher-speed tiers is an indicator of the range of products available from a provider, as well as of the overall quality and capacity of a network. With internet service, today's upper level can quickly become tomorrow's baseline. An area that is behind today is most at risk for being behind in the future.

DISPARITIES IN PERFORMANCE

Nearly all census blocks in New York City have a broadband service option of at least 25 Mbps download and 3 Mbps upload available. That is not the case for download speeds of 1,000 Mbps. Based on the most recent FCC data, large sections of the Bronx and Brooklyn do not have a 1,000 Mbps option. These same areas are also limited in the number of service providers from which to choose.

Map 5: Maximum Available Broadband Speeds in New York City

Source: December 2017 FCC Form 477 Version 2 data, analyzed by the NYC Mayor's Office of the CTO.

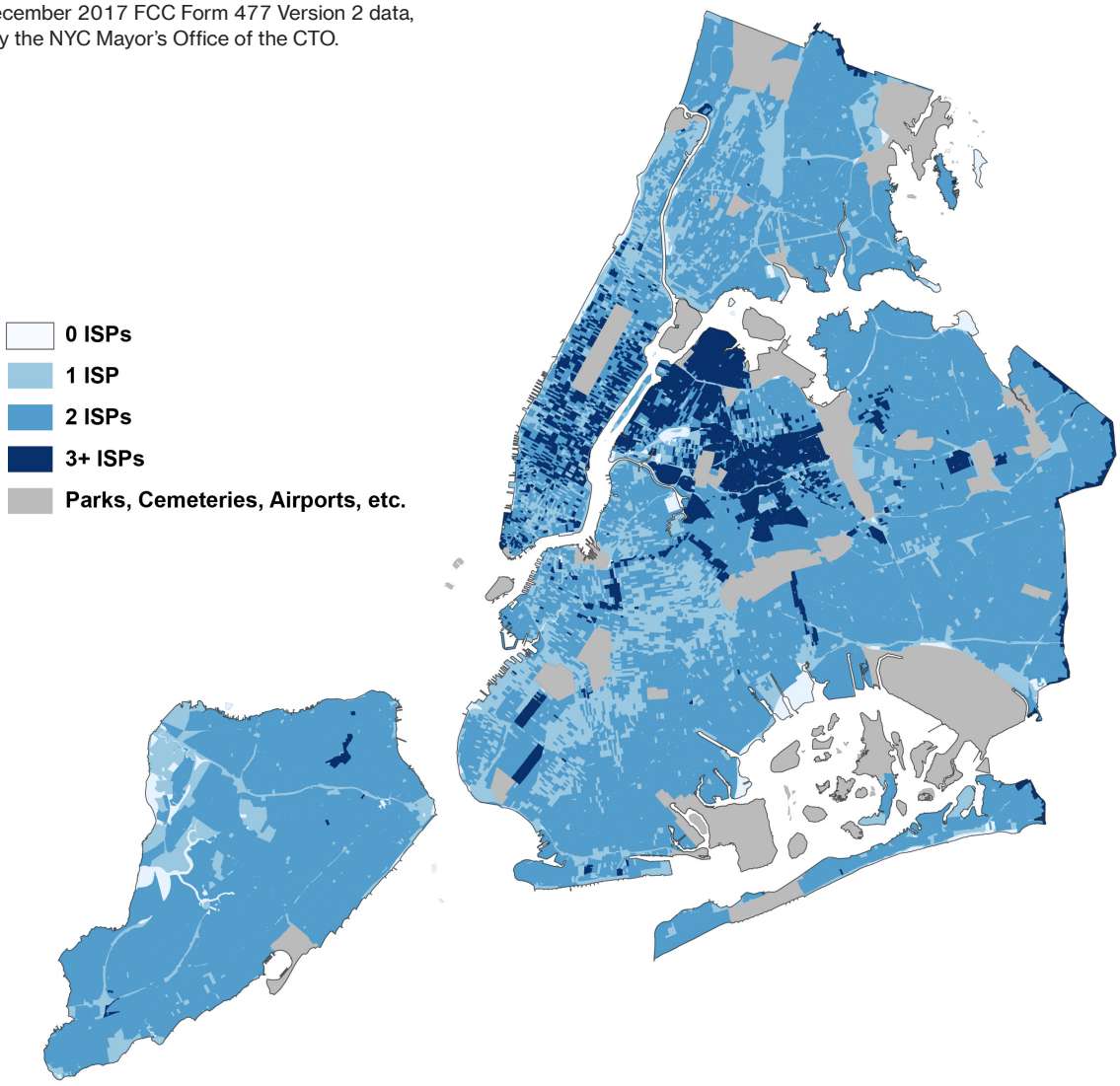


DISPARITIES IN CHOICE

Competitive broadband markets are limited to relatively wealthy and dense neighborhoods. Areas that have three or more residential broadband providers have an average household income 50% greater than households in areas with only two providers. A choice among several service providers can lead to more affordability and improved service, as companies differentiate their products and compete to gain or retain customers.

Map 6: Residential Broadband Choice

Source: December 2017 FCC Form 477 Version 2 data, analyzed by the NYC Mayor's Office of the CTO.



Broadband Infrastructure in New York City Today

The condition of infrastructure and the potential cost of new construction vary considerably across the city. This variation can translate into wide ranges in the cost and time to build new infrastructure, particularly for new market entrants. As a result, areas that already have service tend to get more options and new technologies first, while areas with gaps in infrastructure are persistently left out or left behind, as reflected in lower levels of access and connectivity.

A robust broadband system is comprised of networks of fiber, conduit or aerial pathways, fixed wireless connections, and mobile wireless connections. These are the basic building blocks of internet connectivity. The maps on the following pages show the variations in these components neighborhood by neighborhood.

BROADBAND MARKET SEGMENTS

Understanding how various companies relate to one another, their customers, and their market segments illustrates the workings of the broadband market in New York as well as internet provision generally. The biggest users of broadband, including large companies and internet service providers (ISPs) themselves, rely on a combination of backhaul, enterprise fixed wireless, and neutral host. Medium-size and tech-savvy small businesses require specific levels of service – a segment called "business class" – which can be delivered by wired or fixed wireless connection.

The majority of residential and small business customers purchase consumer-grade service that has minimal service-level requirements. Most rely on a small number of large providers, often referred to as the "incumbent" providers for their long-held dominant position in the market. There are also smaller internet service providers

Figure 17: Broadband Market Segments

MARKET SEGMENT	TYPE OF SERVICE	CUSTOMER TYPE
Backhaul	Dark or lit connections between major data centers and large institutions to connect enterprise networks to the internet.	Enterprise or Neutral Host companies. Backhaul providers connect to each other at major data centers.
Construction	Infrastructure built by digging the streets or installing equipment.	Backhaul, Enterprise, or Neutral Host companies.
Enterprise	High-end internet service, point-to-point transport between business locations, and dark fiber.	Large businesses or institutions. Fixed wireless providers use a wired enterprise connection.
Enterprise Fixed Wireless	Point-to-point and point-to-multipoint data with transmission rates and reliability comparable to fiber optic connections up to a point.	Larger businesses or institutions, often for redundancy or cost-savings compared to wired enterprise connections.
Neutral Host	Connections and supporting equipment for mobile wireless.	Mobile wireless companies.
Business Class	Midrange service, some level of quality of service, dedicated capacity on a network, prioritization by the network operator. Can be wired or fixed wireless.	Medium-size and tech-savvy small businesses.
Consumer	"Up to" speeds, no quality of service guarantees, many customers contending for the same capacity, lowest prioritization by the network operator. Can be wired or fixed wireless. 24/7 customer support.	Residential and small businesses.
Startup, Niche, or Community-based Service Providers	Tailored to the needs or values of a particular neighborhood or community, or otherwise focused on a particular market segment.	Residential and small businesses.
Managed Service Provider	Manage the local network in a building to distribute service from an enterprise or business class provider to the building tenant. Can use wired or wireless within the building.	Office building and large multi-family residential building owners or property managers.
Mobile Network Operators	"Up to" speeds, reliability depends on location. Include data caps or pricing mechanisms to disincentivize extensive use of bandwidth. 24/7 customer support.	Mobile users of all sizes of businesses.
Mobile Virtual Network Operator	Reselling capacity from one or more mobile wireless company, potentially supplemented by Wi-Fi connections. 24/7 customer support.	Low-cost mobile users.

Figure 18: Broadband Roles and Functions

PHASE	FUNCTIONS	
Engineering	• Network design • Field surveys • Site visits • Drawings	• Permitting • Lease or license negotiation • Procurement of equipment
Construction	• Cable pulling into existing conduit • Trenching/boring for new conduit • Overlashing new cable to existing aerial plant • Attaching new cables to utility poles • Construction and installation of drop cable	• Construction of space to house network equipment, including installation of electrical, HVAC, and security components • Construction of telecom distribution cabinet on the ground or mounted to utility pole
Installation	• Installation and configuration of equipment at core network or customer location required for provision of services	• Wireless provisioning: site preparation, structure modification, equipment and electric service installation, site testing, turn up
Maintenance	• Underground locates for outside plant infrastructure • Adds, changes, moves, and repairs to infrastructure	• Annual inspection and maintenance for wireless equipment
Network Operations	• Network monitoring • Network Operations Center (NOC) activities	• Customer service, call center • Marketing

serving pockets of residential and small business markets. These may be niche ISPs with a specific customer base, startups with an innovative approach looking to scale within an area or with a particular class of customers, or community-based providers motivated by a sense of shared principles with their neighbors.

In some cases, a building owner contracts with a managed service provider who interfaces between the commercial or residential tenant and one or more internet service providers. In that case, the ISP generally comes to the point of entry to the building where the managed service provider handles the connection to the local network in the building that reaches the individual tenant. For mobile service, consumers and businesses buy from the same class of companies, which offer a range of services. There are also a group of resellers known as mobile virtual network operators that buy in bulk from the mobile network operators. Some resellers, particularly cable companies, integrate some of their own infrastructure into their mobile virtual network operations.

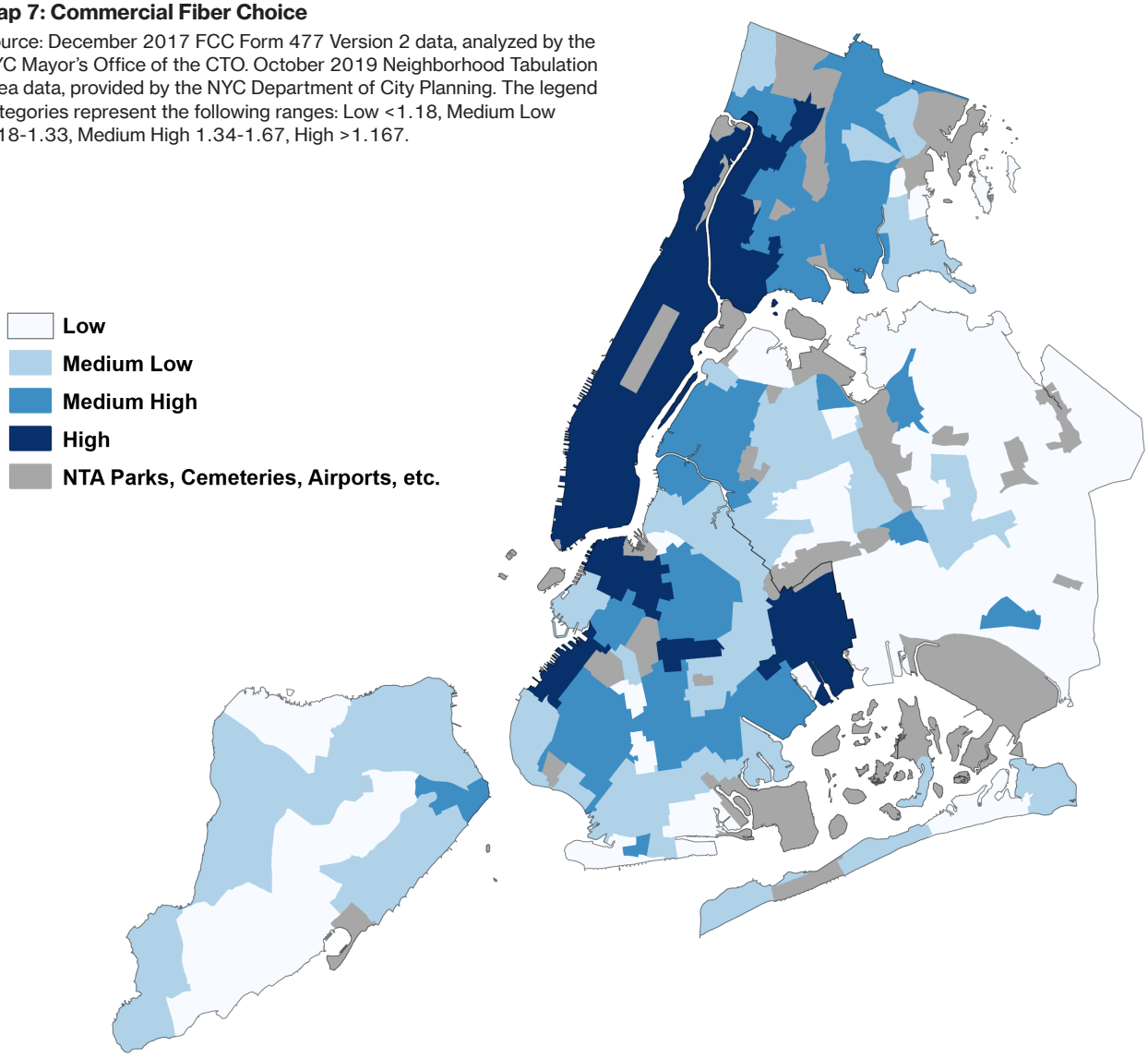
Example of Network Equipment Rack
Source: New York City Housing Authority

COMMERCIAL FIBER CHOICE

The geographic variability of broadband service is clearly illustrated by the availability of commercial fiber across New York City. Most areas in Manhattan have three or more commercial fiber providers nearby; similar levels of choice are largely limited to small, scattered patches in the city's other four boroughs. Overall, 72% of neighborhoods have at least a single census block that has three or more options for commercial fiber optic service.

Map 7: Commercial Fiber Choice

Source: December 2017 FCC Form 477 Version 2 data, analyzed by the NYC Mayor's Office of the CTO. October 2019 Neighborhood Tabulation Area data, provided by the NYC Department of City Planning. The legend categories represent the following ranges: Low <1.18, Medium Low 1.18-1.33, Medium High 1.34-1.67, High >1.167.

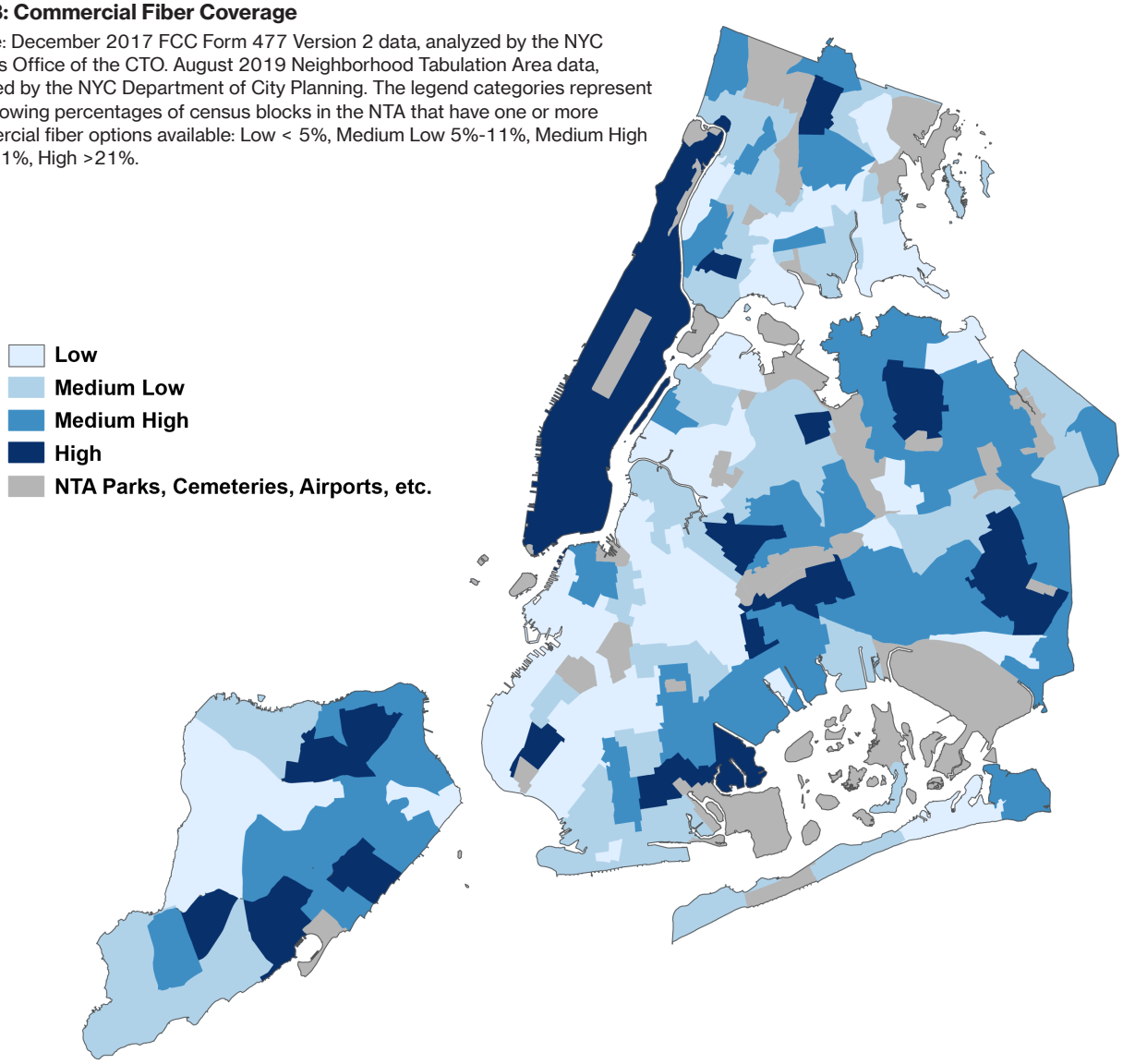


COMMERCIAL FIBER COVERAGE

The extent of even the most basic fiber optic infrastructure varies from neighborhood to neighborhood. Map 8 shows four levels of coverage based on how much of each neighborhood lacks commercial fiber service availability. Manhattan is completely covered while in every other borough there are neighborhoods with low levels of fiber coverage. The first fiber optic construction in an area can sometimes be the most complicated and highest cost, so low levels of coverage can indicate the presence of barriers for new commercial development or broadband services in these areas.

Map 8: Commercial Fiber Coverage

Source: December 2017 FCC Form 477 Version 2 data, analyzed by the NYC Mayor's Office of the CTO. August 2019 Neighborhood Tabulation Area data, provided by the NYC Department of City Planning. The legend categories represent the following percentages of census blocks in the NTA that have one or more commercial fiber options available: Low < 5%, Medium Low 5%-11%, Medium High 12%-21%, High >21%.

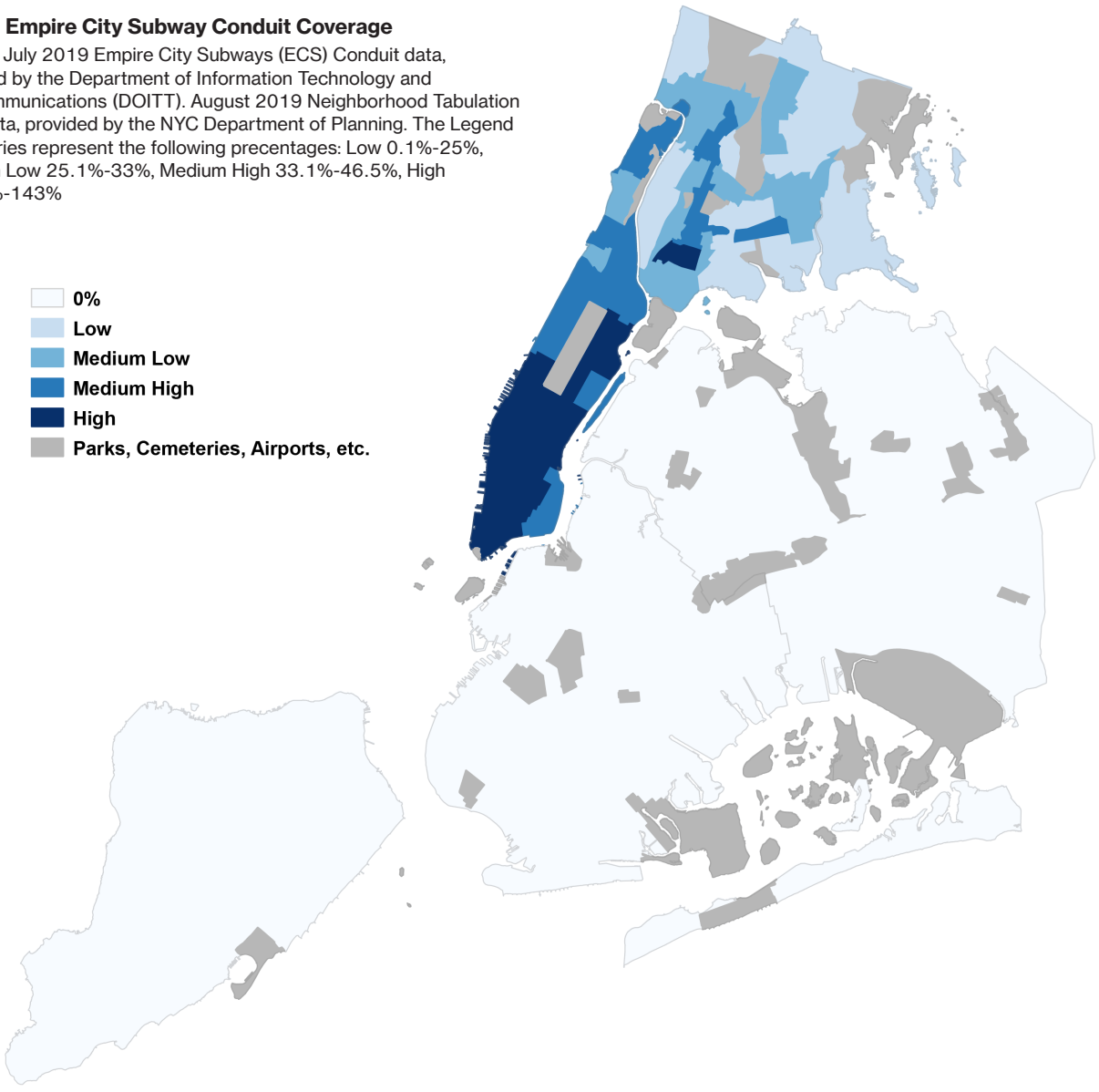


FIBER DELIVERY MODES

Fiber infrastructure takes one of two forms: underground, in which fiber is fed through conduits beneath the street; and aerial, in which fiber is attached overhead to utility poles. Underground conduits are generally better-suited to protect fiber from environmental conditions, while aerial construction can provide cost savings by eliminating the need for street excavation. The City reviewed available industry data and conducted surveys of sample neighborhood areas, extrapolating from those surveys to predict conditions citywide. Based on these predictions, the densest areas of the city – all of Manhattan plus portions of the Bronx, Brooklyn, and Queens – are positioned for underground delivery. Aerial fiber delivery is found in parts of the eastern Bronx, eastern Queens, southern Brooklyn, and all of Staten Island. In large swaths of the Bronx, Brooklyn, and Queens, fiber delivery happens through a combination of underground conduits and aerial utilities.

Map 9: Empire City Subway Conduit Coverage

Source: July 2019 Empire City Subways (ECS) Conduit data, provided by the Department of Information Technology and Telecommunications (DOITT). August 2019 Neighborhood Tabulation Area data, provided by the NYC Department of Planning. The Legend Categories represent the following precentages: Low 0.1%-25%, Medium Low 25.1%-33%, Medium High 33.1%-46.5%, High 46.51%-143%

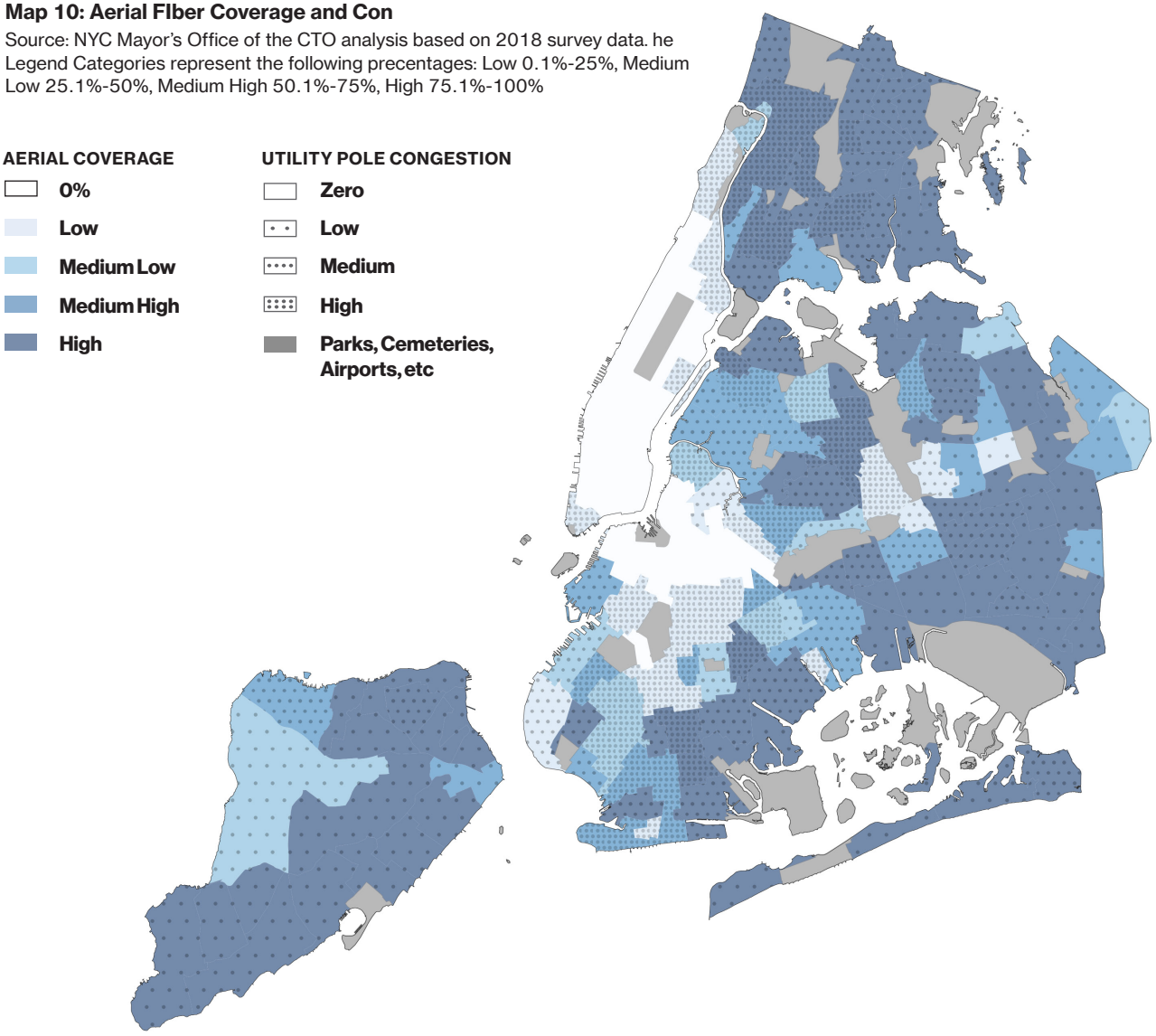


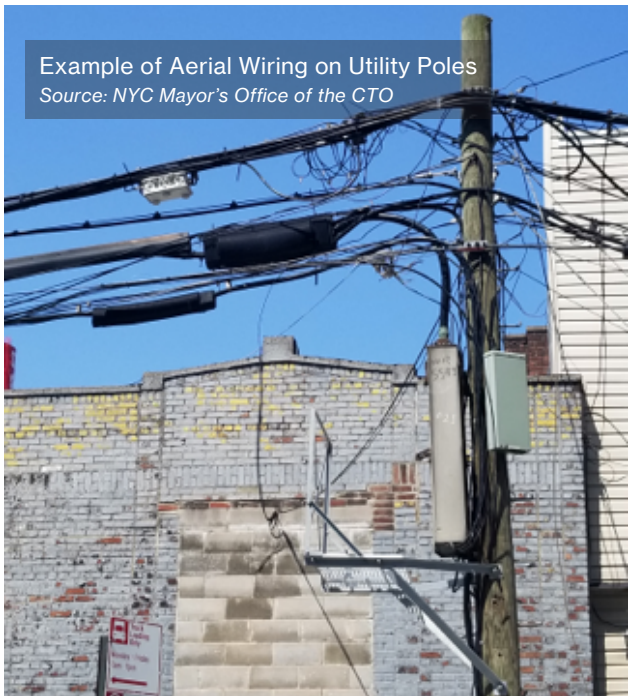
FIBER DELIVERY CONDITIONS

Underground conduits vary in coverage, the extent to which they are utilized, and their spare capacity. Aerial fiber conditions factor into congestion on utility poles, and affect how many adjustments or "moves" would be needed to accommodate additional cables. Short lengths of fiber can be constructed through microtrenching, which involves burying fiber cables in small, shallow trenches.

Map 10: Aerial FIber Coverage and Con

Source: NYC Mayor's Office of the CTO analysis based on 2018 survey data. he Legend Categories represent the following precentages: Low 0.1%-25%, Medium Low 25.1%-50%, Medium High 50.1%-75%, High 75.1%-100%





Example of Aerial Wiring on Utility Poles
Source: NYC Mayor's Office of the CTO

Above Ground Cable Infrastructure

Where utility poles are available, space constraints on the pole impact the sustainability of aerial infrastructure. Some poles can become overburdened, which can lead to unsightly or even unsafe conditions. The level of coverage and congestion of aerial fiber impacts the cost of new fiber construction.

Underground Fiber Infrastructure

Underground conduit availability in Manhattan and the Bronx is a product of the Empire City Subway (ECS) network.[5] The distribution of the ECS system is not even across Manhattan and the Bronx. In boroughs where ECS conduit is not available, the City – and any potential private partner – must work with private owners (e.g., Verizon, Con Ed) to leverage their existing conduits, as required by state and federal law,[6] or to construct new conduit. Data on the conditions of these conduit systems are not publicly available.

Figure 19: Total Coverage of Fiber Delivery Modes

ABOVE GROUND NETWORK (UTILITY POLE PRESENCE) LAND AREA	UNDERGROUND NETWORK LAND AREA
69%	45%

NOTE:

The Bronx and Manhattan are served by ECS conduits. Overlapping areas may be served by a combination of aerial or underground fiber.

Microtrenched Fiber

Microtrenching is a construction technique where small conduits with fiber-optic cables are placed in shallow slot-cut trenches. In comparison to conventional trenching, microtrenching is a low-impact deployment method that has yielded significant cost and time savings for broadband deployment across the country. In NYC, current microtrenching techniques are best suited for "drop" installations, or the process of connecting fiber from the street curb to a home or business.

More information about microtrenching, and the City's 2012 pilot program can be found on the NYC Department of Information Technology and Telecommunications' (DOITT) microtrenching webpage.[7]

Example of Underground Wiring
Source: NYC Mayor's Office of the CTO

WIRELESS EQUIPMENT

Mobile and fixed wireless equipment is distributed throughout the city in a pattern similar to the distribution of fiber. Wireless equipment is placed in or attached to both public and private properties, or infrastructure along the public rights-of-way, such as street light, traffic light, and utility poles.

Rooftop Wireless Installations Rooftop wireless installations are used for both mobile and fixed wireless installations. Rooftop wireless installations may be subject to City regulatory approval[8] and City safety regulations.[9] Rooftops are also used throughout the city as hub sites for fixed wireless broadband service.

Pole Attachment Wireless Installations The City has approved a standard pole attachment box in two distinct designs: one is 35" high by 15.5" wide by 9" deep; the other is 25" high by 18" wide by 11" deep. Both include an antenna up to 60" high with a 2" diameter. In addition to the two sets of standard boxes to house radio equipment, the City also permits the installation of small radios, such as Wi-Fi access points.

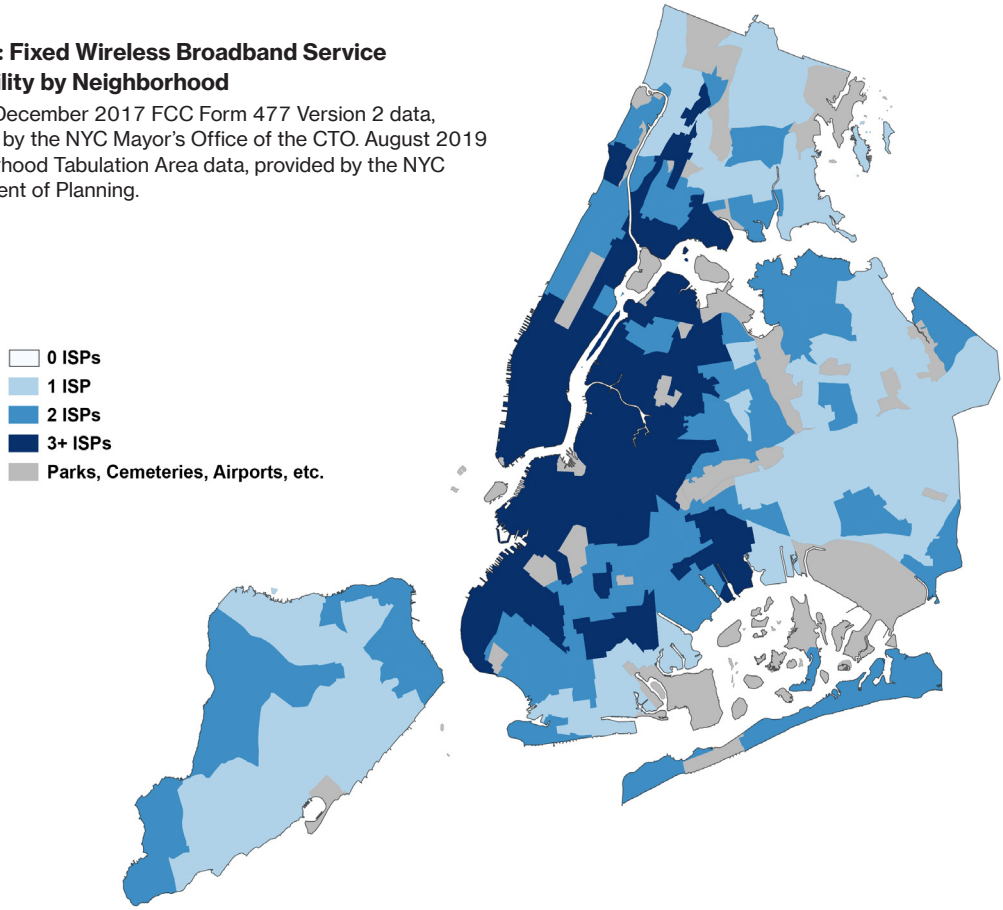
Example of Approved Standard Mobile Telecom Pole Attachment
Source: NYC Mayor's Office of the CTO

FIXED WIRELESS SERVICE

Fixed wireless service is available at various levels in every neighborhood, according to data from the Federal Communications Commission. Lower Manhattan and the portions of Brooklyn and Queens closest to Manhattan tend to have more options for fixed wireless service than other regions of the city.

Map 11: Fixed Wireless Broadband Service Availability by Neighborhood

Source: December 2017 FCC Form 477 Version 2 data, analyzed by the NYC Mayor's Office of the CTO. August 2019 Neighborhood Tabulation Area data, provided by the NYC Department of Planning.

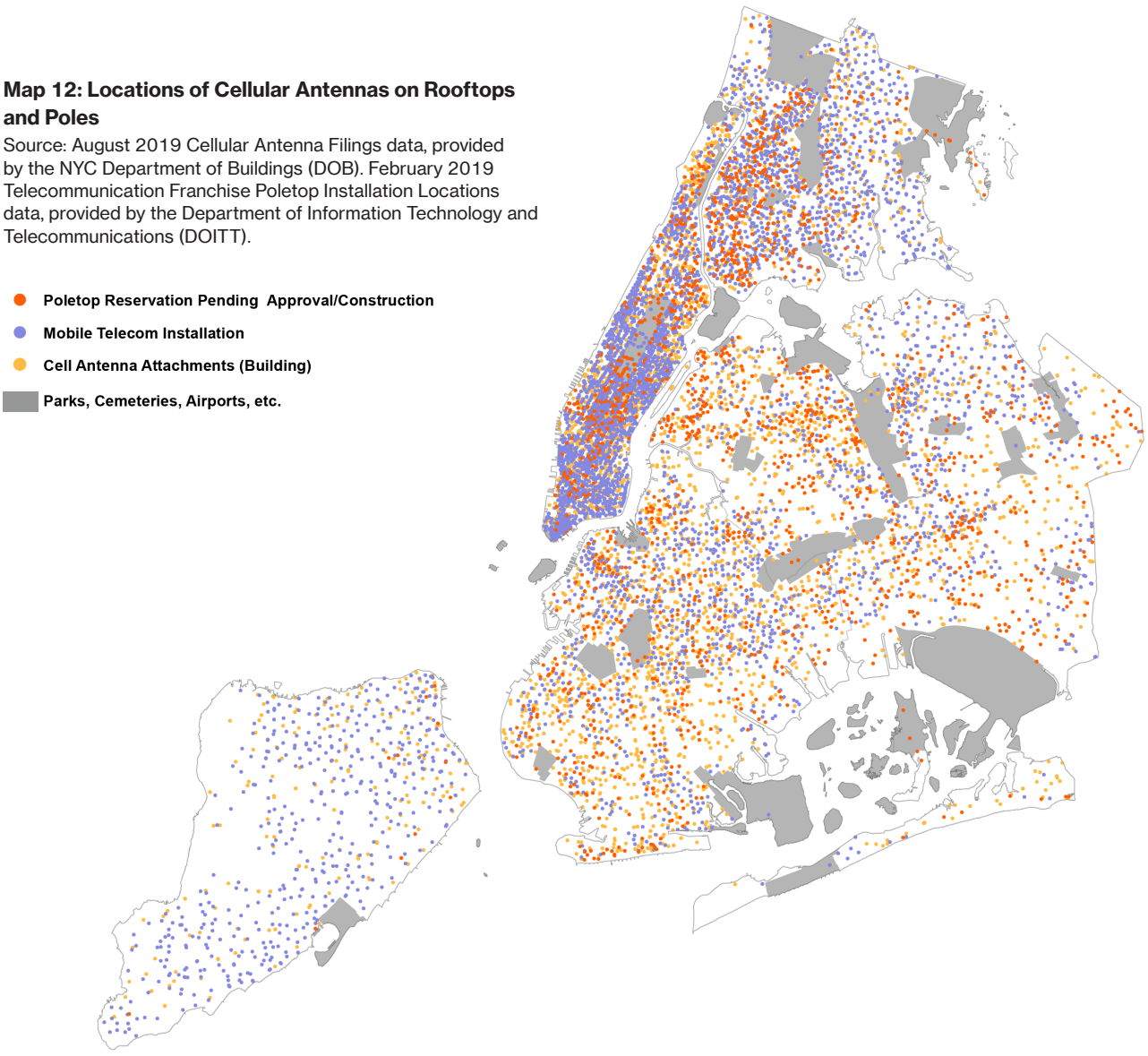


MOBILE WIRELESS EQUIPMENT INSTALLATIONS

Mobile wireless equipment installations generally consist of "macro sites" that are mostly installed on rooftops and "small cells" that are frequently installed on poles. The difference in height of the installation translates into differences in the size of coverage area, with macro sites covering a larger "cell" than a small cell, and all of the cells together providing "cellular" coverage. Antenna distribution in Manhattan is generally denser compared to other boroughs. More densely populated areas of the Bronx, Brooklyn, and Queens such as Concourse, Highbridge, and Fordham in the Bronx, central Brooklyn (Bushwick, Bedford-Stuyvesant, Crown Heights, Flatbush), and western Queens (Astoria, Woodside, Jackson Heights) have denser cellular antenna distributions.

Map 12: Locations of Cellular Antennas on Rooftops and Poles

Source: August 2019 Cellular Antenna Filings data, provided by the NYC Department of Buildings (DOB). February 2019 Telecommunication Franchise Poletop Installation Locations data, provided by the Department of Information Technology and Telecommunications (DOITT).

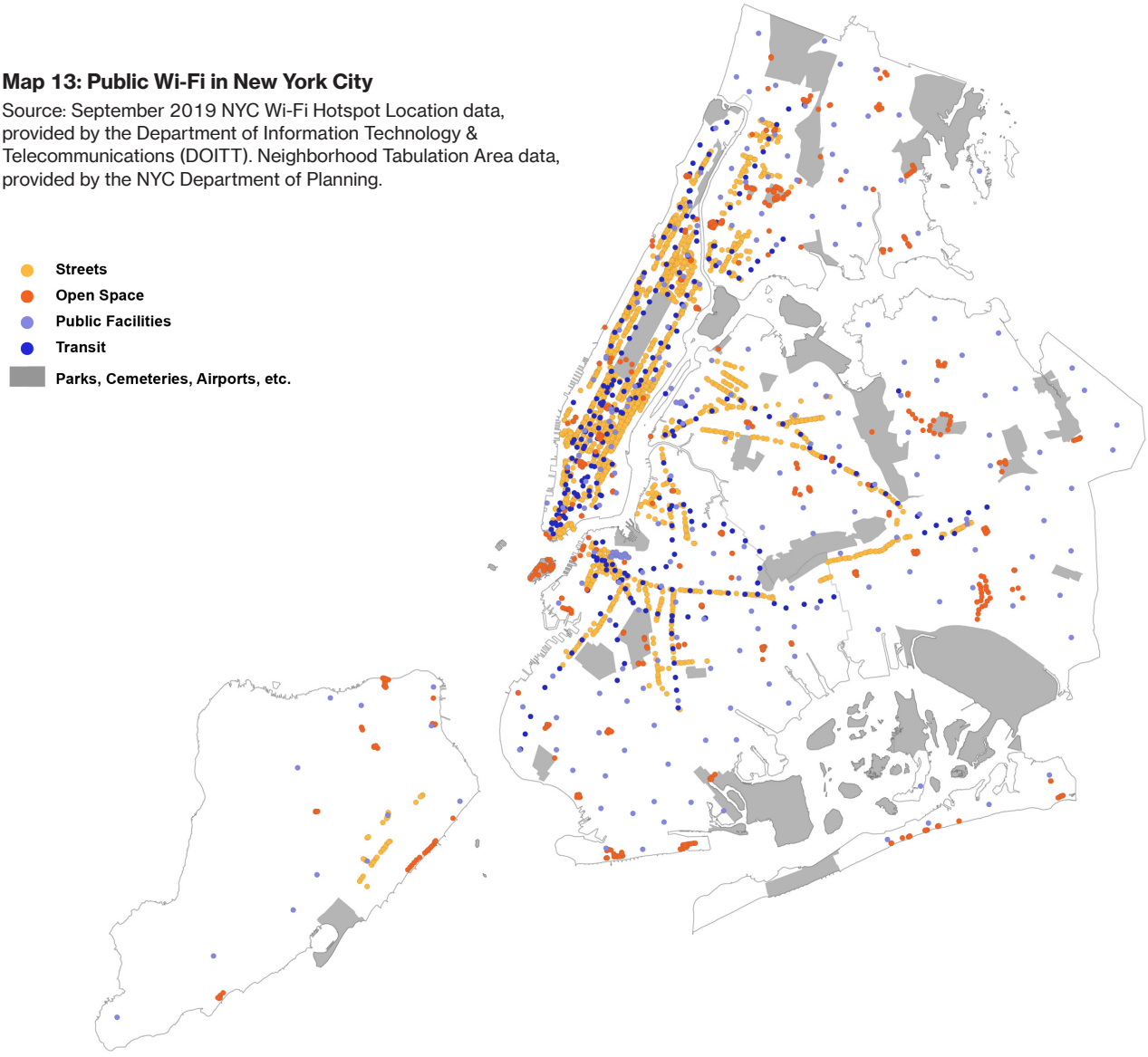


PUBLIC WI-FI

The City measures Public Wi-Fi coverage based on four use cases: streets, open space, public facilities, and transit. Wi-Fi coverage for open space, public facilities, and transit is generally spread across the city according to the patterns of parks, public computer centers, and subway stations.[10] Wi-Fi coverage on streets is more concentrated in Manhattan and in areas with dense fiber optic infrastructure. The priority for city streets is serving pedestrian corridors – zones of commercial activity in each neighborhood that attract the greatest numbers of people and local businesses. Of the 195 neighborhoods that have any area zoned for commercial use, 81 neighborhoods, or 42 percent, have at least one hotspot in a commercial area. Neighborhoods without this type of service are generally in the outer areas of the Bronx, Brooklyn, Queens, and Staten Island.

Map 13: Public Wi-Fi in New York City

Source: September 2019 NYC Wi-Fi Hotspot Location data, provided by the Department of Information Technology & Telecommunications (DOITT). Neighborhood Tabulation Area data, provided by the NYC Department of Planning.



FACTORS SHAPING FUTURE PRIVATE INVESTMENT

Broadband market segments, and even individual companies, weigh different factors in considering where to invest within New York City. Generally, companies consider a balance of construction costs and potential revenue. In some cases, such as consumer and business class ISPs that have to spend to acquire and maintain new customers, the cost accounts for difficulty winning new customers, and the revenue assessment is based on the average revenue per unit (ARPU). For example, newly built large apartment buildings present an opportunity to gain a lot of customers quickly, whereas larger or wealthier households may purchase higher-end products for a higher ARPU.

Certain publicly-available data points indicate the perceived market opportunity:

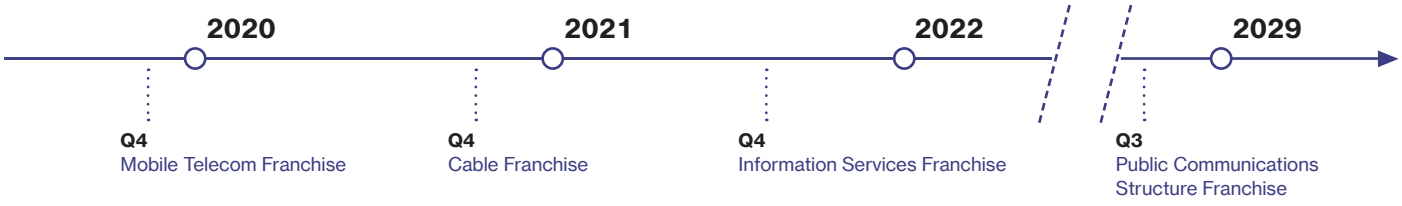
- High residential and commercial account density
- High building height variance
- Large average household sizes
- High projected population growth
- High concentration of commercial square footage
- High pedestrian counts
- High subway turnstile counts

When combined with the information in this section on where broadband infrastructure already exists, these data points indicate where private investment in new infrastructure is likely to occur in the absence of any government intervention.

New York City's Broadband Infrastructure Agreements

The New York City Charter assigns DOITT the authority "to administer all franchises and revocable consents relating to telecommunications."[11] This includes existing agreements for private companies to use public rights-of-way for conduit, cable television, mobile telecommunications, public communications structures, and information services (including broadband).[12] In addition, RCN, the fourth largest broadband provider in the city in terms of census blocks with available service, operates pursuant to an Open Video Services Contract. Transit Wireless has a Mobile Subway Stations Franchise to install fiber optic cables and related equipment to deliver wireless services in the subway stations operated by the Metropolitan Transit Authority. There may be opportunity for developing new franchise or other agreements, consistent with applicable laws. These franchise agreements can last up to 15 years and are periodically subject to new agreements post-expiration.

Figure 20: Timeline of Franchise Milestones



The United States Supreme Court
Source: Claire Anderson/Unsplash

Regulatory Environment

Telecom providers must adhere to federal and state requirements including those of the Federal Communications Commission and the New York State Public Service Commission. Since 2017, the FCC has taken several actions that favor large telecom companies at the expense of consumers and local governments, including the elimination of privacy protections, affordability programs, and net neutrality requirements, leaving the City striving to ensure more broadband options are available to all New Yorkers.

Use of City assets for broadband deployment requires adherence to local regulations and rules. Starting with the City level, the Mayor's Office of the Chief Technology Officer works to solve technology and access issues that New Yorkers face and monitors and advocates for changes on federal, state, and local broadband matters. The City's Department of Information Technology and Telecommunications (DOITT) is empowered by the City Charter to negotiate and enter into telecommunications franchises and contracts – the primary mechanism for broadband infrastructure delivery today.

Bushwick Library Computer Lab
Source: Gregg Richards/Brooklyn Public Library

Digital Privacy

American consumers know their privacy is at risk when they use the internet, but believe there is little they can do to address it on their own. Only 20% trust email providers or cell phone companies to protect their data, while only 14% trust retailers, and just 9% trust social media companies. Evidence suggests that this lack of trust deters certain populations from going online.

Nonetheless, companies have capitalized on the absence of comprehensive federal privacy protections for consumers with data collection practices that advance business interests at the expense of consumers. New online tracking methods make it harder for internet users to know that companies are collecting their data, and harder for users to opt out of data collection. Too often, companies' terms of service and widespread data sharing confound individuals' ability to delete their data, once collected.

Meanwhile, a growing number of digital devices support companies' data collection. In homes, data streams from devices ranging from digital door locks and doorbell cameras to internet-connected utility meters and digital personal assistants' always-on microphones. Sold with the promise of improving performance and convenience, these data collections are often used for other profit motives or surveillance, with few protections in place. For example, the maker of a widely used digital assistant has allowed contractors to transcribe and analyze raw recordings of customers speaking to their devices.

The mixed nature of companies' data collection is nowhere more apparent than in the robust economy for mobile phone-derived location data. Location data can be used for good; however, widespread use of mobile phone location data can lead to abuses of customer data and the terms of customer consent: telecom companies routinely sell consumer location data to companies whose known customers include bounty hunters and other unauthorized buyers.

Recognizing these threats to New York City residents, the City of New York has launched a holistic approach to privacy protection spanning administrative and legislative solutions, consumer education, and new technical tools to ensure consistent privacy protections across the city without impeding important business operations or innovation. The City maintains strong privacy protections in the user policies for the LinkNYC Wi-Fi system, and has strengthened public Wi-Fi networks with Quad9 DNS-based cybersecurity and a free mobile threat detection app, NYC Secure, that alerts users to suspicious activity on their cell phones.

The City has improved its internal governance, establishing the Mayor's Office of Information Privacy to govern City agencies' and contractors' handling of New Yorkers' identifying information. This systemwide effort works to ensure that New Yorkers can use City services without fear of exposing sensitive personal information. The City continues to consider legislative, advocacy, and public education measures to protect New Yorkers' privacy in the use of the internet and connected technologies.

NYC's Achievements Toward Universal Broadband

Over the past several years, the City of New York has developed and implemented a series of pilot projects and initial actions that have connected more New Yorkers to the internet and informed the development of this overarching Master Plan. These actions have included no-cost internet service for thousands of low-income households and for millions of New Yorkers in public space, a citywide program to make digital inclusion services universally available, leading cities around the world in the fight for digital rights, and developing a strategic vision for broadband infrastructure.

EXPANDED INTERNET SERVICE FOR NEW YORKERS

The **Queensbridge Connected** program brings broadband to improve quality of life at Long Island City's Queensbridge Houses, which is the largest public housing development in the nation. The program serves the community's 7,000 residents with free high-speed Wi-Fi service in households and common areas for three years. The City has also put in place an onsite customer care office, a tech lab operated by the Queens Public Library offering tech skills training, and a community computer center with digital literacy trainings for seniors. With approximately 90% of households having signed up for the service, Queensbridge Connected has become a national model for achieving universal broadband.[13]

Beginning in 2016, the New York City Economic Development Corporation (NYCEDC) supported the development of **resilient Wi-Fi networks operated by community-based organizations** (CBOs) for small businesses impacted by Hurricane Sandy in six neighborhoods across the city through **RISE:NYC**. Resilient mesh networks were installed in partnership with The Point Community Development Corporation in Hunts Point, the Bronx; Fifth Avenue Committee in Gowanus; Kings Bay Y in Sheepshead Bay; Silicon Harlem in East Harlem, Manhttan; and the Rockaway Development and Revitalization Corporation in Far Rockaway, Queens, in a project led by the New America Foundation. The Red Hook Initiative expanded on an existing community Wi-Fi network in Red Hook, Brooklyn. The partnering CBOs led community outreach and small business enrollment, and each network has been supported by a group of "Digital Stewards" who were trained to install and maintain the networks and are there to help the neighborhood re-connect in the event of another storm or other disaster. NYCEDC also delivered the **ConnectIBZ** program with public-private partnerships to address digital deserts in four of the city's industrial business zones.

The City brought **ConnectHome** to the Bronx in partnership with the New York City Housing Authority, the U.S. Department of Housing and Urban Development, and T-Mobile. The program, funded entirely by the City and T-Mobile, distributed connected tablets to over 5,000 families with school-aged children living in public housing in the Bronx for two years ending in fall 2019. It was the largest such implementation among the 30 communities participating in the national ConnectHome program. The City and its three public library systems also began a program in 2015 to loan out **10,000 mobile Wi-Fi hotspots** to patrons across the city, with many still in circulation.

Since 2015, the City has more than tripled the number of free public Wi-Fi access points, including a seven-fold increase in the number of neighborhoods that have Wi-Fi in a commercial corridor. Much of this increase is due to **LinkNYC,** the largest, fastest municipal Wi-Fi system in the world. More than five million people have used LinkNYC since its launch.

UNIVERSAL DIGITAL INCLUSION

New York City operates the largest system of public computer centers and digital literacy programs in the country. Across its libraries, senior centers, and community centers, the City provides a diverse array of resources to support internet use, which can include knowledgeable staff, varied software, language and disability access tools, and advanced equipment, such as digital media production kits, single-board computers, and 3D printers. Additionally, the City operates four "Digital Vans," which are mobile computer labs that circulate among New York City Housing Authority developments and surrounding communities to provide free access to computers and the internet, as well as onboard instructor support.

Figure 21: New York City Digital Inclusion Resources

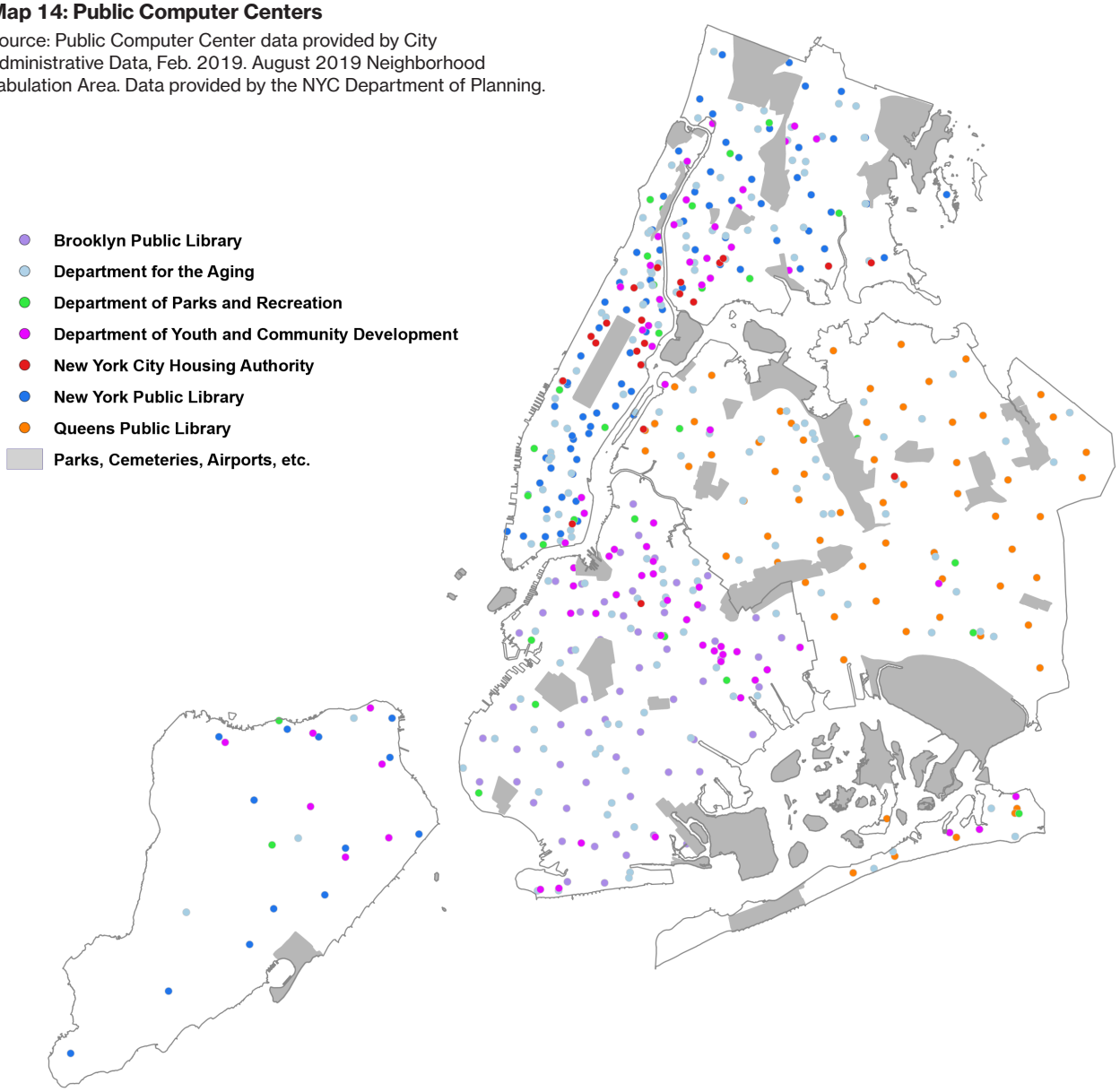
PUBLIC COMPUTER CENTERS	COMPUTER WORKSTATIONS	WEEKLY OPEN LAB HOURS	WEEKLY DIGITAL LITERACY TRAINING HOURS
508	11,000	21,000	2,500

The City's public computer centers further provide over 2,500 hours per week of digital skills training programs, which range from basic training in using devices and the internet, to advanced courses in coding, design, media literacy, civic engagement, and more. The Mayor's Office of the Chief Technology Officer published the first comprehensive inventory of these computer centers and resources in 2019.[14]

This office has built on this citywide network to launch new, strategic education campaigns.[15] In 2017, it partnered with the Metropolitan New York Library Council, Mozilla Foundation, The New School, Brooklyn Public Library, New York Public Library, and Queens Public Library to develop **NYC Digital Safety: Privacy & Security,** a best-in-class digital curriculum specifically designed for the needs of library staff. The program has already trained more than 1,000 library staff to answer patron questions about online privacy and digital security, including at least one person at every library branch throughout New York City. The program further established **Library Privacy Week,** an annual series of public events across the city to raise public awareness of the importance of online privacy.[16] In 2018, the Mayor's Office of the Chief Technology Officer additionally partnered with the Mayor's Office of Immigrant Affairs, Mozilla Foundation, and Research Action Design to implement the **Stronger NYC Communities** project to advance the digital security capacities of CBOs that work

Map 14: Public Computer Centers

Source: Public Computer Center data provided by City Administrative Data, Feb. 2019. August 2019 Neighborhood Tabulation Area. Data provided by the NYC Department of Planning.



directly with immigrant populations.[17] Finally, the New York City Cyber Command (NYC3) released the **NYC Secure** App in 2018, a no-cost City-funded mobile app that alerts users if a mobile device or tablet encounters threats such as a potentially unsecure Wi-Fi network or system tampering.[18]

The New York City Department of Education (DOE) plays a critical role in connecting New York City's 1.1 million students to the digital resources and skills they need. In 2017, DOE launched a partnership as part of Sprint's national "1Million" program to provide over 30,000 high school students with access to free, take-home internet hotspots. In October 2019, DOE announced the completion of a ten-fold increase in the minimum public school internet bandwidth, ensuring that every public school in the city has access to speed of at least 100 Mbps. These connectivity efforts bolster DOE's work to equip New York City youth with digital skills – through its **CS4All** program to integrate Computer Science education, its tech-focused **Career and Technical Education** programs, and its school-level **digital inclusion and digital citizenship** initiatives. DOE is further committed to making digital platforms accessible to people with disabilities and embraces WCAG 2.00 AA standards.

The City is engaged in a broader range of efforts to ensure its digital tools and platforms are inclusive and accessible. The New York City Mayor's Office for People with Disabilities (MOPD) provides training and technical assistance to City employees on digital accessibility and publishes a recurring report on the state of digital accessibility for the City.[19] In 2018-19, MOPD, the Mayor's Office of the Chief Technology Officer, and the Mayor's Office of Creative Communications hosted "NYC Digital Inclusion" conferences focused on this subject.[20] The City's Local Law 30, established in 2017, sets out a range of requirements to ensure that residents can access City information and services – including those online – in designated languages.[21]

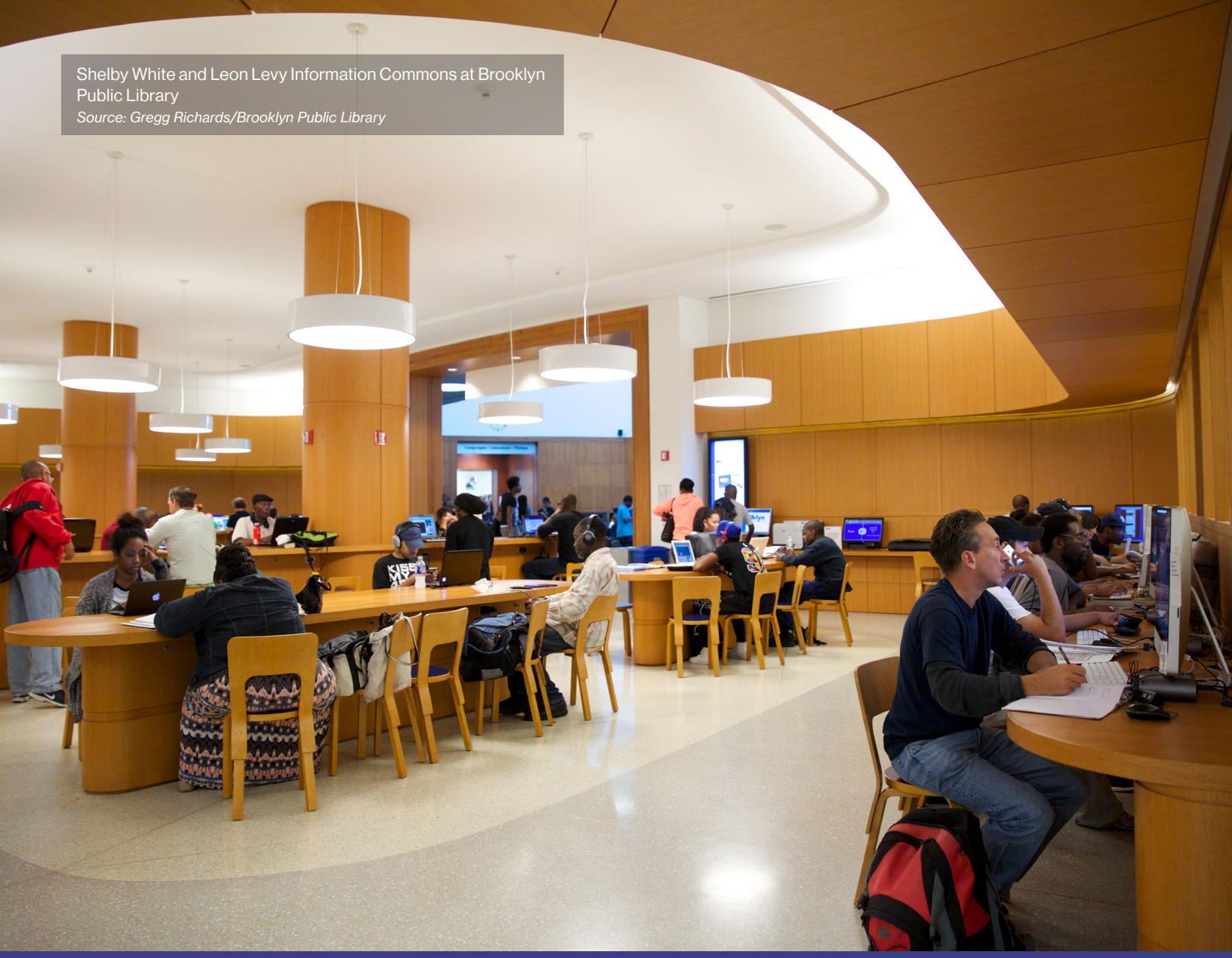
WORLD LEADER ON DIGITAL RIGHTS

In March 2018, Mayor de Blasio announced the **Cities Open Internet Pledge**, mobilizing more than 100 mayors who represent more than 25 million people across the U.S. to "take all available steps to ensure the internet remains open, and to keep gatekeepers from throttling, blocking, or limiting government content on the internet."

In November 2018, New York City joined with City of Barcelona and Amsterdam to launch the **Cities Coalition for Digital Rights** focused on five key principles:

- Universal and equal access to the internet, and digital literacy;
- Privacy, data protection, and security;
- Transparency, accountability, and non-discrimination of data, content and algorithms;
- Participatory democracy, diversity, and inclusion;
- Open and ethical digital service standards.

The coalition has been endorsed by the United Nations Human Settlements Programme (UN-Habitat) and is growing quickly.[22]



Shelby White and Leon Levy Information Commons at Brooklyn Public Library
Source: Gregg Richards/Brooklyn Public Library

Truth in Broadband Reports & Datasets

The Mayor's Office of the Chief Technology Officer has gathered stakeholder input, organized and verified existing data, and analyzed new information to create a comprehensive and detailed view of existing connectivity conditions in New York City. Together with this Internet Master Plan, these findings will inform the City's strategy for shaping the internet of the future.

Access & Connectivity in New York City (2018): This report analyzes publicly available data offering the clearest picture of the digital divide in the city.

Public Wi-Fi in New York City (2019): This report discusses current and planned coverage, and establishes standards for free public Wi-Fi service.

Citywide Public Computer Center Data (2019): the Mayor's Office of the Chief Technology Officer has published the City's first-ever comprehensive inventory of its 508 public computer centers (PCCs) on NYC's free public data portal, Open Data. The PCC dataset catalogs hours, locations, internet speeds, equipment, language and disability access resources, and digital literacy programs.

Due to these efforts, dozens of new data sets have been added to the City's Open Data portal.

Endnotes

1. The available census data do not allow for the same level of geographic granularity in analyzing the different categories of home and mobile adoption, so many of the data points in this section rely solely on the home broadband measure.

2. See the forthcoming book, *The Digitally Invisible: How the Internet is Creating the New Underclass*, by Nicol Turner Lee.

3. Assuming a rate of $50 per month for each service. The U.S. poverty threshold is $24,858 for a family of four (source: U.S. Bureau of the Census). Approximately 50% of New York City households in poverty have a home broadband subscription. The median household income for households in poverty with broadband is $10,415, for which a $100 monthly expense for broadband would be 10%.

4. See Larry Barrett, "77% of Teachers Assign Internet-Required Homework: Survey," Multichannel News, (March 2015) at https://www.multichannel.com/news/77-teachers-assign-internet-required-homework-survey-298980.

5. The extent of the Empire City Subway system is not even across Manhattan and the Bronx. Data about the variations in the ECS conduit system from neighborhood to neighborhood is available at https://data.cityofnewyork.us/Business/ECS-Conduit-Data/x9i6-ckbm.

6. For example, see New York Consolidated Laws, Public Service Law - PBS § 119-a. "Attachments to utility poles;use of utility ducts, trenches and conduits" and 47 U.S. Code § 224. "Pole attachments."

7. The DOITT microtrenching webpage is available at https://www1.nyc.gov/site/doitt/business/microtrenching.page. Microtrenching is subject to current Department of Transportation Office of Construction Mitigation and Coordination (OCMC) permitting requirements.

8. Installations on rooftops of cellular equipment are permitted in New York City under applicable local laws and regulations, such as, but not limited to, guidelines established by the Department of Buildings and the Fire Department. For more information, see, for example: https://www1.nyc.gov/assets/buildings/pdf/code_notes_antenna-cellular-telecom-alterations.pdf.

9. See, for example, New York City Fire Code § 504.4 "Rooftop access and obstructions" at https://www1.nyc.gov/assets/fdny/downloads/pdf/about/Chapter-05.pdf.

10. For a comprehensive assessment, see New York City Mayor's Office of the Chief Technology Officer, "Truth in Broadband: Public Wi-Fi in New York City," (May 2019) at https://tech.cityofnewyork.us/wp-content/uploads/2019/07/NYC-Connected-Truth-in-Broadband-Public-Wi-Fi-Report_v2.pdf.

11. See The New York City Charter, Chapter 48, Section 1072, "Department of Information Technology and Telecommunications, Powers and duties of the department," at https://library.amlegalcom/nxt/gateway.dll/New%20York/charter/newyorkcitycharter?f=templates$fn=default.htm$3.0$vid=amlegal:newyork_ny.

12. For more information on the DOITT franchise process, see: https://www1.nyc.gov/site/doitt/business/franchise-process.page.

13. See Rakeen Mabud and Marybeth Seitz-Brown, "Wired: Connecting Equity to a Universal Broadband Strategy," published by Roosevelt Institute and The New School, (September 2017) at http://rooseveltinstitute.org/wp-content/uploads/2017/09/Wired_Roosevelt-Institute.pdf and Gideon Lewis-Kraus, "Inside the Battle to Bring Broadband to New York's Public Housing," *Wired*, (November 2016) at https://www.wired.com/2016/11/bringing-internet-to-new-york-public-housing.

14. Mayor's Office of the Chief Technology Officer, "Citywide Public Computer Centers" on NYC OpenData Portal at https://data.cityofnewyork.us/Social-Services/Citywide-Public-Computer-Centers/cuzb-dmcd.

15. For an overview of New York City's digital inclusion initiatives, see Meghan McDermott, "New York City Internet Health Report" published by Mozilla Foundation, (April 2019) at https://foundation.mozilla.org/documents/18/New_York_City_Internet_Health_Report.pdf.

16. For information on NYC Digital Safety: Privacy & Security see https://nycdigitalsafety.org. For information on Library Privacy Week see https://libraryprivacyweek.nyc.

17. For information on Stronger NYC Communities see https://stronger-communities.info. For the tools and ideas from the workshops, see "Stronger NYC Communities Organizational Digital Security Guide" (Summer 2018) at https://foundation.mozilla.org/documents/16/Stronger_NYC_Communities_-_Full_Guide.pdf.

18. For more information on NYC Secure, see https://secure.nyc/.

19. See "New York City Digital Accessibility Report 2019" at https://www1.nyc.gov/site/mopd/about/reports-publications.page.

20. For more information about the 2019 conference, see https://www1.nyc.gov/site/mopd/about/pr-2019-05-17-digital-inclusion-conference.page.

21. For more information on Local Law 30 and on the broader work the Mayor's Office of Immigrant Affairs does to support meaningful access to City information and services for New Yorkers with Limited English Proficiency, see https://www1.nyc.gov/site/immigrants/help/city-services/language-access.page.

22. For more information on Cities for Digital Rights, see https://citiesfordigitalrights.org/.

New York Public Library Branch Exterior
Source: Edwin J. Torres/Mayoral Photo Office

04

THE NETWORK FOR UNIVERSAL BROADBAND

THIS SECTION DESCRIBES THE PUBLIC ASSETS, INFRASTRUCTURE, AND RANGE OF TECHNOLOGIES THAT WILL DELIVER UNIVERSAL BROADBAND IN NEW YORK CITY.

Introduction

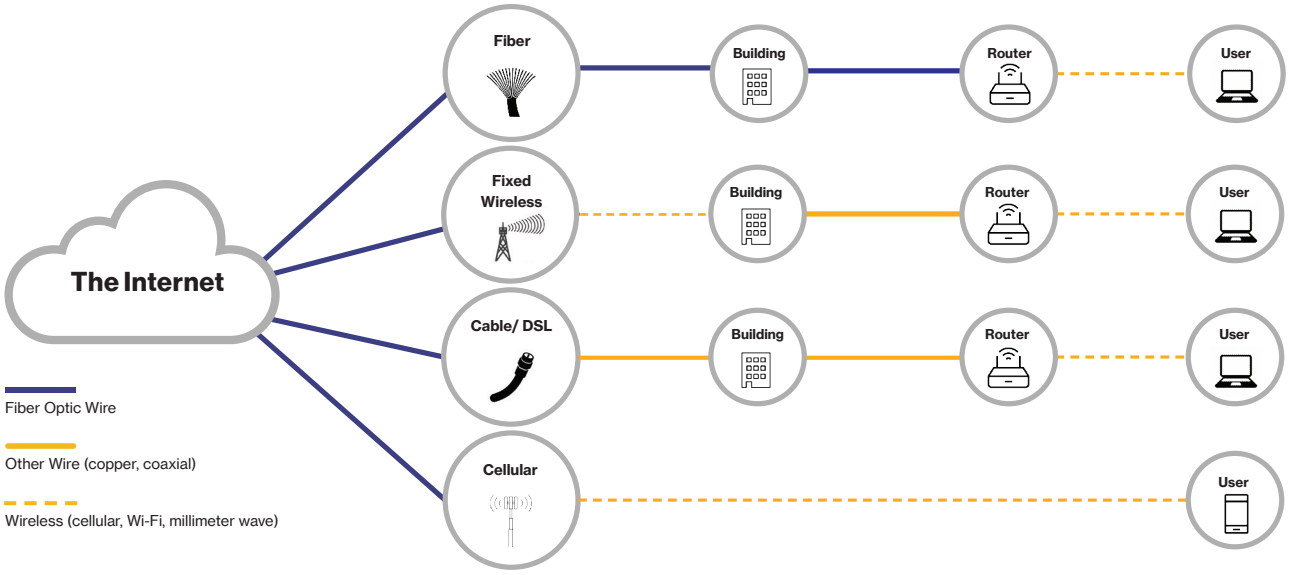
The incredible diversity of New York City and the robust level of private sector activity here mean universal broadband throughout the five boroughs of New York City will require multiple operators using a range of technologies. The City's proposed network for universal broadband will support New Yorkers' multi-modal use of the internet: constantly, seamlessly mobile with robust, reliable service at home and at other fixed locations. The proposed network will prioritize and optimize infrastructure that can be shared by multiple operators to lower costs, increase competition, minimize physical disruption to the city and incentivize private-sector investments to reach and serve customers. Such broadband infrastructure – available to any operator on a neutral or shared basis – is known as "open access" or "neutral host."

Based on the data and analyses contained in this Master Plan, the City has determined that universal broadband calls for an open access fiber optic infrastructure built out to nearly every street intersection with an aggregation point in every neighborhood. A network operator would be able to extend the fiber optic infrastructure from the intersection to a pole or building and deliver service using any of a number of potential technologies. Specifically, the Master Plan leverages City real estate assets and public rights-of-way to deploy new infrastructure. The goal for this infrastructure is to support the rapid and equitable deployment of multiple choices for service in keeping with the broadband principles.

The planned infrastructure, were it to be built entirely new throughout the whole city and rely on the existing open access conduit system in Manhattan and the Bronx, is estimated to cost $2.1 billion. Such new infrastructure at a hyperlocal neighborhood scale is estimated to cost between $1 million and $42 million per neighborhood, assuming a backhaul connection to the internet is available at an existing aggregation point. Infrastructure build out will prioritize those neighborhoods that today have low levels of commercial fiber service. In addition, priority will be given to those neighborhoods where the City's analysis shows the cost of new construction to be a barrier to entry for providers and services. By contrast, areas where fixed wireless access may be technologically and logistically feasible, relying on public rooftops or poles, will likely require less fiber infrastructure initially. Determinations will be made on a detailed neighborhood-by-neighborhood basis.

This fiber network will be overlaid with a neutral radio access network capable of providing mobile wireless service throughout every neighborhood. This wireless network will use shared spectrum to support multiple operators. The envisioned shared-spectrum mobile wireless network will require a radio at approximately every other intersection to provide coverage throughout the city. The infrastructure for the wireless network will include no-cost high-speed Wi-Fi in pedestrian corridors and public spaces. The mobile network will enable the efficient deployment of licensed spectrum by commercial operators to provide the most advanced mobile telecommunications services available anywhere. The Master Plan prioritizes mobile wireless infrastructure in low-income areas where New Yorkers are most dependent on mobile service, as well as in areas where commercial cellular deployment is already placing the heaviest burden on City assets.

Figure 22: Methods of Internet Delivery



With regards to citywide fiber and wireless infrastructure, the Master Plan accounts for mature, widely-used broadband technologies, as well as emerging and future technologies that show promise for use in New York City. The Master Plan focuses on the required real estate assets and infrastructure, but equipment, operations, and service are also necessary to deliver broadband to users. Deployment using City real estate assets and public rights-of-way will be financed through both public and private investment or connecting with existing private infrastructure where possible. This section reviews the relevant technologies, describes the basic elements of the broadband network envisioned by the Master Plan, and describes how City assets will be used to implement the networks for universal broadband.

Broadband Technologies

Generally, there are three types of broadband connections: wired, fixed wireless access, and mobile wireless.[1] In addition to the standard technologies already in widespread use within these types of connections, there are a number of emerging technologies that will change the way New Yorkers receive internet service in the next five to ten years. Newly-available spectrum bands and technological breakthroughs, facilitated by new technical standards such as 5G and Wi-Fi 6, are coming to market now and are expected to reach wide-scale deployment over the next decade due to significant private investment. Other technologies, such as Free Space Optics or Mesh Wi-Fi, show potential to impact internet service delivery at large scale with cost reductions or community-driven deployment models. Importantly, many of these technologies have the capacity to deliver gigabit speeds.

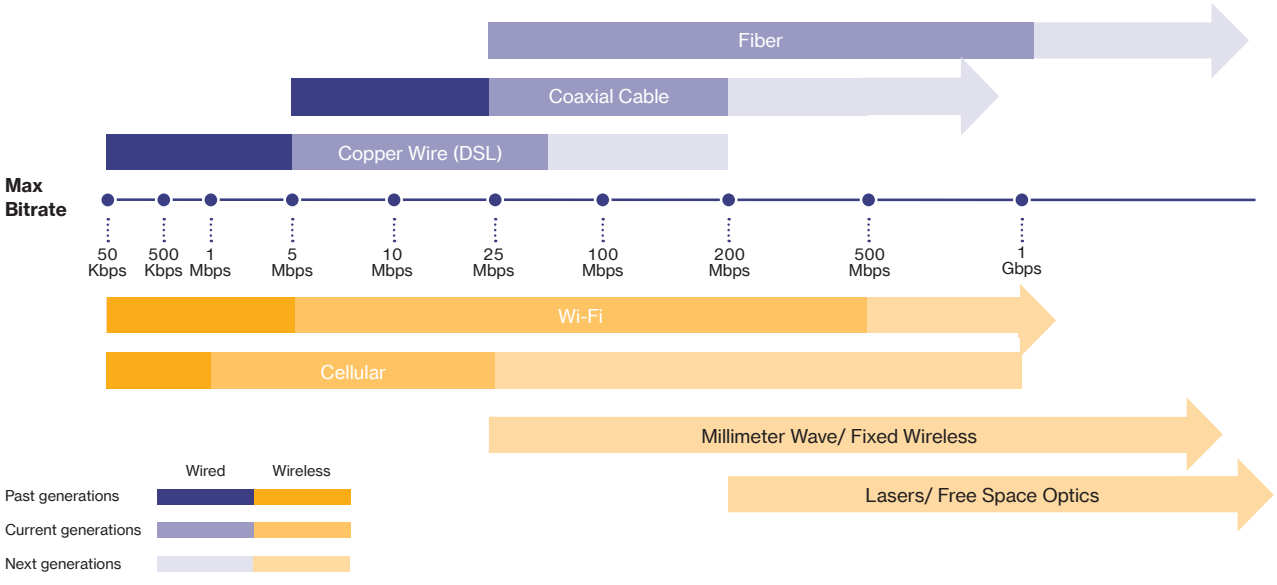
WIRED

Wired broadband technologies can run below ground or above ground, meaning that the primary real estate requirement is space in conduit or on utility poles. The wire connects to a building, where the signal is then redistributed within the building. Among wired broadband infrastructure, there are two broad types:

- ***Fiber Optics*** – Fiber optic technology sends data via light through glass fibers that are roughly the diameter of a human hair. Fiber provides scalable capacity beyond thousands of gigabits per second; it is not susceptible to interference and can support multiple users. The useful life of fiber cable has not been determined, as neither use nor time appears to produce any degration of fiber infrastructure. A fiber optic connection is generally the most reliable, highest capacity type of connection.

- ***Cable or Digital Subscriber Line (DSL)*** – Existing coaxial or copper wires, originally installed for cable television or telephone service, are also used for wireline internet service in combination with fiber optics. While new innovations are extending the useful life of copper in some locations, fiber optic lines are favored for all new deployments.

Figure 23: Internet Transmission Media



FIXED WIRELESS ACCESS

Wireless broadband uses radio links between stationary sites, usually with one side connected with fiber optics and serving as a "hub" for multiple wireless links. Depending on the type of wireless technology, the distance of the connection and line of sight, a fixed wireless connection can support multi-gigabit speeds with high reliability. It does not have the same potential capacity as fiber optics, but is often a faster and less expensive way to deliver high-speed connections for limited numbers of users. Fixed wireless might connect to a building, where the signal would then be redistributed within the building. Rooftops are the primary real estate requirement for common fixed wireless infrastructure. Particularly useful are rooftops on tall buildings connected to fiber optics in areas with high variation in building heights. Fixed wireless theoretically presents significant potential for cost-effective implementation and a great opportunity, but the technology has not yet reached maturity as a residential broadband solution.

Millimeter Wave Fixed Wireless Access

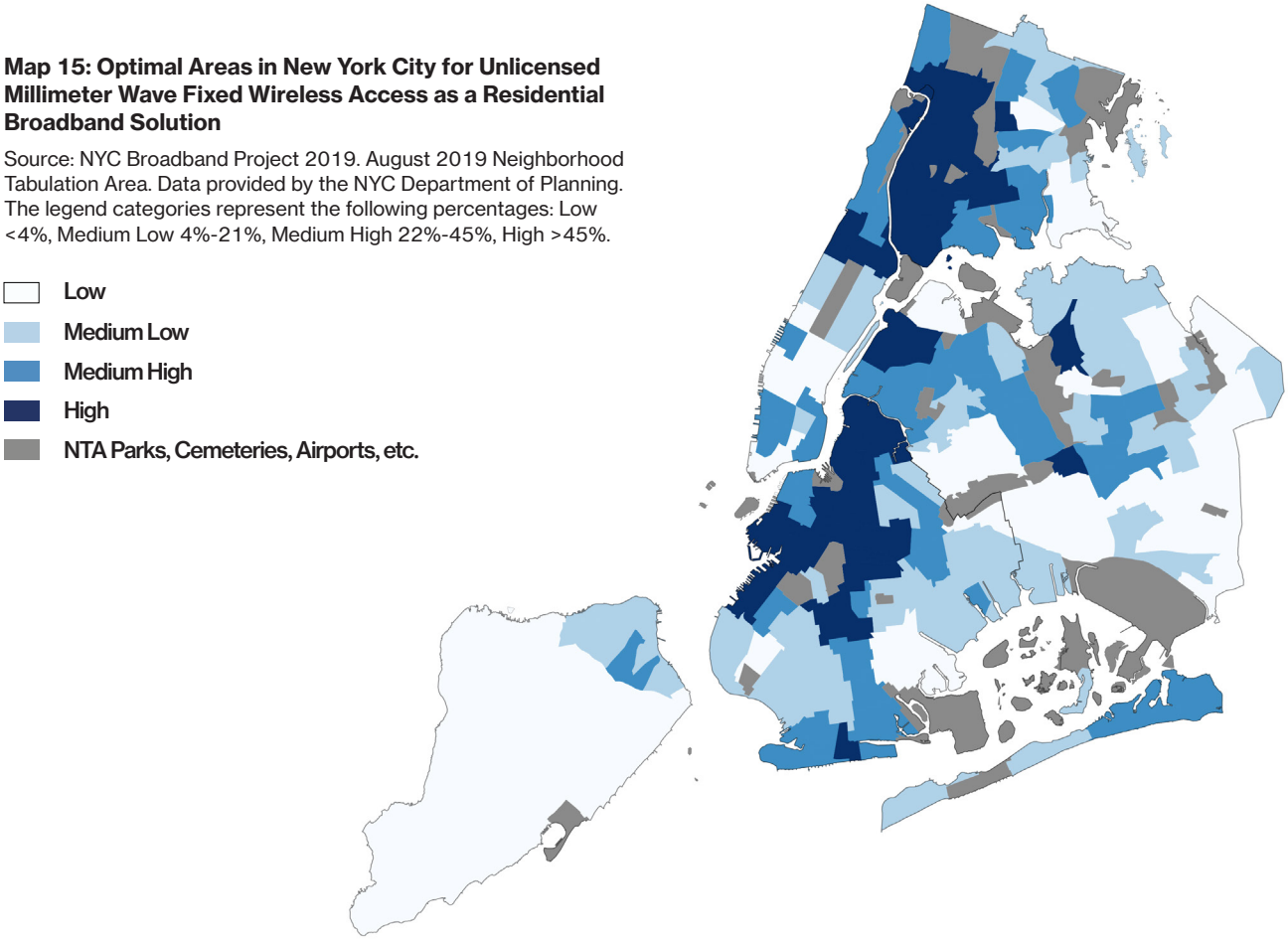
Millimeter Wave Fixed Wireless Access (mmWave-FWA) can deliver bandwidths comparable to that of fiber-to-the-premises connections, but with less construction because a fiber connection is not required at each lot line. However, mmWave signals are highly susceptible to interference, which limits the viability of this technology in neighborhoods that lack building height variation or have substantial tree cover or other obstructions. Currently, mmWave bands (including 28 GHz and 39 GHz) that are licensed are generally being incorporated into 5G deployments; companies that hold these licenses can also use these deployments for fixed wireless service. In addition, there are publicly available unlicensed mmWave bands (around 60-90 GHz) that use different technological standards (including a modification of Wi-Fi called Wi-Gig) and equipment that can be much smaller than the 5G mmWave radios.

Incorporating unlicensed mmWave equipment into street-level installations can reduce the need to connect fiber to every pole and can expand service to homes and businesses. MmWave-FWA along these lines can potentially serve relatively dense communities, estimated up to 2,500 units per square mile, though this approach has not yet been fully implemented at scale. As with the mobile use of these frequencies, an unobstructed line of sight is required between sender and receiver, in most instances, and a signal may not reach higher floors from the street.

Some equipment manufacturers and internet service providers have developed non-line-of-site (NLOS) millimeter wave solutions for broadband service, and others use a dense system of radios to route around obstructions. These solutions may

Map 15: Optimal Areas in New York City for Unlicensed Millimeter Wave Fixed Wireless Access as a Residential Broadband Solution

Source: NYC Broadband Project 2019. August 2019 Neighborhood Tabulation Area. Data provided by the NYC Department of Planning. The legend categories represent the following percentages: Low <4%, Medium Low 4%-21%, Medium High 22%-45%, High >45%.



not reliably deliver a bidirectional gigabit connection, but they make mmWave-FWA more practical and potentially viable in more areas. There are also more robust mmWave solutions that can connect rooftop to rooftop with 10 Gbps links.

Free Space Optics

Free Space Optics refers to the use of visible light and laser beams for wireless communication. No license is required and the technology supports connections of 1 Gbps up to 10 Gbps. There is no radio frequency interference between adjacent laserbeams so multiple links can be placed close together to multiply the overall link capacity. However, any physical obstruction blocks the signal completely and fog, smog, or water can cause disruptions. Properly installed links can transmit over long distances, but typical applications are for shorter distances with secure, unobstructed line of sight. For example, the technology could do well connecting two buildings across the street from each other.

Mesh Wi-Fi

Mesh Wi-Fi refers to a method of Wi-Fi deployment utilizing multiple transmitters that repeat a Wi-Fi signal and spread the reach of the network. This can reduce the number of wired connections needed and, where the Wi-Fi access points can get signals from multiple repeaters, can add resilience to the network. A Mesh Wi-Fi network is dependent on robust enterprise backhaul to be able to distribute broadband speeds to all users. However, Mesh Wi-Fi can also operate as independent networks, supporting highly localized applications and communication even without connecting to the internet, or if the connection to the internet is interrupted or damaged.

Because Mesh Wi-Fi can be a way to share an internet connection and reduce the cost per user, community-based organizations and decentralized volunteer networks have used the technology to build community-controlled networks – so much so that Mesh Wi-Fi is often used as a synonym for Community Wi-Fi, even though community networks can incorporate other types of unlicensed wireless connections. Mesh Wi-Fi is also an increasingly popular method of distributing an internet connection indoors, extending signals within a home or apartment building. What these networks lack in private investment, they aim to make up through community organizing and social capital.

MOBILE WIRELESS

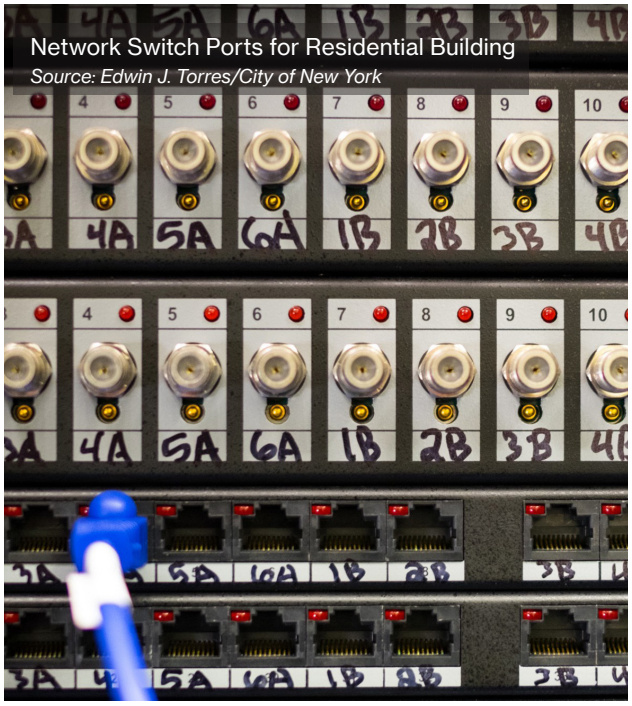
Mobile broadband allows for one side of a wireless link to stay connected while moving through a coverage area, which may be served by multiple stationary radios. Each radio's coverage area is called a "cell," leading to mobile wireless often being referred to as "cellular" or "cell service." The tradeoff for mobility is usually slower speeds and less reliability than a fixed connection. Mobile wireless can be supplemented with "hotspots" of higher capacity and more reliable connectivity. Moving from hotspot to hotspot is sometimes called "nomadic" connectivity. Mobile wireless connects directly to a user's device, which can be carried outside or inside, but sometimes requires additional equipment to bring the signal inside. Poles and low-rise rooftops can be used for mobile wireless.

5G

5G refers to the technical standard for the next generation – the fifth generation – of mobile connectivity. The technical specification calls for speeds that are projected to be at least 10 times faster than the current 4G network speeds, with lower latency, lower battery power consumption, and capacity to handle many more connections from a single radio. As with past technological evolutions, wireless companies generally will need to add

How New York City will stay on the cutting edge of broadband technology

In 2018, Rutgers University, Columbia University, New York University, City College of New York, University of Arizona, Silicon Harlem, and IBM – in partnership with the City of New York – secured a $22.5 million grant from the National Science Foundation (NSF) to build the nation's first urban-scale advanced wireless research testbed in Harlem. The Cloud-Enhanced Open Software Defined Mobile Wireless Testbed for City-Scale Deployment ("COSMOS") covers approximately one square mile with software-defined radios and will incorporate mobile devices on Columbia University vehicles, enabling simulations of a plethora of network designs. NSF plans to grant up to $300 million for research using the testbed and three others like it that will be built around the country. Through COSMOS, New York City expects to play an active, hands-on role in the research agenda that will shape future generations of broadband technology. The COSMOS research team is also working with teachers from New York City schools to develop a K-12 curriculum so every student will have access to this world-class learning environment and can develop the knowledge to use it. More information can be found at: www.cosmos-lab.org.



Network Switch Ports for Residential Building
Source: Edwin J. Torres/City of New York

new equipment for the next generation of devices while maintaining the old network for the previous generation. 5G will initially be built as a supplement to 4G, with equipment for both networks existing side-by-side, rather than as a complete replacement.

Some wireless companies are beginning to use millimeter wave frequencies for mobile service. These frequencies can carry large amounts of data at high speeds with little latency, but millimeter wave signals are generally only reliable over a few hundred feet and can be obstructed by nearly any material, including a building, a billboard, or even the leaves of a tree. Compared to other frequencies and past generations of cellular service, the coverage cells for mmWave 5G will be much smaller, requiring many more transmitters and therefore requiring access to a significantly higher number of unique parcels of real estate.

The exponential increase in the number of new equipment elements and the number of sites, as additions to the 4G equipment, poses a practical challenge in terms of where they can be placed. The challenge is exacerbated by the sheer number of fiber optic lines required to connect all of the equipment, the number of places needed to tap into that fiber and house the splice points along the route, and the need for electrical power for each radio.[2]

Citizens Broadband Radio Service

The Citizens Broadband Radio Service (CBRS), utilizes newly available radio frequency spectrum in the 3.5 GHz band (3550-3700 Mhz). 3.5 GHz can handle some level of obstruction while still covering an area of up to a quarter mile in radius outdoors, so it is applicable in many environments. CBRS can be used for fixed or mobile wireless, though it is not yet sufficient for ubiquitous bidirectional gigabit-speed services. CBRS is being further developed to support 5G.

The CBRS ecosystem is still developing, but it has the potential to create new opportunities for broadband providers, businesses, and communities to deploy mobile networks in targeted areas.[3] These networks can be standalone private networks (e.g., to connect machines within a factory) or phones, sensors, and vehicles within a business district. The networks can also integrate with traditional cellular networks to extend coverage into unserved or indoor areas. CBRS has potential to unlock additional opportunities to use the Internet of Things (IoT) without having to rely on a paid connection for each device. The CBRS spectrum may also be used by commercial wireless carriers to supplement existing networks.

Wi-Fi 6

Wi-Fi 6 is the next generation of Wi-Fi, which continues to be the most common and most heavily used kind of wireless connection for internet service. One study estimated that Wi-Fi contributed nearly a half-trillion dollars to the U.S. economy in 2018.[4] Wi-Fi's popularity and value come primarily from the fact that it is available for use by anyone according to a standard set of rules, even without a license. Wi-Fi's ubiquity can also pose a challenge: multiple network operators can crowd into the same area, causing interference and decreasing signal quality for all users. Wi-Fi 6 is designed to improve performance under such conditions. It also increases the maximum theoretical data speed of a Wi-Fi network from 1 Gbps today to 10 Gbps. In addition, Wi-Fi 6 improves power consumption and enhances security.[5] The City has published a plan for Wi-Fi deployment citywide based on four use cases for no-cost public service.[6] Under certain conditions, Wi-Fi can also improve mobile service by supplementing or offloading cellular network traffic.

Edge Cloud

Edge Cloud describes a transition from a reliance on large data centers far away to having more, smaller data centers closer to the dense parts of a network. The potential benefits of this architecture include: decreased latency, since storage and processing can happen closer to the user; privacy, since less information has to leave a community; and efficiency, by avoiding the cost and burden of transporting information back and forth across hundreds of miles. An Edge Cloud location can be as compact as a small room, with the proper environmental controls and power backup. However, in order to function as intended, there will need to be orders of magnitude more Edge Cloud sites than there are data centers today.

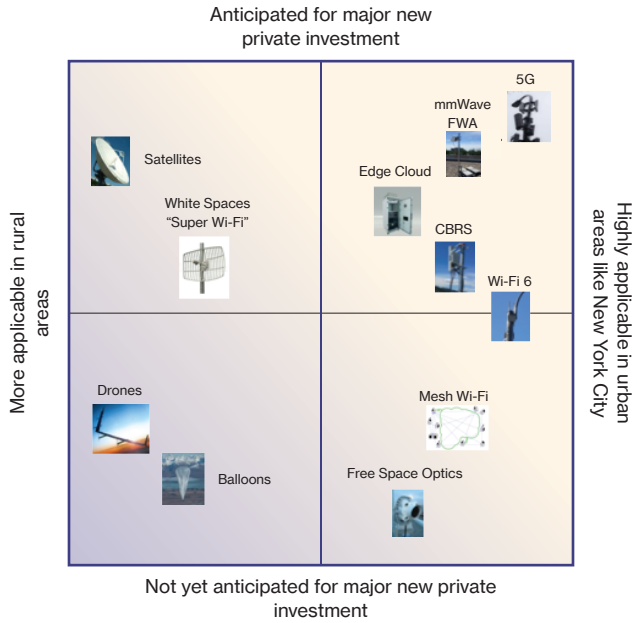
DRIVERS OF PRIVATE INVESTMENT IN NEW INFRASTRUCTURE

Some of the emerging wireless technologies reviewed above can reduce the amount of access-level fiber needed to connect a building or a pole. However, as each will ultimately need to be supported by a fiber optic wireline connection, collectively, they are likely to require additional fiber optic infrastructure in many areas. Legacy fiber optic deployments might not have been designed with connecting points at every street intersection. In other cases, there may not be sufficient space on utility poles for the aerial deployment needed to support the necessary amount of new fiber optic lines. Overall, the combined demand for many more sites to place radios – all much closer together, all connected with fiber, and potentially supported by Edge Cloud data centers – calls for not only additional fiber infrastructure, but a new network architecture.

At present, operators of 5G, mmWave-FWA, CBRS, and Edge Cloud technologies seem best positioned to drive new private investment in infrastructure in New York City.[7] Since these technologies require many of the same real estate and infrastructure elements, coordinated investments can support their collective deployment with greater efficiency. That shared infrastructure, in turn, can be a boon to other existent or emerging broadband technologies that also rely on fiber optic backhaul at poles or rooftops.[8] Other emerging technologies, such as satellite, have financial backing but are unlikely to contribute to new infrastructure in New York City. White Space – sometimes called "Super Wi-Fi" – is being used primarily in rural areas where there are available, unused television channels.

Figure 24: Which Emerging Solutions Suit New York City?

There are many emerging broadband technologies, but only some will have an impact on dense urban areas like New York City.



Network Design

This Master Plan anticipates competing internet service providers using a diverse combination of technologies that can potentially meet the City's goals while adhering to its principles and standards. The broadband technologies considered above all require a deployment of fiber optic cables to a set of real estate assets, such as poles and rooftops. Considering the real estate assets that would most commonly be required by those diverse networks, the shared infrastructure to support those networks includes fiber optics to each intersection with connections to rooftops or poles for wireless access. This infrastructure can be deployed at the scale of a single neighborhood, connecting from a collocation facility – a room where multiple fiber networks aggregate and interconnect – to buildings, poles, and manholes through a variety of paths. Multiple neighborhoods with this infrastructure can be connected using existing backhaul fiber with diverse, redundant paths between the collocation facilities and the region's major data centers.

NETWORK ELEMENTS

This Master Plan considers a broadband network based on six elements that can each be delivered distinctly: Real Estate, Infrastructure, Wireless Spectrum, Equipment, Operations, and Services, as described below. Rather than a technical review, this breakdown reflects the necessary contributions and matrix of responsibilities to deliver internet service. The network elements provide a framework for both urban planning and business planning.

Real Estate

Real Estate includes the land or structure upon or within which network infrastructure is built, including underground conduit, surface-level rights-of-way, utility poles for attaching fiber and other cables, rooftop and pole-top access points for mounting wireless equipment, and other critical network facilities such as rooms within buildings or space to locate smaller free-standing cabinets on sidewalks, rooftops, or other interior and exterior locations. Real estate assets can be private assets, City assets, or some combination of both public and private assets. While real estate is fundamental to any broadband network, real estate assets are not specific to communications infrastructure and can have many other functional purposes. They are both capital intensive and extremely long-lasting. Notably, the City of New York is the largest real estate holder in the city, in addition to its authority over public rights-of-way.

Examples of real estate assets for broadband deployment include:

Rooftops: The technical requirement for rooftops is generally a 4'x4' space to host wireless equipment, or

Figure 25: Broadband Network Elements

NETWORK ELEMENT	DESCRIPTION
Real Estate	Conduit, rights-of-way, light and utility poles, hardened rooms, rooftops, and other facilities whose purposes are not solely to support communications networks.
Infrastructure	Passive (non-electronic) infrastructure, including fiber, in-building wiring, towers, cabinets, racks, and other purpose-built structures to support equipment.
Wireless Spectrum	The electromagnetic spectrum exists all around us, but only some portions can be used for broadband networks. The available wireless spectrum is similar to passive infrastructure, but is used in different ways that make it a unique element in a network.
Equipment	Active electronic communications equipment including routers, modems, switches, radios, and antennas that transmit, receive, and manage the signals that carry packets of data.
Operations	Labor, knowledge, and recurring costs required to run the equipment, "light" the passive infrastructure, and maintain the real estate.
Service	Labor and knowledge required to engage with network users to market, sell, educate, and support the people who use the network.

larger to incorporate multiple types of equipment. Rooftops ideally have clear 360-degree line of site for as great a distance as possible. In some cases, lower rooftops are useful for intermediate connections where line of site is not available or to support mobile wireless connections in the surrounding streets.

Rooms or Other Spaces: The technical requirement is generally for ~20'x10' enclosures (or outdoor space for a telecommunications shed) to host fiber connections and network equipment that aggregate individual customers' paths to the fiber backbone internet. These facilities are called Aggregation Points-of-Presence or "AgPOPs." Although not necessary to operate a network, rooms prepared for network equipment are also logical locations for small data centers, which are increasingly important and widespread as content providers put their content closer to their users and as network applications rely on edge computing power.

Poles or Street Furniture: The technical requirement is generally that these sites be 15 feet tall at the very least. To serve a broadband purpose, the poles must be connected to electrical power and fiber optic lines, although in certain cases they can be served with a wireless connection instead of fiber. Utility poles are also required in areas that are suitable for aerial fiber wiring.[9] Access to the right-of-way itself may be of value, particularly in areas where the number of poles is insufficient to support the density of demands. One option the City is considering is the deployment of multi-company, neutral-host structures to include the infrastructure of a number of different companies using a range of technologies.

Underground Conduit, Space on Utility Poles, or Construction in the City-owned Rights-of-Way: A citywide network could require pathways for fiber optic lines in or along all 8,000 miles of the city's streets. In some cases, pathways would be needed on both sides of a street in order to interconnect data centers, provide backhaul to equipment on rooftops and poles, and – in some cases – to serve end users directly. If the only need were to connect a subset of poles and manholes at key intersections, the number of fiber pathways needed could be reduced by about half. Even fewer may be needed if wireless backhaul can be used.

City Real Estate Assets

A set of networks that connect every New York City household with fiber optic service and include fixed wireless service where possible, along with basic mobile wireless coverage throughout city streets, would involve connecting up to 25,000 real estate assets with fiber optic cable running through all 8,000 miles of city streets. That includes the use of 24,000 street poles or comparable street furniture, 800 rooftops, and 180 rooms. The rooms and most of the poles would be distributed evenly throughout the city, generally with one pole at every other intersection.

The asset allocation estimates are based on a subset of potential broadband technologies – fiber-to-the-premises, fixed wireless access, and CBRS, specifically – overlapping in coverage and sharing infrastructure where possible. Other technologies, such as 5G, Wi-Fi, and Edge Cloud, would require additional assets, but could also use the shared infrastructure.

Rooms: A room could serve as a point of aggregation for the fiber optic cables installed in the surrounding neighborhood. Each of these Neighborhood Fiber Collocation Facilities

Fixed wireless access is more feasible where there is variation in building height

Source: CTC Technologies, Inc.

(NFCF) would be in a City-owned or City-controlled facility, or – in some cases – could be installed as a small hut in a parking lot or similar location. A citywide network may require rooms or spaces generally distributed in each of the 180 Neighborhood Tabulation Areas of the city.

Each NFCF would aggregate the fiber infrastructure to the intersections in that neighborhood. The fiber would be sufficient to connect approximately 120 to 150 assets in each neighborhood. These assets would be the poles and rooftops required for CBRS coverage, plus mmWave-FWA deployment where feasible. An NFCF could also serve as a site for Edge Cloud infrastructure – essentially a small data center – under the right conditions.

Each NFCF needs to be served by a core fiber optic backbone network. The goal would be for each NFCF to host multiple fiber operators, creating a dense, redundant network with diverse paths to other NFCFs and critical sites throughout the city. Major fiber operators might choose to have a presence in a particular NFCF in order to connect to the fiber optic cables serving the surrounding neighborhood. The NFCF would be the point where multiple private networks could connect to shared public infrastructure.

NFCFs could potentially be in public facilities where there is already sufficient network capacity and physical space with the ability to meet the required specifications for power, climate control, security, and physical access. Numerous City-controlled facilities are already connected by core networks for which the public has already paid and that meet robust criteria for capacity and redundancy. For example, the City's public schools, public hospitals,

Map 16: Rooftop Fixed Wireless Access Opportunities Based on Presence of City Buildings

Sources: October 2019 City Facilities data, provided by the NYC Department of City Planning. August 2019 Neighborhood Tabulation Area data, provided by the NYC Department of City Planning. The legend categories represent the following counts: None = 0, Low = 1, Medium Low = 2, Medium High = 3, High > 3.

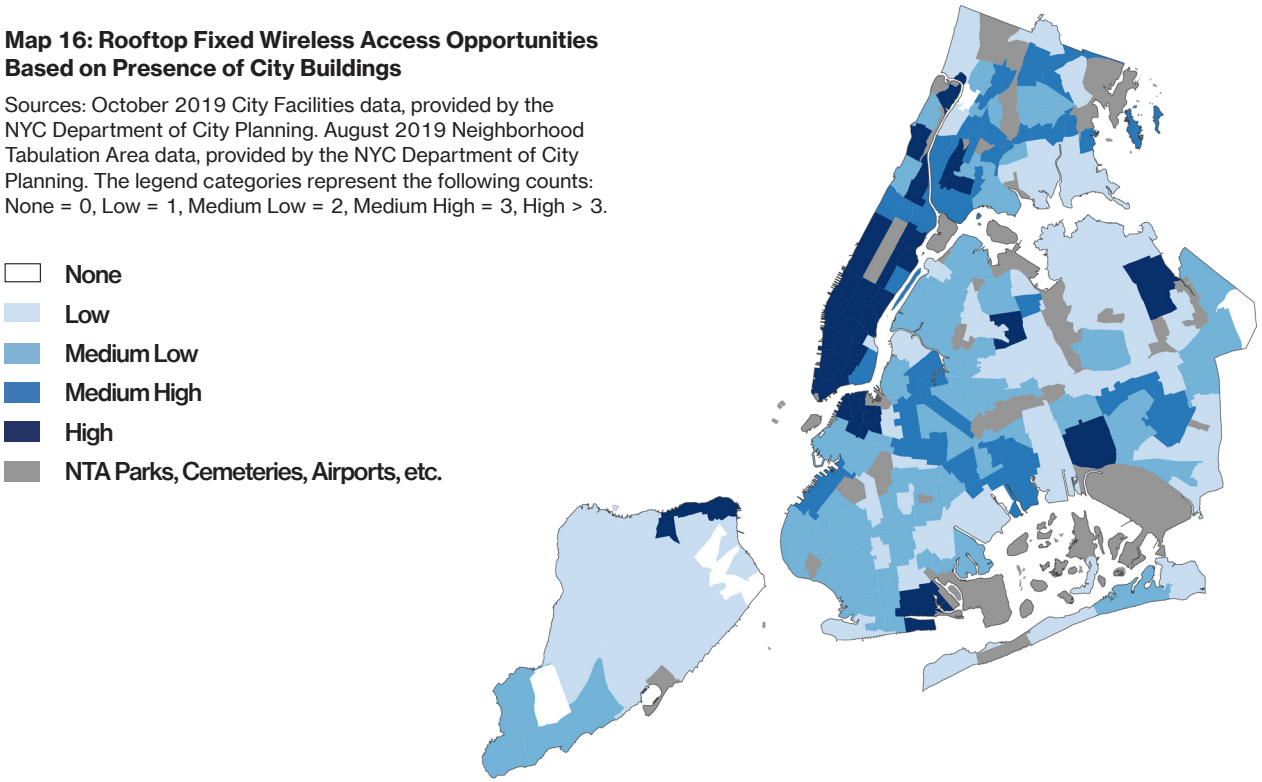


Figure 26: Anticipated Real Estate Assets for Potential Citywide Network

ROOMS	FIBER PATHWAYS	ROOFTOPS	POLES
180	8,000	800	24,000

and certain cultural institutions each already have their own core networks. The NFCFs present an opportunity to interconnect those networks in order to add redundancy or share capacity.

Rooftops: Fiber-connected rooftops with line of sight to surrounding buildings will serve as wireless hub sites. These sites should be at least seven stories tall and taller than the surrounding buildings. Map 16 shows the relative distribution of City facilities of over seven stories. The neighborhoods for these hub sites would be areas with suffient variation in building height to allow for a taller structure to have distant lines of sight.

These hub sites can be useful for a range of fixed wireless technologies. Each neighborhood should support at least one such site.

A citywide network would likely involve the use of approximately 800 rooftops distributed throughout the city, with at least one in each neighborhood.

Poles: A full mobile wireless network, using CBRS and the 3.5 GHz band, overlaid across the entire city to provide outdoor service would require placement of one radio at approximately every other intersection. A citywide network would require 20,000 poles or other comparable assets (in terms of height and location) across the city. A 3.5 GHz network alone would not have the capacity to deliver gigabit speeds to every household and business in New York City. Such a system would, however, meet current mobile broadband needs and lay the groundwork for 5G. Additional poles would be required where mmWave-FWA would be deployed. Other technologies, such as 5G and Wi-Fi, would require additional sites.

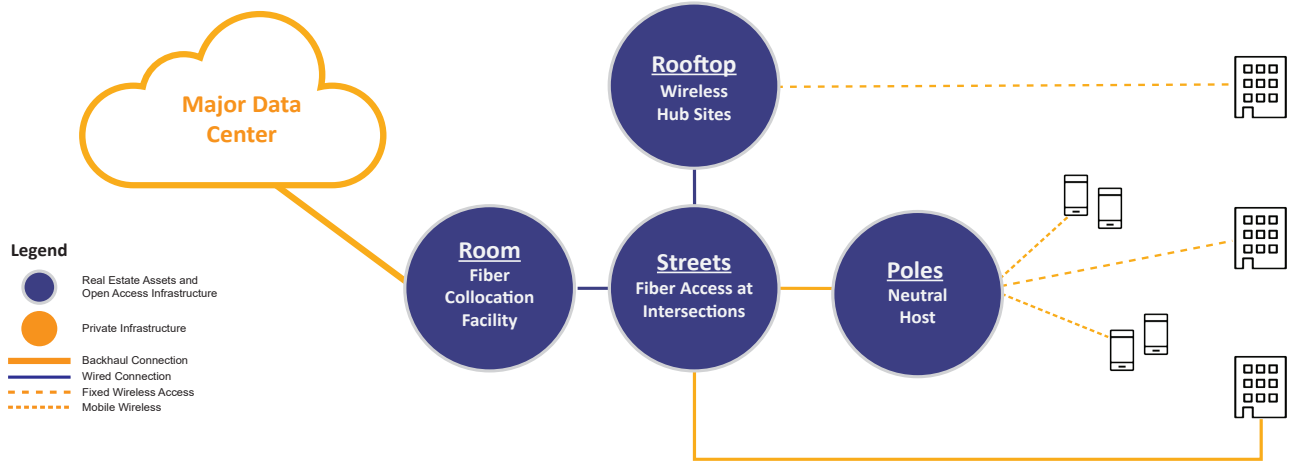
Infrastructure

Infrastructure includes passive network components such as fiber optics, coaxial cable, copper cable, or in-building wiring, as well as hub sites, cabinets, and splitters. While these components do not consume power, the infrastructure includes the wiring and hookups necessary to energize the system with electricity. Broadband network infrastructure also includes purpose-built infrastructure such as towers and monopoles that support wireless service. Generally, network infrastructure has a lifespan of many decades and requires a significant capital cost, but requires a lower operating cost relative to other network elements.

Open Access Fiber

Different network technologies will need different densities of fiber infrastructure, whether to connect rooftops and poles or to connect service directly to individual premises. The presence of a mere single source of fiber infrastructure may not be sufficient to support growth in services. For example, fiber that is fully in use or where the fiber owner will not permit it to be used would not be considered available for neutral uses.

Figure 27: Planned Neighborhood-Scale Infrastructure



LEVELS OF NEW INFRASTRUCTURE

New infrastructure needs to be planned for each neighborhood based on the specific conditions and needs in that community. This Master Plan presents various indicators of the current conditions in each neighborhood. The indicators can inform the development of fiber infrastructure to support different network types.

Figure 28: Sample Broadband Infrastructure Metrics for Informing the Placement of New Infrastructure

BROADBAND INFRASTRUCTURE TYPE	SUITABILITY METRICS	PRIORITIZATION METRICS
Neighborhood Fiber Collocation Facility	• Low Commercial Fiber Coverage • Low Commercial Fiber Choice	• Fiber delivery mode • Congestion in fiber delivery
Fiber to Rooftop Hub Sites	• High Rooftop Opportunity • Low Home Broadband Choice	• Commercial fiber coverage • Commercial fiber choice
Fiber to the Intersection or to Poles (Neutral Host)	• Optimal mm-FWA Areas • Low Home Broadband Choice	• Pole Demand • High Mobile Adoption / Low Home Adoption

There are three broad approaches that the City will employ to ensure fiber infrastructure is both present and available on a neutral basis:

Fiber Choice: If there are at least three commercial fiber providers in a neighborhood, that will be deemed sufficient fiber infrastructure to support new operators in that neighborhood without the need for additional backhaul fiber. The level of coverage of a neighborhood by three providers will determine the need for new fiber infrastructure within the neighborhood.

Fiber Certainty: It may be feasible for a single, private operator to serve an area on a neutral basis. The biggest challenge with the use of a single fiber provider is the uncertainty about the initial time and cost of connecting to that provider, which can then impact the ongoing cost of service. The key conditions to resolve this challenge are for that provider to be in a neutral collocation facility that has room for other operators and for the initial provider to have transparent, contractually guaranteed, non-discriminatory rates for the use of its fiber. For example, the City has master services agreements with multiple fiber operators that, in some cases, include a schedule of products and prices. If a single provider is in a City-controlled NFCF with such a schedule of services, that would satisfy the need for backhaul fiber.

Public Fiber: If the City owns fiber infrastructure in an area, it can determine the conditions of its use. Fiber that is available for anyone to use is sometimes referred to as "open access fiber." Fiber infrastructure can be built to facilitate connections at multiple points, for example with handholes or splice boxes at every intersection, in order to maintain flexibility. With this design, any pole, street furniture, or building can be reached with minimal further construction.

Public fiber infrastructure does, however, require a backhaul connection to the internet. Such an architecture enables the deployment of multiple technologies.

Neutral Host Wireless

Collocation of multiple wireless technologies is possible within existing approved wireless installation shroud designs. New shapes to accommodate alternate antenna designs could also encourage collocation. Another approach could involve new street furniture designs or modifications to existing street furniture designs, subject to further City approval, to enable them to incorporate wireless and telecommunications equipment.

Shared infrastructure lends itself to use as a distributed antenna system (DAS), where multiple operators share the same fiber and radio network in a given area. In such a case, any operator could connect to the network at the NFCF and then share the comprehensive coverage of the neighborhood without the need for further construction or equipment. DAS is now used, for example, in arenas and in the New York City subway. This type of neutral, shared radio access network may be the only means of enabling multiple 5G operators to cover the most densely populated areas of the city. It would limit the amount of equipment needed to serve parks and similar public spaces and would lower the overall cost to expand competition in areas that today have limited broadband infrastructure.

In the future, CBRS may provide an approach to DAS that is less expensive and less difficult to design and build than a traditional DAS. However, equipment is still in the early days of use, so its role in the neutral host wireless solution is still in formation.

Worker Inspects Broadband Network Components
Source: Edwin J. Torres/City of New York

Distributing Internet Service in a Building

This Master Plan focuses on the infrastructure, governance, and business opportunities related to ensuring that broadband service reaches every doorstep in New York City, but such connections will need to go further still in order to get inside every apartment unit. In-building distribution will become an even more critical component of broadband deployment as mobile service advances in performance but with weaker penetration into buildings. However, distributing internet service in a building can be a challenge, particularly for older buildings that do not have wiring or conduit risers in place.

The good news is that a number of technological advancements are driving down the cost and complexity of distributing an internet connection within a building. G.hn is a new way of re-using old telephone wires to provide broadband connections through an old building. The Wi-Fi Alliance has developed the EasyMesh standard to promote interoperability among providers of Wi-Fi repeaters. CBRS aims to be a solution for distributing wireless signals within a property, potentially in combination with new Wi-Fi 6 access points. Many large properties may still require a significant amount of new wiring for new internet service providers to reach every unit.[10]

The increasing viability and simplicity of emerging in-building technologies creates a new business opportunity for a market segment called Managed Service Providers (MSPs). A building owner may retain an MSP, who will typically purchase an enterprise connection to the building and then install a system for distributing that high-capacity connection throughout the property. If the enterprise connection – for example from a commercial fiber provider – is nearby, there can be a substantial difference in cost when choosing between neighbors sharing a connection or each purchasing a typical residential service individually. As such in-building distribution becomes easier to set up and maintain, barriers to becoming or retaining an MSP should go down, making that option even more favorable in comparison.

Opportunities could be found here by startups, minority- or women-owned business enterprises, and cooperatives. Some well-organized apartment buildings or block associations may decide to set up their own networks.

Wireless Spectrum

Radio frequency spectrum comprises the signals used in wireless communications. Spectrum is divided into frequency bands that have different propagation characteristics, technical capabilities, levels of existing use, and associated equipment costs. Generally, lower spectrum bands propagate further and go through or around some obstructions, while higher spectrum bands, including "millimeter wave" bands do not propagate as far.

All spectrum in the United States belongs to the public. Certain bands are reserved for federal government use or for particular purposes, such as public safety.[11] Some bands are licensed to commercial operators and others are available for use without a license.

Unlicensed Mid-band Spectrum: The Federal Communications Commission (FCC) has allocated segments of unlicensed mid-band spectrum in the 2.4 GHz, and 5 GHz bands, which are available for use by any entity. This category includes Wi-Fi, which is valuable in serving users in both indoor and outdoor public spaces. Because it is available to any user, these bands can become congested, limiting their utility.

Shared License Mid-band Spectrum: The new Citizens Broadband Radio Service (CBRS) at 3.5 GHz band can effectively serve mobile and outdoor users with broadband speeds without the need for a direct line of sight.[12] The FCC recently made this band available under a three-tier sharing framework. The highest tier will be incumbent licensees, including U.S. Navy radar; mid-tier access will include Priority Access Licenses; and the lowest tier access will be for unlicensed users.

Roughly half the band (70 MHz) is dedicated to Priority Access Licenses that will be auctioned in June 2020 based on geographic license areas, typically counties, including the five counties comprising New York City. The rest (80 MHz) will remain available for general access on an effectively unlicensed basis. In the areas where the priority licensees have not yet deployed, the entire band (150 MHz) will be available for general use.

An automated geolocation database system authorized by the FCC will coordinate among tiers and protect higher-tier users from interference from lower-tier users.

Lightly-licensed and Unlicensed Millimeter Wave Spectrum: The high-frequency millimeter wave (mmWave) spectrum in the 70, 80, and 90 GHz bands is designated as lightly-licensed and the 60 GHz band is designated for unlicensed use.[13]

Until recently, these bands have had limited utility due to the propagation characteristics, which required clear line of sight for a reliable connection. However, advancements in antenna design and innovative network architectures

Broadband is not a one-size-fits-all technology. Infrastructure consisting of open access fiber and neutral host wireless can maximize the diversity of services available in a neighborhood.

are making these frequency bands more usable. Today, equipment using these bands reliably deliver 1 to 10 Gbps speed for a variety of use cases, including enterprise backhaul, backhaul for Wi-Fi access points, and fixed wireless access.[14]

Equipment

Network equipment contains active (i.e., powered) components such as routers, modems, and switches. Relative to network infrastructure, network equipment has a shorter lifespan (typically under 10 years) and requires constant monitoring as well as regular maintenance and replacement, in addition to the recurring cost of electrical power. The equipment ensures that the fiber infrastructure provides a highly scalable platform capable of providing reliable connectivity between critical sites, particularly the points where multiple networks converge. Over time, equipment can be upgraded to maximize use of available fiber infrastructure.

Various kinds of equipment are needed to connect users of different broadband technologies. Equipment for accessing the network can be upgraded to improve performance based on the ability to use wired or wireless capacity efficiently, manage congestion from multiple simultaneous users, and support secure segmentation of data traffic. Every year, manufacturers bring to market new equipment featuring improved performance or additional capabilities. Adding equipment may not require new construction; however, providing seamless mobility or managing a network in real-time requires a substantial network management capability that can be capital-intensive to implement.

Operations & Services

Operations refers primarily to the people with the labor capacity and knowledge required to activate infrastructure and equipment to deliver internet and other services. Operational knowledge must be updated and workers must be retrained as technology evolves and customer demands change. This operations element is often the most costly annual expense for a broadband network.

Figure 29: Broadband Network Elements: The Costs and Pace of Change

NETWORK ELEMENT	EXPECTED LIFESPAN (INVESTMENT RETURN PERIOD)	COSTS (CAPITAL AND OPERATING EXPENSES)	MARKET INNOVATION (PACE OF CHANGE FOR TECHNOLOGIES AND BUSINESSES)
Real Estate	40-100 yr.	Capital Intensive	Generational
Infrastructure	20-40 yr.	Capital Intensive	Generational
Wireless Spectrum	10-20 yr.	Capital Intensive (for licensed)	Decade
Equipment	5-10 yr.	Balanced CapEx + OpEx	Annual
Operations	Not Applicable	Operating Intensive	Quarterly
Services	Not Applicable	Operating Intensive	Quarterly

Services are the labor required to interface with customers and users, and to develop a comprehensive internet product. Services can be provided on a wholesale basis (i.e., to a third party who directly markets service and manages end-user accounts) or a retail basis. Like operations, this labor and operational knowledge carries significant ongoing cost. Companies may seek to change their approach to operations and service rapidly in response to market shifts.

Choice of Service Providers

Broadband is not a one-size-fits-all technology. New Yorkers need to be able to choose a service provider that works for them, from a set of service options that are consistent with the City's five principles of equity, performance, affordability, privacy, and choice. Infrastructure consisting of open access fiber and neutral host wireless can maximize the diversity of services available in a neighborhood. It allows high-capacity enterprise providers to administer core elements of a network while lowering the barrier to entry for local startups, new market entrants, and community-based providers who want to prioritize community needs or provide a choice of broadband services in areas that have historically been underconnected.

Methods for Private Financing of Public Infrastructure

A variety of partnership models can direct private investment into public infrastructure. Multiple methods can even be implemented in parallel. Partnership models can be compared to one another based on their composition of public and private involvement across a spectrum of activity. These responsibilities include the full range of activities associated with the delivery of broadband, starting with one-time and ongoing capital and operational requirements, and extending to financing, asset management, marketing, and customer services. The implications of involvement for both public and private entities are reflected in their respective risk profiles and ownership of specific network elements. A diagram depicting the spectrum of delivery models is included in Figure 30.

At the two ends of the involvement spectrum are the entirely private and the entirely public models of infrastructure delivery. Currently, the entirely private model is the status quo in New York City. Private companies that wish to provide internet service build out their own networks. On the other end of the spectrum, the entirely public model would require the City to function as a municipal ISP, providing all network infrastructure and operations, to the exclusion of private investment.

Between the two extremes lies a series of delivery models that are described as public-private partnerships (P3). Two main models of public-private partnership that lead to long-term public ownership of infrastructure are Revenue Opportunities and Operating Contracts:

- **Revenue Opportunities:** This model generally involves a multi-year or long-term partnership between public and private entities, in which private entities take responsibility for some combination of design, construction, financing, operations, and maintenance. These responsibilities are typically undertaken in exchange for funding, availability payments, or use guarantees by the public entity over the term of the contract. In practice, there are two principal examples of Revenue Opportunity partnerships that could be used for broadband infrastructure in New York City:
  - Build-Operate-Transfer (BOT): The City grants to

a private partner or multiple partners the right to develop, own, and operate the infrastructure for a certain period, after which the ownership of the assets are transferred to the City. The private partner receives the revenues from the assets during the term of the contract.

- Design-Build-Finance-Operate-Maintain (DBFOM): A long-term model in which asset ownership begins and remains with the City in perpetuity, while capital investment, construction risk, and commercial risk are assumed by the private partner, in exchange for a negotiated payment from the public sector. DBFOMs tend to have longer terms than BOTs.

↗ **Operating Contracts:** In an operating contract model, capital expenses are assumed by the City. For other types of risks and responsibilities, the City enters into operating contracts with private partners. The degree of involvement of the private partners in the management of the assets depends on the structure of the operating contract.

LEVELS OF PUBLIC INVESTMENT

Public investment in the infrastructure for universal broadband can be segmented into four levels, each mobilizing a corresponding level of private investment and laying the foundation for further intervention. An initial seed investment establishes the City's role in shaping broadband infrastructure, develops a baseline set of market responses and generates impacts in targeted areas. The second level expands to address the most prominent gaps in infrastructure establishing multiple connected neighborhoods. The amount of City control grows as the level of investment increases. Public investments in open access infrastructure can only be made where the private sector is prepared to partner with the City, use the infrastructure, and invest further to connect to the household or mobile user. The amount of private capital that can be mobilized in partnership with City investments is influenced by the selection of neighborhoods and anticipated rates of return in those areas.

Training Session at Brooklyn Public Library's Shelby White and Leon Levy Information Commons
Source: Gregg Richards/Brooklyn Public Library

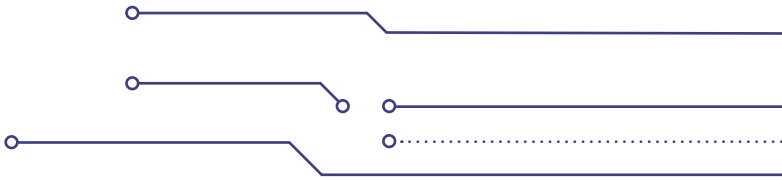


Figure 30: Potential Broadband Delivery Models

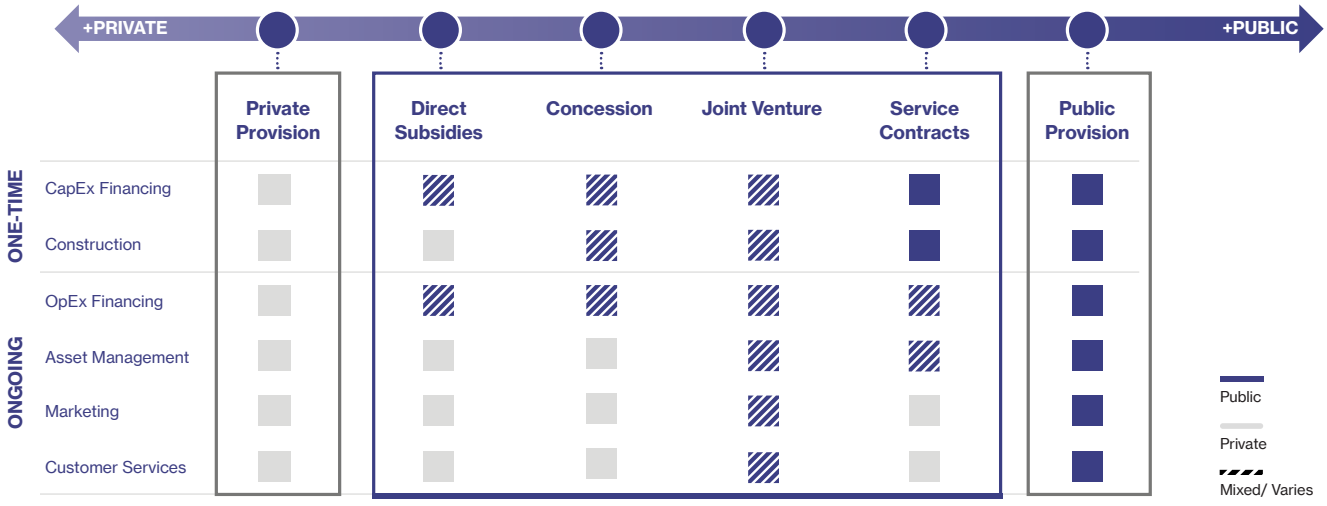


Figure 31: Levels of Public Investment

	SEED INVESTMENT	CONNECTED NEIGHBORHOODS	CITYWIDE INFRASTRUCTURE	PUBLIC UTILITY
Description	Open access infrastructure in select locations to establish successful technical and partnership models.	Open access infrastructure in high-priority neighborhoods to resolve gaps in broadband infrastructure or meet other focused policy objectives.	Open access infrastructure citywide to stimulate private investment in service delivery and unlock competition from multiple technological solutions.	Citywide mobile coverage and a fiber connection to every home and business that can be shared by multiple operators with minimal further capital investment.
Anticipated Broadband Outcomes	Greater broadband access and choice in targeted geography, testing of market responses, with a path to universal broadband.	Greater broadband access and choice in large areas of the city; testing of multiple partnership models, with a path to universal broadband.	Universal broadband with multiple options for home and mobile service everywhere.	City ownership and control of all broadband infrastructure.

Endnotes

1. See the Federal Communications Commission's descriptions of the type of broadband connections at https://www.fcc.gov/general/types-broadband-connections.

2. There is also a cost associated with this intensity of deployment: Research from Accenture suggests that wireless operators will invest as much as $275 billion nationwide over seven years as they build out 5G, though much of that is associated with spectrum licensing and testing of architecture, in addition to the cost of deploying new hardware. See Accenture, "Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities," (January 12, 2017) at https://newsroom.accenture.com/content/1101/files/Accenture_5G-Municipalities-Become-Smart-Cities.pdf.

3. See, for example, CBRS Alliance, "Connectivity Wireless Deploys CBRS Trial in Times Square," (October 8, 2019) at https://www.cbrsalliance.org/news/connectivity-wireless-deploys-cbrs-trial-in-times-square.

4. Raul Katz, Fernando Callorda, "The Economic Value of Wi-Fi: A Global View (2018 and 2023)," Telecom Advisory Services (October 2018) at https://www.wi-fi.org/downloads-registered-guest/Economic%2BValue%2Bof%2BWi-Fi%2B2018.pdf/35675.

5. Wi-Fi Alliance, "Wi-Fi 6: High Performance, Next Generation Wi-Fi," (October 2018) at https://www.wi-fi.org/download.php?file=/sites/default/files/private/Wi-Fi_6_White_Paper_20181003.pdf.

6. New York City Mayor's Office of the Chief Technology Officer, "Truth in Broadband: Public Wi-Fi in New York City," (May 2019) at https://tech.cityofnewyork.us/wp-content/uploads/2019/07/ NYC-Connected-Truth-in-Broadband-Public-Wi-Fi-Report_v2.pdf.

7. This assessment is based on the information MOCTO gathered directly from stakeholders, as well as from numerous published reports and industry statements. The Edge Cloud industry has formed the Kinetic Edge Alliance (see https://www.vapor.io/kinetic-edge-alliance) to establish standards and develop the nascent industry. As an example of a more established company's plans for edge cloud and its connection to wireless technologies such as 5G and Wi-Fi, see Eric Knorr, "HPE's CEO lays out his technology vision," Network World (May 13, 2019) at https://www.networkworld.com/article/3394879/hpe-s-ceo-lays-out-his-technology-vision.html. For projections of growth in the mmWave market, see Mordor Intelligence, "Millimeter Wave Technology Market - Growth, Trends, and Forecast (2019 - 2024)" at https://www.mordorintelligence.com/industry-reports/millimeter-wave-technology-market.

8. For examples of open access fiber networks and a discussion of the opportunities and challenges of that business model, see "Open Access Networks" on Community Networks from the Institute for Local Self-Reliance at https://muninetworks.org/content/open-access.

9. See *New York City Administrative Code Title 24, Chapter 4*, sections 24-406 – 24-418 at http://library.amlegal.com/nxt/gateway.dll/New%20York/admin/title24environmentalprotectionandutiliti/chapter-4gasandelectriclines?$q=%2724-406%27.

10. The New York City Economic Development Corporation helped launch WiredScore, which evaluates a building's broadband readiness. A list of certified buildings is available on the City's Open Data portal at https://data.cityofnewyork.us/NYC-BigApps/WiredNYC-Certified-Buildings/37it-gmcp/data. For more information, see https://wiredscore.com.

11. Regarding spectrum currently designated for uses other than commercial or public broadband, the City prioritizes reserving spectrum currently allocated for public safety and other governmental needs. The City supports greater public access to spectrum for broadband purposes through unlicensed or shared licensing frameworks only where those existing City uses can be fully preserved. That perspective informs the City's involvement in the debates over spectrum policy at the Federal Communications Commission with respect to pending or future rulemaking. See "Comments of the City of New York before the Federal Communications Commission in the Matter of Unlicensed Use of the 6 GHz Band" (ET Docket No. 18-295) at https://ecfsapi.fcc.gov/file/10215753013l3/City_of_New%20York_Re_6GHz%20NPRM_Final.pdf.

12. "Comments of the City of New York before the Federal Communications Commission in the Matter of Promoting Investment in the 3550-3700 MHZ Band" (GN Docket No. 17-258) at https://ecfsapi.fcc.gov/file/122855644222/City%20of%20New%20York_3550%20MHz%20Comment_FINAL.pdf.

13. For a description of the licensing framework for the 70/80/90 GHz Millimeter Wave bands, see the Federal Communications Commission's information page at https://www.fcc.gov/wireless/bureau-divisions/broadband-division/microwave-services/millimeter-wave-708090-ghz-service.

14. "Enabling Neutral Host Network Economics: CCS case study," GSM Association (August 2018) at https://www.gsma.com/futurenetworks/wp-content/uploads/2018/09/180920-CCS_GSMA_Case_Study-FINAL_NE-Modelling-removed.pdf.

05

PHASES OF IMPLEMENTATION

THIS SECTION ESTABLISHES THE OVERALL STRATEGY AND PRIORITY ACTIONS THAT THE CITY WILL TAKE TO IMPLEMENT THE INTERNET MASTER PLAN THROUGH A NEW APPROACH TO CITY ASSETS AND A NEW UNIVERSAL SOLICITATION FOR BROADBAND.

Introduction

Equitable broadband infrastructure is essential for New York to be the fairest big city in the country. While broadband is already foundational for New York City's economy, its importance seems destined to grow over the course of the next half-century. How this service is delivered will shape the future of industries and neighborhoods and quality of life for generations of New Yorkers. To ensure maximum benefits reach New Yorkers, it is vital that broadband service adhere to the five broadband principles.

The City of New York has a once-in-a-generation opportunity to enable affordable, high-performing, reliable broadband service for all. Emerging wireless technologies are accelerating private-sector demand for public assets while also lowering the barriers for new providers to enter the markets for both home and mobile service. The City has engaged more than fifty stakeholders, convened nearly two dozen City agencies, and studied the current landscape of every neighborhood to identify the areas of greatest need and opportunities for new public infrastructure.

The ubiquity and variety of the City's real estate assets make these facilities a valuable resource for private partners seeking to expand service. When made available for broadband use, City assets – including rooftops, rooms, poles, conduit and fiber – can serve as host sites and mounting points for fiber and fixed wireless technologies, consistent with land use and other considerations.

As the importance of broadband grows, the City must ensure that New Yorkers have access to this essential technology. The City will expand its role across all broadband components by increasing coordination among permitting entities, optimizing City real estate, building fiber optic lines to connect City assets, enabling service providers, and promoting those services that meet the City's principles. Specifically, the City will:

- **Coordinate City Processes:** The City will build on interagency contributions to this Master Plan to maintain the consistency and clarity of City policies as broadband deployment increases.

> **"To accelerate broadband access, the City will transform its approach to deploying broadband infrastructure by becoming a more active partner with the private sector."**
>
> *OneNYC 2050: Building a Strong and Fair City*

- **Optimize Public Assets:** The City will invite proposals for the coordinated use of public assets, including street poles, street furniture, rooftops, and rooms within City buildings. Private operators will be able to respond with requests for assets from multiple City agencies. The City will prioritize approaches that enable multiple operators to share in the use of an asset. Based on responses, the City will consider additional ways in which it can maximize public benefit created from the use of public assets.

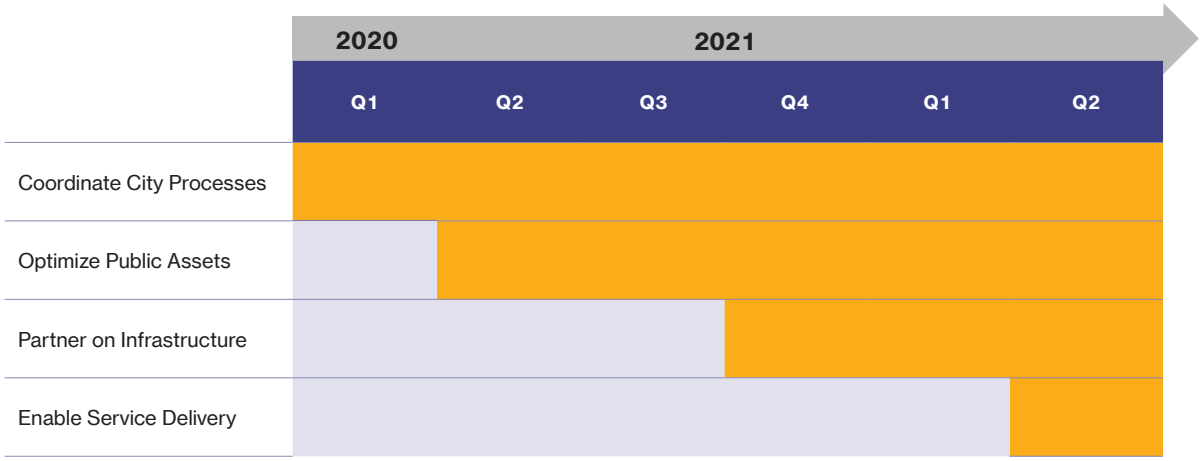
- **Partner on Infrastructure:** The City will invest in new infrastructure that can be shared by multiple broadband operators. The City will begin with a seed investment and leverage public-private partnerships for the use of City assets. The City will prioritize long-term public ownership of the most durable infrastructure elements, such as fiber optic lines and conduit, or other elements necessary to secure the City's authority. The City will form partnerships with the private sector to operate and maintain the infrastructure.

- **Enable Service Delivery:** The City will promote the use by broadband operators of new, shared infrastructure to reach more areas with more services. New Yorkers will have more reliable and affordable broadband options that meet the City's principles. City digital inclusion and digital rights programs will ensure all New Yorkers benefit from connectivity.

Figure 32: An Expanded Role for the City in Broadband Delivery

Real Estate Assets			Infrastructure	Service	
Permit the use of private property	Permit the use of public assets and public rights-of-way	Optimize and coordinate public assets	Optimize existing infrastructure and build new open access infrastructure that can support multiple operators	Install, operate, and maintain infrastructure and equipment	Acquire and support subscribers
City's Role Today		City's Role Expands		Role of Partners	

Figure 33: Internet Action Plan Timeline



Implementation Timeline

The City will take action to implement the Master Plan in four phases.

First, the City will introduce its new role through a Universal Solicitation for Broadband (USB). The solicitation will identify the critical areas of need for public infrastructure, outline an initial seed investment of City capital, and invite proposals from the private sector for the use of public assets.

In phase two, the City will establish partnerships for new broadband infrastructure and service through the award of public-private partnership agreements. The Mayor's Office of the Chief Technology Officer, which oversees the City's broadband strategy, will coordinate across City agencies to review proposals for public-private partnerships and will launch the new initiatives.

Phase three will consist of the implementation of the partnerships and construction of new, necessary broadband infrastructure. The benefits of increasing open access infrastructure will build over time as more operators benefit from lower costs, enabling them to serve wider areas. Through an iterative process with the solicitation, the City may select multiple vendors or partners in different neighborhoods and can continuously update offerings to reflect the value of new infrastructure. The City intends to establish multiple partnerships to maintain options to manage the core infrastructure and ensure an open, competitive market for services in New York City.

As these public-private partnerships develop, the City will advance a fourth phase where the use of public infrastructure will bring new service options in line with the City's principles. To help the partnerships succeed and ensure that all New Yorkers benefit from connectivity, the City will consider targeted expansion of digital inclusion programs, evaluate subsidy models for the lowest income New Yorkers, and promote job training and business opportunities related to broadband deployment. The scale of new programs will be based on the level of public-private investment in the earlier phases and may require new support from the private sector, philanthropy, or other levels of government.

Once established through these four phases, the City will have the governance capacity, policies, and tools in place to shape broadband service in targeted and dramatic ways. These phases of implementation are designed to build market response over time and steadily increase the City's influence over broadband infrastructure. Depending on the level of private sector engagement, the City may decide that greater public investment or involvement in further aspects of internet delivery is warranted. This Master Plan lays a foundation for the City to strategically increase its direct responsibility for New Yorkers' internet service.

Phase 1: Introduce New Role for City Government

As the first phase in an expanded role in broadband infrastructure and service delivery, the City will identify priorities for new public and private investment in broadband infrastructure, invite proposals for the coordinated use of City assets, and mobilize investment in new infrastructure.

PRIORITIZE AREAS FOR NEW PUBLIC/ PRIVATE INVESTMENT

The City will use the framework in this Master Plan, updated as new data become available, to identify areas where investments in new shared infrastructure can have greatest impact. A focus of this Master Plan is to address gaps in broadband infrastructure, prioritizing impacts for

low-income or under-connected households and businesses. Areas with dense infrastructure where multiple operators are engaged in ongoing construction (with each seeking to add more wireless equipment) may be prime candidates for shared radio access networks to employ scarce City assets most effectively.

Prioritization will consider the type of infrastructure and the conditions of the internet in New York City today. New conduit or dark fiber may have greatest impact in those areas identified as having congestion in aerial deployment or minimal conduit coverage, particularly in areas of Brooklyn and Queens where Empire City Subway is not available.

Neighborhood Fiber Collocation Facilities (NFCFs) will be a priority in areas that do not have sufficient options in commercial fiber service. Where there is not sufficient choice in residential broadband service today, new rooftop hub locations for fixed wireless will serve the residential market with the greatest impact including an emphasis on where City facilities are currently underutilized for this solution.[1]

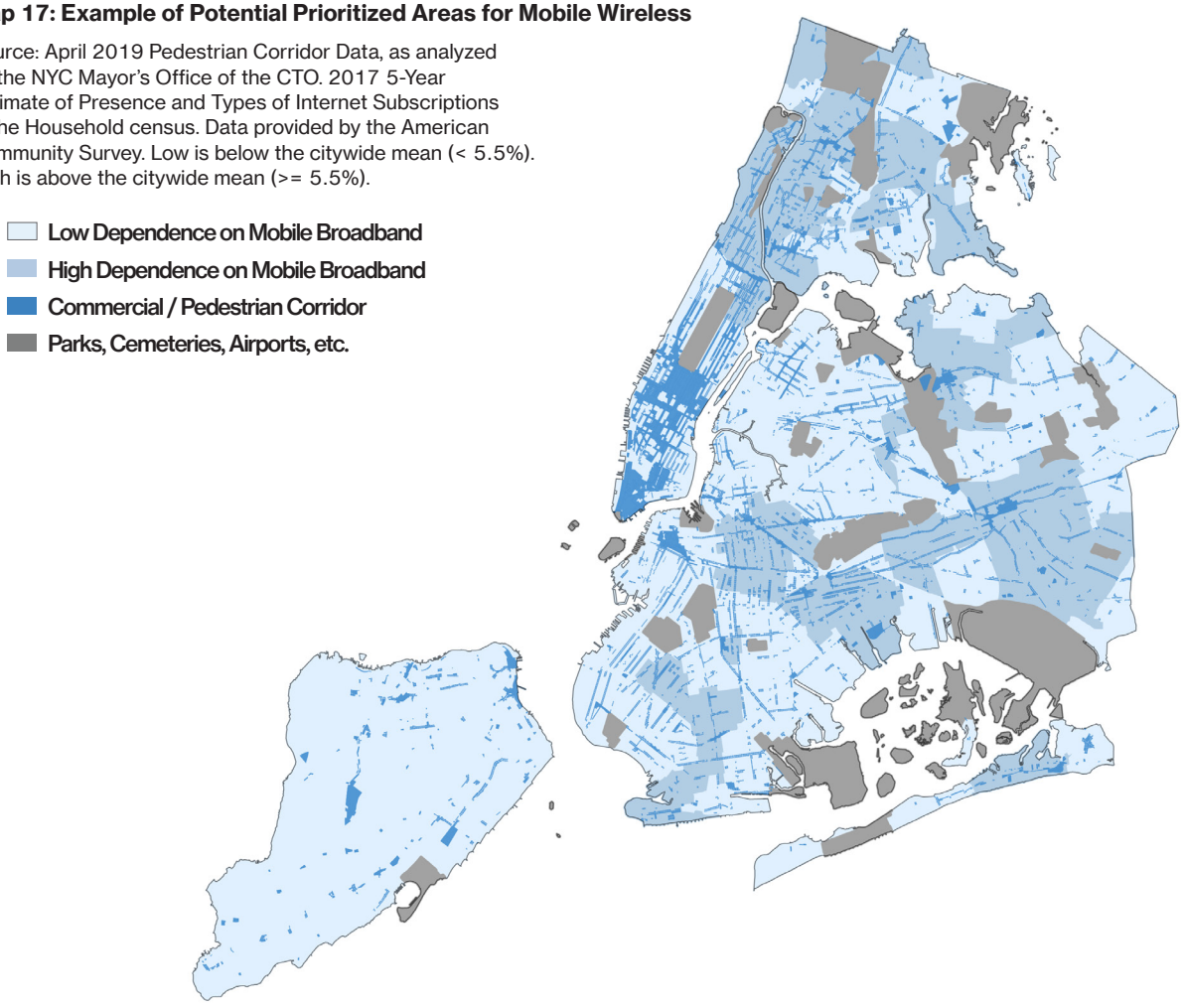
Consistent with the City's focus on free public Wi-Fi in commercial corridors,[2] CBRS radios will be prioritized in those corridors, particularly in neighborhoods with high rates of dependence on mobile broadband. From those corridors, coverage can expand throughout entire neighborhoods. CBRS coverage would provide baseline infrastructure to support the equitable deployment of mobile wireless service by multiple operators, or it could be deployed in combination with a neutral radio access network for 5G.

Generally, determinations will be at the scale of Neighborhood Tabulation Areas (NTAs), which the City uses as a unit of planning with consistent population size. A New York City neighborhood is a viable scale for startups, new entrants, or niche operators, some of which are already based in particular communities. At the same time, some neighborhoods are also attractive to large incumbent operators, or multiple NTAs can potentially be bundled for greater economies of scale.

The City will align broadband-related interventions with other actions that will be mutually reinforcing, such as digital inclusion programs. The City can tailor actions to meet the needs of each neighborhood in combination with other place-based City programs.

Map 17: Example of Potential Prioritized Areas for Mobile Wireless

Source: April 2019 Pedestrian Corridor Data, as analyzed by the NYC Mayor's Office of the CTO. 2017 5-Year Estimate of Presence and Types of Internet Subscriptions in the Household census. Data provided by the American Community Survey. Low is below the citywide mean (< 5.5%). High is above the citywide mean (>= 5.5%).



Performance and Open Internet Monitoring

Accountability through performance and open internet monitoring is essential to ensuring that the City's broadband infrastructure and service meets the needs of New Yorkers.[3] The City will implement proof of concept trials of a combination of hardware and software solutions for the monitoring of internet service provider (ISP) network performance and compliance with the Mayor's Open Internet Pledge. New York City's broadband monitoring proofs of concept could be expanded to benefit New Yorkers across the state, either by running in parallel to efforts at the state level or through the establishment of a statewide broadband monitoring program.[4] This work can build on the measurement programs of other states, such as California, whose Public Utility Commission currently measures mobile broadband connections to test speed and reliability without relying on self-reported ISP data for its measurements.[5] If ultimately shown to be effective and if implemented at scale, New York City's approach would represent the most ambitious and comprehensive approach to broadband transparency of any jurisdiction in the world.

INVITE PROPOSALS FOR THE COORDINATED USE OF PUBLIC ASSETS

The City will release a Universal Solicitation for Broadband (USB) for public infrastructure to meet neighborhood-level connectivity needs. The USB will initiate the first investments in municipal infrastructure for public broadband service, will be the first formal process ever presented to the private sector to request bulk access to City assets, and will invite proposals for City assets never before made available for providing internet service to the public. The City seeks the lowest-cost solutions and is always open to innovative, alternative approaches.

City Asset Opportunities

Many City assets or facilities, such as poles, rooftops, rooms, or small outdoor spaces, hold potential value for broadband deployment. Notwithstanding important challenges – including limited space, sufficient electrical power, building access procedures, and the historic conditions of the buildings – the overall value of these assets increases with greater volume, speed, and predictability with which assets can be made available. In tandem, fiber optic lines connected to City assets improve the readiness of these assets and can facilitate their shared use by multiple private-sector partners. The City can offer the use of these assets to potential partners consistent with applicable law and in a manner that preserves their use for their primary purposes.

City Assets Bundled for Broadband

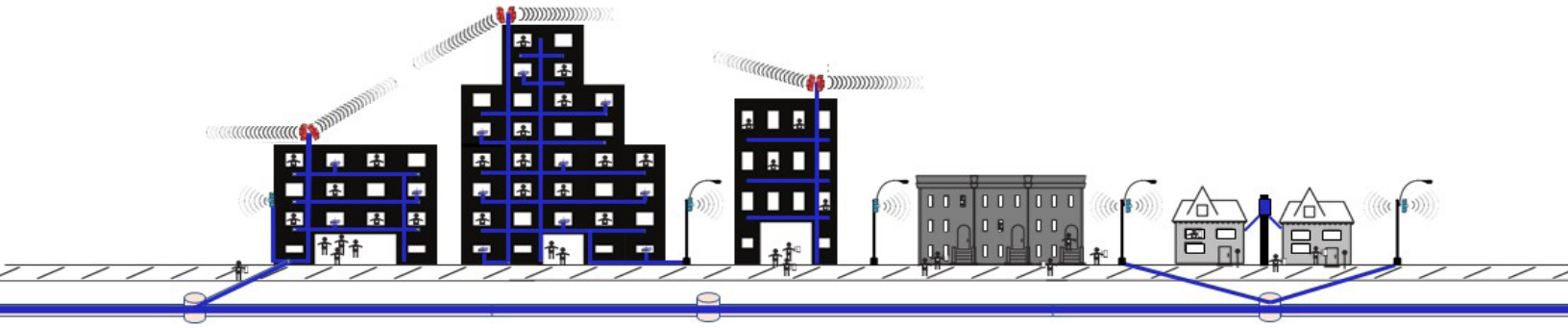
The USB will provide an opportunity for the City to efficiently solicit any number of innovative solutions from the broadest range of market respondents to address broadband connectivity challenges. The City may select multiple partners in multiple geographies and structure an iterative process, updating the USB to reflect the value of available infrastructure assets and the declining costs of service delivery based on the availability of that new infrastructure.

In the USB, the City will identify a scope of infrastructure as well as priority areas. In the responses to the solicitation, a vendor will identify the City assets it would seek to use to deliver the infrastructure and where it would prioritize deployment. Based on the response, the City will be able to determine three broad categories of neighborhoods: 1) where the use of City assets is desired by multiple vendors, 2) where only one vendor has proposed a use, and 3) where no vendor has expressed interest. With private sector interest demonstrated through the USB, the City can bundle the use of the City's real estate assets in offers to the private sector in order to maximize utility and speed deployment while lowering the cumulative administrative burden on the City.

MOBILIZE INVESTMENT IN NEW INFRASTRUCTURE

The City will offer the first seed investments in new, public broadband infrastructure. Initial investments will establish successful technical and partnership models, with private partners extending the public infrastructure using complementary private investment. In some cases, the value of bundled assets and revenue from the infrastructure may be enough to attract private-partner participation. At minimum, the City will seek a partner who will maintain the infrastructure, make it available to operators on a non-exclusive basis, and add its own equipment and operations capacity to ensure new services become available.

Figure 34: Elements of Broadband Assembled[6]



Community Planning for Broadband

A neighborhood-based approach does not only mean assessing broadband market and infrastructure conditions at the neighborhood level. It also means combining citywide planning with community engagement. What communities need and want from the internet can be even more varied across neighborhoods than adoption rates, perceived market value, and the distribution of City assets.

An effective engagement process for broadband will align the technical and economic interventions of the Master Plan with social and educational strategies through, for example, digital literacy programming at local libraries. It will also mobilize champions and organizers who can contribute to the success of new broadband providers looking to serve hard-to-reach customers.

The City engages in many other kinds of community planning efforts. The Department of City Planning conducts place-based planning studies to foster diverse, livable neighborhoods with mixed-income housing and supportive services. The Department of Housing Preservation and Development leads *Where We Live NYC*, a collaborative planning process to better understand how challenges like segregation and discrimination impact New Yorkers' everyday lives. The Mayor's Office of the Chief Technology Officer runs Co-Labs, a partnership with the NYC Economic Development Corporation, which brings together local residents, government, academia, and technologists to identify, co-develop, and test smart-city solutions to neighborhood-specific concerns.

Community Boards are an established level of City Government that gives residents a voice in land use decisions and the delivery of certain services. City Councilmembers are engaged in local digital inclusion: Each member of the City Council receives an allocation of funds under the Digital Inclusion and Literacy Initiative, administered by the Department of Youth and Community Development. The funds are usually distributed to one of the city's public computer centers, such as a local library or another digital literacy provider.

The city's library branches are well-positioned to convene stakeholders and produce digital needs assessments. Libraries have citywide scale, already act on the frontlines of community digital needs, and can be a trusted mediator between residents and City Government. In 2017, the Brooklyn Public Library (BPL) conducted "digital access needs assessments" in three communities under its BKLYN Connect initiative: Brownsville, Bedford Stuyvesant, and East New York.[7]

BPL conducted demographic research, stakeholder and resident interviews, resident surveys, and community workshops all aimed at understanding local internet needs and usage patterns in detail. BPL then produced a series of reports with conclusions from the assessment and presented them back to the communities. The immediate focus for BPL was on where and how to set up a community Wi-Fi network, but the strategy of developing a comprehensive map of local community resources, organizations, and stakeholders can be leveraged toward supporting many broadband goals.

BPL employed graduates of a library-run youth tech training program to implement *BKLYN Connect*. For other, similar kinds of programs, the City's Summer Youth Employment Program can be a resource to staff efforts while providing valuable summer employment experiences for participating young people.

Phase 2: Establish Partnerships for New Broadband Infrastructure and Service

The City will review responses to the USB, award public-private partnership agreements, coordinate across participating agencies, and provide oversight and data management for the launch of new services.

COORDINATE ACROSS AGENCIES

The Mayor's Office of the Chief Technology Officer, in partnership with the Department of Information Technology and Telecommunications, will lead the multi-agency team to review responses to the USB and launch the new infrastructure and service options. This will require two broad capabilities in New York City government:

1. **Coordinate and facilitate private-partner use of the City's real property assets as a pathway to expanding broadband infrastructure in New York City.**
2. **Direct the deployment of new broadband infrastructure, monitoring service levels and market conditions to track progress toward universal service.**

The public-private partnership agreements will likely include commitments regarding new broadband assets, as well as payments to the City. Oversight of these agreements will require regular field inspection, asset tracking, and fiscal oversight.

COORDINATE USE OF CITY ASSETS

Through the USB review and finalization, stakeholder agencies will consider multi-year agreements for private-sector use of City broadband assets. The City will develop the expertise to represent and advise relevant City Agencies in dealings with private industry for all attachment agreements. The City will coordinate standards for contracting to the extent feasible, which may relieve burdens from City agencies and serve as a valuable resource to private partners.

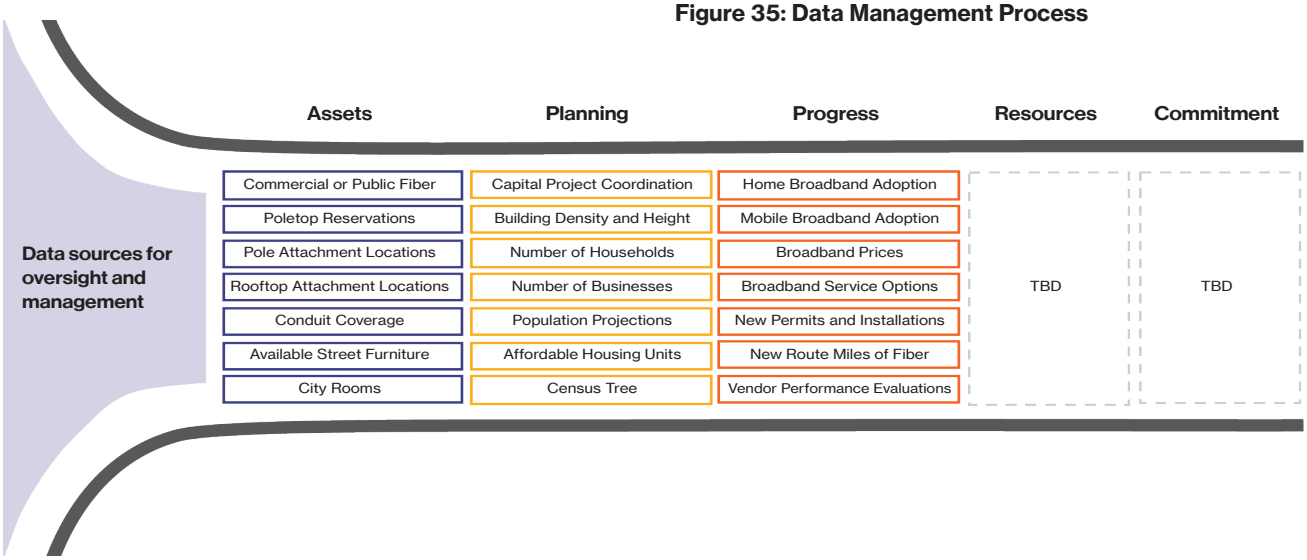
DELIVER BROADBAND INFRASTRUCTURE IN PARTNERSHIP WITH THE PRIVATE SECTOR

The public-private partnership agreements will include commitments to construct or deliver infrastructure that meets the City's specifications. In most cases, the private entity that delivers the infrastructure will also maintain, operate, and make use of the infrastructure. Nevertheless, the City will oversee the design and delivery of these capital projects and will reserve the right to assume or transfer operational control if the private partner fails in its commitments. The City will monitor and evaluate multiple partnerships in parallel to oversee implementation and inform future awards and agreements.

PROVIDE OVERSIGHT AND DATA MANAGEMENT

Implementing the Internet Master Plan will necessitate significant coordination and monitoring of information across City agencies and private partners. The broadband industry increasingly relies on near real-time data to coordinate workflow, monitor assets, and inform decision-making.

Figure 35: Data Management Process



The City will standardize and consolidate the various asset tracking systems for various types of pole attachments, street furniture, site license agreements, City facilities, and fiber optic construction, as needed. Internally, such data will be valuable to oversee vendor performance, update progress on the Master Plan, and coordinate with other uses of City assets.

Phase 3: Expand Service to More New Yorkers

ITERATE SOLICITATION FOR MORE SERVICE OPTIONS USING NEW PUBLIC INFRASTRUCTURE

The benefits of more shared broadband infrastructure will build over time as operators face lower costs to serve wider areas. The USB will serve as a new procurement structure for broadband infrastructure deployment, iterating over procurement cycles to address infrastructure and service goals in new batches of neighborhoods or for new bundles of assets. Such an approach allows the City to develop market response and City capacity in tandem. A steady release of new City offerings will allow innovative market operators to reach stabilization incrementally rather than across the entire city at once, and will amplify the City's ability to influence private broadband investment. After an initial series of projects is realized, the City anticipates having new bundles of City assets, new neutral-host infrastructure, and potentially further capital investments to be incorporated into subsequent rounds of solicitations and proposals.

Phase 4: Ensure All New Yorkers Benefit from Connectivity

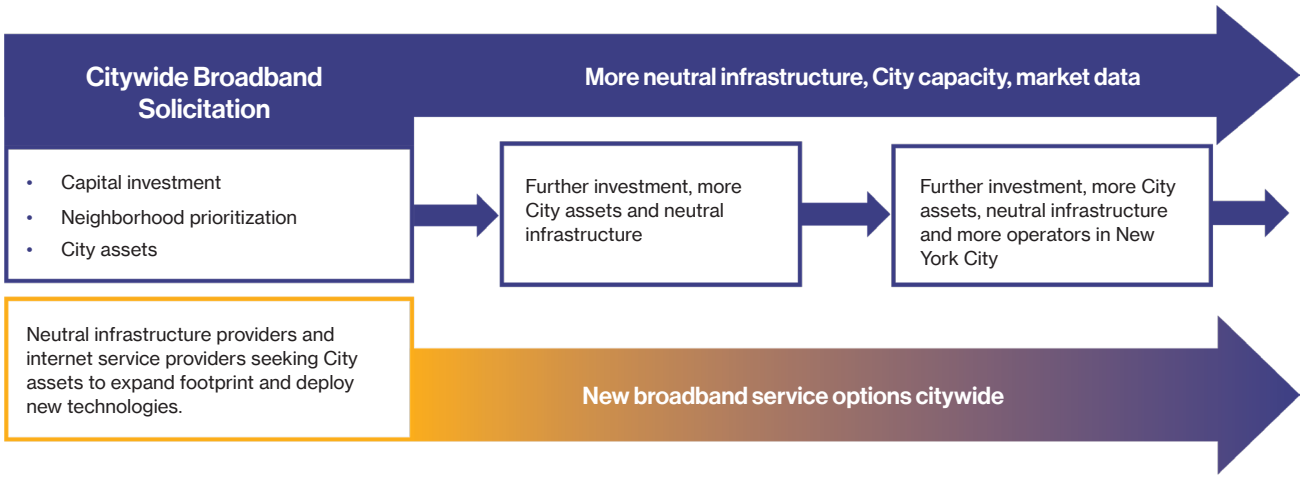
City intervention in phases one, two, and three will lower the market price for broadband service and introduce new low-cost options. However, equitable access to broadband does not, on its own, beget equitable use of it. Even a low-cost service may be cost prohibitive for some households, which makes a range of affordable service options critical. With greater City authority and governance capacity, the City will consider measures to ensure that no one is left out of improvements to and equitable use of broadband by all New Yorkers. Lastly, the City will take steps to further strengthen its authority and support broadband service providers that meet the City's principles.

CITYWIDE DIGITAL RIGHTS AND INCLUSION

The coordinated planning and oversight of digital inclusion and digital rights efforts is critical to support safe and equitable use of broadband. Access to devices, diverse digital skills training, and supportive community spaces for tech exploration are needed on an ongoing basis, even beyond the achievement of ubiquitous, affordable service. The protection of New Yorkers' digital rights is essential for universal broadband.

Today, the City delivers digital inclusion resources and digital rights education through a citywide network of public computer centers (PCCs) that are managed by the Department for the Aging, the Department of Parks and Recreation, the Department of Youth and Community Development, the New York City Housing Authority, Brooklyn Public Library,

Figure 36: Iterative Solicitation for More Service Options Using New Public Infrastructure



New York Public Library, and Queens Public Library. The Mayor's Office of the Chief Technology Officer supports these activities through the Connected Communities program. Additionally, the NYC Digital Inclusion and Literacy Initiative addresses disparities in internet access and digital literacy via grants through the Department of Youth and Community Development to a variety of non-profit organizations across the city. The Department of Education supports programs to provide both connectivity, devices and digital skills training to students, including its citywide CS4All initiative to bring Computer Science education to every elementary, middle, and high school by 2025, as well as numerous school-based digital literacy and digital citizenship programs. The Mayor's Office of Workforce Development, the Department of Small Business Services, Human Resources Administration, and the Department for the Aging oversee workforce development programs with digital literacy components.

The City has identified five key areas of opportunity to improve awareness, accessibility, coordination and quality across digital inclusion and digital rights resources and programs:

Opportunity 1: Promote awareness of available digital inclusion services and increase their accessibility

The City has established a standard inventory of the citywide network of public computer centers, including the resources available at each one, the hours they are open, the spoken languages supported, and the level of wheelchair accessibility. The City will refresh this inventory on an annual basis and will connect New Yorkers who need services with the information, for example, through 311. The Mayor's Office of the Chief Technology Officer and its stakeholders will look to improve language and disability access and will conduct targeted outreach in high-need areas and to particular populations, working with existing partners and established community engagement efforts, such as the Mayor's Action Plan for Public Safety and the Civic Engagement Commission.

Opportunity 2: Strengthen coordination among digital inclusion service providers

There is opportunity to coordinate resources, and facilitate referrals between the City's sites and programs. There are also numerous community-based organizations providing digital inclusion support services today that can be integrated into the City's efforts. The City will continue to develop standardized metrics and information-sharing across public computer centers, particularly about the types of services and levels of utilization. This data will be an essential component of joint, long-term strategic planning for citywide digital inclusion and for regular coordination on the implementation of the strategy.

Opportunity 3: Continually improve the quality of digital inclusion services to meet the needs of New Yorkers

Each digital inclusion service provider strives for the highest-quality services tailored to their constituents. By coordinating needs assessment and sharing best practices across providers, the City can improve the quality of digital inclusion services and better meet the needs of New Yorkers. The City can coordinate professional development support where there is a citywide need, as it already has in training frontline computer center staff to better respond to patrons' concerns about online privacy, and can support the development and sharing of effective training materials and programs.

Opportunity 4: Reach the hardest to reach

The City will promote awareness of existing service options, as it has already begun to do through the Mayor's Office of the Chief Technology Officer's *Truth in Broadband* reports. Some populations, however, experience particularly pronounced challenges and require specialized supports. The City can conduct targeted outreach to disconnected and hard-to-reach populations, working through City agencies and community-based organizations that already connect with these residents, to ensure they have the information they require to make informed decisions about broadband service and related programs like Lifeline. As part of this effort, the City will work with internet service providers to ensure that information about the available products is clear, accessible, and available in languages New Yorkers use.

Opportunity 5: Protect New Yorkers' Digital Rights

The City will build on its position as a global leader in protecting digital rights by creating standards and principles that advance New Yorkers' safe and equitable participation in the digital world. The City will proactively assess the impacts of emerging technologies on digital rights and educate the public about these impacts. The City will expand its capacity to monitor and address threats to New Yorkers' digital rights, including through the enforcement of applicable laws and policies in order to protect New Yorkers in their use of technology and in how technology use by others affects them. The City will continue to work with the Mayor's Fund to Advance New York City to build partnerships and philanthropic support for these digital inclusion and digital rights efforts.

POTENTIAL APPROACHES TO AFFORDABILITY FOR THE LOWEST-INCOME NEW YORKERS

As low-income households struggle to pay for broadband service alongside other daily expenses such as food, housing, and healthcare, subsidized service can help make life in New York City more affordable overall. By eliminating or minimizing the cost barrier for internet service, the City can address the difficult choice for a household between daily essentials and broadband internet, the lack of which can lead to negative outcomes in terms of social inclusion, education, job opportunities, and health.

JOBS AND NEW BUSINESS OPPORTUNITIES

City action to accelerate broadband deployment by multiple private partners will likely contribute to job growth in the sector, particularly in broadband construction.

The City will continue to support the rights of workers through prevailing wage requirements or other protections, where possible under law. Worker safety is essential; the City can work with companies, organized labor, and other stakeholders to ensure workers operate with appropriate equipment and in conditions that are safe and contribute to New York City having the highest-quality infrastructure.

The City can also increase opportunities for minority- and women-owned business enterprises (M/WBE) to thrive in this growing industry by ensuring project opportunities are of varying size and well-publicized. The City will continue to build the pipeline of businesses into the certification program and include M/WBE subcontracting requirements in its contracts.

For companies of all sizes, the City can highlight the businesses and business leaders who are contributing to making New York City the fairest big city in the country by hiring, retaining, and advancing a diverse workforce and expanding opportunities for young New Yorkers entering the job market. In-demand cabling and installations skills are already being taught in programs that the City could look to expand, such as those provided by LaGuardia Community College[8] and the Brooklyn Networks program from Brooklyn Workforce Innovations.[9]

FURTHER CITY ACTIONS

There are additional actions the City could take to improve the economics of all or some of the internet service providers in the city to foster more equitable, affordable service. Private partners will be able to express how important one or more of these actions may be through the Universal Solicitation for Broadband (USB). The City can consider these actions as a potential complement to the priority actions described above.

Endnotes

1. The City can also consider crowdsourced information on demand for new services, such as from WiredScore (see https://app.wiredscore.com/public/map) or NYC Mesh (see https://www.nycmesh.net/map).
2. See New York City Mayor's Office of the Chief Technology Officer, "Truth in Broadband: Public Wi-Fi in New York City," (May 2019) at https://tech.cityofnewyork.us/wp-content/uploads/2019/07/NYC-Connected-Truth-in-Broadband-Public-Wi-Fi-Report_v2.pdf.
3. In January 2018, the City issued a Request for Information (RFI) that sought input from stakeholders on methods or systems that would identify internet service providers network management practices or incidents that block, throttle, or otherwise interfere with content delivery based on the specific content, content provider or upstream service provider, as well as methods or systems that would identify network management practices or incidents that prioritize or otherwise favor an affiliated service. These incidents or practices would represent violations of the principle of an open internet.
4. These measures could rely on the advertising and other related consumer protection standards from New York State's settlement agreements with internet service providers (Charter, Verizon, Altice, RCN, and Frontier), and potentially support compliance with the New York State Attorney General's standards set in these agreements (see https://ag.ny.gov/press-release/ag-underwood-announces-settlements-establishing-industry-wide-standards-marketing and https://ag.ny.gov/press-release/ ag-underwood-announces-record-1742-million-consumer-fraud-settlement-charter).
5. For more information about California's mobile broadband testing program, see https://www.cpuc.ca.gov/General.aspx?id=1778.
6. Image designed using the "(Re)Building Technology Shared Graphics Library" at https://communitytechnology.github.io/list-assets.html and available under an Attribution-ShareAlike 4.0 International (CC BY-SA 4.0) Creative Commons License.
7. For more information about BPL's digital needs assessments, see https://www.bklynlibrary.org/about/reports-publications.
8. More information on the LaGuardia Community College C-Tech continuing education program can be found at https://www.laguardia.edu/ce/pages/career-skills-and-training/c-tech.
9. More information on the Brooklyn Networks program from Brooklyn Workforce Innovations can be found at https://bwiny.org/bwi-programs.

06

CONCLUSION

New York City is entering what may be the most pivotal period for its communications infrastructure since the dawn of the internet. Broadband is already a major economic driver and the foundation for technologies that will transform the urban environment, major industries, and daily life for New Yorkers over the next decade. This is an urgent moment to address persistent disparities in broadband access and infrastructure. In the absence of City action, the digital divide could become so entrenched over the next decade that it would be practically insurmountable.

With the New York City Internet Master Plan, the City is steering its technological future in a way no other big city has before. The City, in partnership with the private sector, will drive growth in broadband access and infrastructure to address a significant contributor to poverty, expand opportunity, and enable a thriving economy.

The City launches this Master Plan from a solid foundation: the largest free public Wi-Fi system in the country, the largest network of public computer centers, the largest deployment of commercial wireless equipment on municipal infrastructure, and perhaps the most vibrant commercial broadband market in the country.

The Master Plan will not transform the entire city overnight. The digital divide results from more than two decades of access to an essential service being dictated by one's ability to pay. In recent years, the challenges have worsened due to a federal government that has sought to sideline broadband affordability programs, remove basic privacy protections, and restrict municipalities' authority over local infrastructure. Reorienting these policies and practices will take years and they are not problems one city can solve on its own. Large incumbent service providers, startups, community-based organizations, and a range of committed stakeholders have communicated to the City that they are ready to work in collaboration with the public sector toward these important goals.

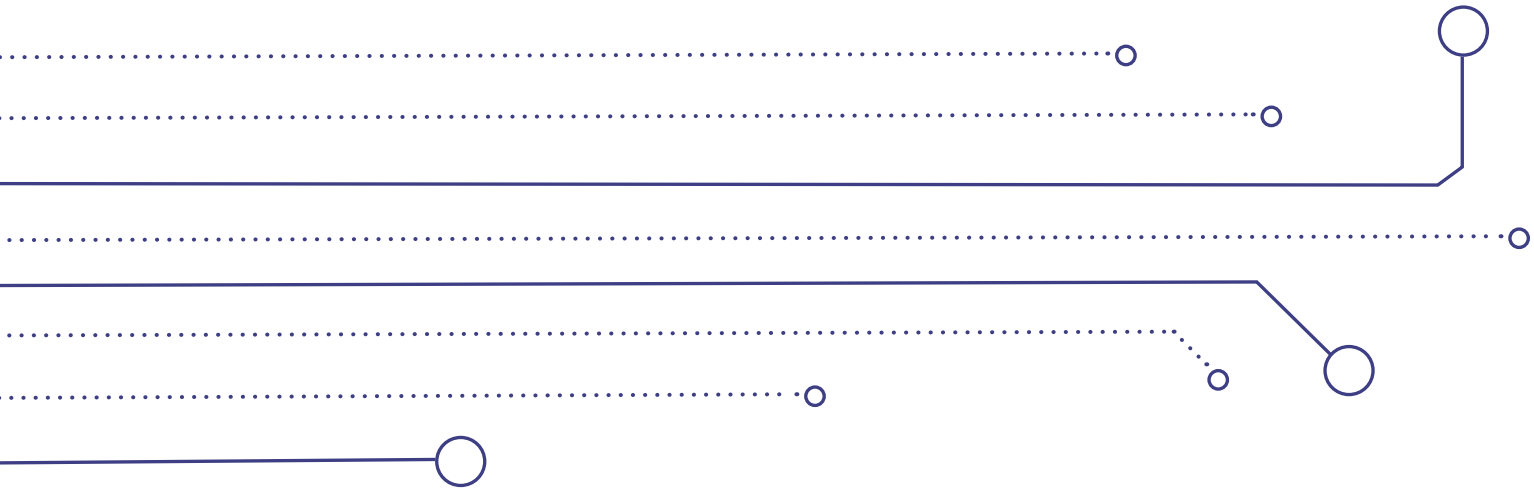
The City of New York has a once-in-a-generation opportunity to transform its role in enabling affordable and reliable broadband service for all.

To realize the vision of universal broadband, the City invites all service providers to use the New York City Internet Master Plan independently or in partnership with the public sector. A new Universal Solicitation for Broadband (USB) will be an initial step in implementing the Master Plan. While the City will initially seek to procure a specific type of infrastructure – conduit and fiber optic connecting City assets in priority neighborhoods – respondents will also be able to propose other solutions and areas of focus. The City will consider entering into multiple agreements through the USB, guided by the vision and principles detailed in this Master Plan.

The New York City Internet Master Plan is a roadmap to a future-ready city. As these changes take root, more children will have access to online educational resources, more adults will expand their access to new skills, and more seniors will be able to connect with their loved ones, among myriad other uses. In short, improved broadband infrastructure and affordability will make the lives of New Yorkers fundamentally better. The City looks forward to realizing this vision to address gaps in the market, spur better service at lower cost, close the digital divide, and bring universal broadband to the homes and fingertips of all New Yorkers.

The City of New York welcomes ideas and suggestions in response to the content of this Master Plan, via email, at:

InternetMasterPlan@cto.nyc.gov.



Data Sources

The Internet Master Plan uses publicly available data and information collected for the preparation of the Internet Master Plan. The sources of public data include the American Community Survey from the U.S. Census Bureau, which is gathered through surveys of residents; the Federal Communications Commission Form 477, which is self-reported by internet service providers; and information from New York City government agencies posted on the NYC OpenData portal.

The American Community Survey (ACS)[1] defines "broadband" based primarily on the technology used (as understood by respondents), rather than the specific upload and download speed of a connection. Fiber, cable and digital subscriber line (DSL) services are grouped together in the survey, even though DSL is not generally capable of delivering a 25 Mbps download speed, and cable service may be delivered at speeds below that level. The City therefore uses ACS data as a means of comparison for purposes of equity across other demographic categories, but not as a means of evaluating the principle of Performance. When using ACS data and as an overall key indicator of the success of the universal broadband program, we focus on the households who said they did or did not have a "broadband" subscription (cable, fiber optic, or DSL service) in their home.

The FCC collects data on fixed broadband providers twice a year through its Form 477 data collection.[2] The Form 477 is submitted by internet service providers (ISPs) and details the name of the company providing service, the census blocks in which service is provided, the maximum advertised upload and download bandwidth, and the technology used to provide service, among other indicators.[3] Any census block where an ISP delivers one connection is counted as having that level of service available across the entire census block. The City uses these data to measure broadband performance and to document where different providers offer broadband service.[4]

This Master Plan includes residential internet pricing and services based on publicly available information from provider websites and information provided by ISPs.

The economic impact analysis in the Internet Master Plan was performed by HR&A Advisors using proprietary information from Regional Economic Models, Inc. Descriptions of the physical conditions in the city, including fiber delivery modes, congestion, and costs are based on expert information collected and analyzed by HR&A, CTC Technology & Energy, Hunter Roberts Construction Group, and Stantec.

Except where indicated, information on neighborhoods in the Internet Master Plan uses the Neighborhood Tabulation Area (NTA) unit of measure from the NYC Department of City Planning.[5] References to poverty are based on the NYCgov Poverty Measure developed by the NYC Mayor's Office for Economic Opportunity.[6]

Endnotes

1. American Community Survey, United States Census Bureau (2016), https://www.census.gov/programs-surveys/acs/. Data is available to the public in Public Use Microdata Areas (PUMAs), geographic areas consisting of at least 100,000 people).

2. Fixed Broadband Deployment Data from FCC Form 477, Federal Communications Commission (Accessed: Nov 18,2019), available at https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477 (hereinafter "FCC Form 477 Data").

3. Explanation of Broadband Deployment Data, Federal Communications Commission (Accessed: Nov 18,2019), available at https://www.fcc.gov/general/explanation-broadband-deployment-data.

4. The FCC has a pending proceeding regarding modernizing the Form 477 Data Program which seeks input from stakeholders on how to improve the accuracy and quality of Form 477 data and address gaps in data collection. See "Establishing the Digital Opportunity Data Collection and Modernizing the FCC Form 477 Data Program (Report and Order and Second Further Notice of Proposed Rulemaking)," Federal Communications Commission, WC Docket Nos. 19-195 and 11-10, 82 Fed. Reg. 40118 (Aug. 6, 2019). The City submitted comments in this proceeding. See City of New York comments in WC Docket Nos. 19-195 and 11-10 (filed Sept. 23, 2019), available at https://ecfsapi.fcc.gov/file/10923922602 66/NYC%20Comments%20to%20FNPRM%20on%20Broadband%20Measurement%20092319.pdf and City of New York reply comments in WC Docket No. 11-10 (filed Oct. 24, 2017), available at https://ecfsapi.fcc.gov/file/1024631803665/New%20York%20City_Reply%20Comment_477%20FNPRM_Final.pdf.

5. This plan uses August 2019 Neighborhood Tabulation Area data provided by the NYC Department of Planning (DCP) available at: https://data.cityofnewyork.us/City-Government/Neighborhood-Tabulation-Areas/cpf4-rkhq (Accessed: Nov 18,2019) as well as information compiled from DCP's facilities database available at: https://capitalplanning.nyc.gov/facilities (Accessed: Nov 18, 2019). For Open Data version see https://www1.nyc.gov/site/planning/data-maps/open-data/dwn-nynta.page (Accessed: Nov 18,2019).

6. More information about the NYC poverty measure is available at: https://www1.nyc.gov/site/opportunity/poverty-in-nyc/poverty-measure.page (Accessed: Nov 18, 2019).

Glossary

Term	Definition
5G	The technical standard for the next generation – the fifth generation – of mobile connectivity. The technical specification calls for speeds that are projected to be at least 10 times faster than the current 4G network speeds, with lower latency, lower battery power consumption, and capacity to handle many more connections from a single radio.
Broadband	According to the Federal Communications Commission (FCC), internet service with a download speed of at least 25 megabits per second (Mbps) and an upload speed of at least 3 megabits per second (Mbps) qualifies as broadband. The City uses this same standard. As we continue to use the internet for more things, the standard will need to go up. This way, broadband will always mean internet service that's fast enough for users to take advantage of just about everything the internet has to offer.
City Asset	In the context of the NYC Internet Master Plan, "City asset" refers to those assets that are owned, operated, or otherwise controlled by the City, or available for City use. Examples of assets include City street poles, street furniture, building rooms and rooftops, conduit, and other facilities that can be used for broadband deployment.
Conduit	In a telecommunications context, conduit refers to the protective casing in which cabling or fiber is run, underground. An underground conduit system also includes manholes or handholes in the street or sidewalks to access the cable/fiber that it protects.
Digital Inclusion	"Digital inclusion" is often used to broadly refer to actions taken to ensure all people and communities are able to access and use Information and Communications Technologies (ICTs). In this Master Plan, the term is used to refer specifically to actions that support safe and equitable use of broadband by all New Yorkers, such as programs that support access to devices, digital skills training, and/or supportive community spaces for technology exploration.
Digital Literacy	The ability to find, assess, use, create, and share content using communication technologies like computers and the internet. What it means to be digitally "literate" is constantly changing, as technology and society change. The City aims to provide digital literacy by ensuring that New Yorkers have the resources they need to keep pace with these changes and benefit equally from the opportunities the digital world offers.
Dark Fiber	Optical fiber that has been installed, but is not currently being used to transmit data (via light).

Glossary

Term	Definition
Fiber / Optical Fiber	The technology/medium used to transmit data as pulses of light through a thin, cylindrical strand or "fiber" made of glass or plastic. Optical fiber technology can carry much more data than other existing telecommunications technologies, and is less prone to environmental damage or interference, because of the materials (glass vs. metal wiring) and signal type (light vs. electricity) used.
Franchise	A contract permitting the private use of public property. In New York CIty a telecommunications franchise agreement allows a private organization, such as an internet service provider, to conduct business using City-controlled rights-of-way.
Gigabit	The speed of an internet connection is measured in the number of "bits" of data that can be transferred in one second between two telecommunication points. A gigabit-speed connection can transfer one billion bits per second. As an example, speed at this level would allow a user to download a file the size of two-hour movie in less than 10 seconds.
Internet Service Provider (ISP)	An entity that provides end users with internet service.
Latency	Network latency refers to any delay in the transmission of data across a network.
Net Neutrality	Principle that all data on the internet should be treated equally, no matter the content or platform of use. Prohibits internet service providers from acting as gatekeepers between users and content by prioritizing, blocking, or slowing access to selected content.
Network Architecture	The specific design of a given telecommunications network, including its hardware, cabling, physical and wireless connections, as well as the software rules and protocols used.
Spectrum	Radio frequency (RF) spectrum comprises the signals used in wireless communications. Spectrum is divided into frequency "bands."
Virtual Network	Telecommunications network that utilizes physical networks, but is structured by software, rather than hardware, allowing flexibility and dynamic definition in the network design.