Improving Bus Service in New York

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By

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Abstract

New York City's transportation system is in a state of disarray. City street are clogged with taxi's and for-hire vehicles, subway platforms are packed with straphangers waiting for delayed trains and buses barely travel faster than pedestrians. The bureaucracy of City and State government in the region causes piecemeal improvements which do not keep up with the state of disrepair. Bus service is particularly poor, moving at rates incomparable with the rest of the country. New York has recently made successful efforts at improving bus speeds, but only so much can be done amidst a city of gridlock. Bus systems around the world faced similar challenges and successfully implemented improvements. A toolbox of near-immediate and long-term options are at New York's disposal dealing directly with bus service as well indirect causes of poor bus service. The failing subway system has prompted public discussion concerning bus service. A significant cause of poor service in New York is congestion. A number of measures are capable of improving congestion and consequently, bus service. Due to the city's limited capacity at implementing short-term solutions, the most highly problematic routes should receive priority. Routes with slow speeds, high rates of bunching and high ridership are concentrated in Manhattan and Downtown Brooklyn which also cater to the most subway riders. These areas would also benefit the greatest from congestion mitigation measures.
Keywords: bus, subway, New York City, congestion, MTA, NYCDOT

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Introduction

New York City grew in part due to its successful subway service and continues to rely on the system which frequently breaks down and faces delays. Trains are at capacity even during optimal conditions. New York City has long served as a model for public and active transportation in the United States. In the last decade the City added 300,000 residents, 700,000 jobs and 16 million tourists (Comptroller, 2017). More than 800,000 people are expected to move to New York City by 2040 though the region's antiquated public transportation infrastructure remains largely without improvement (NYCDCP 2013). Change appears on the horizon as subway lines are upgraded to communications-based train control (CBTC) allowing shorter headways, the East Side Access project allows Long Island Rail Road trains to terminate at Grand Central Terminal and review is underway for upgrading Penn Station and the Port Authority Bus Terminal. Each improvement requires many years to complete and costs a great deal of money at which time even more renovations will be required to meet demand.

Bus service, an undervalued mode of transit daily serves 2.4 million New Yorkers (compared to the subway's 5.7 million); more than twice as much as the nation's next largest system and more than Metro North Railroad, Long Island Railroad, New Jersey Transit and Port Authority Trans-Hudson combined (MTA 2017, Comptroller 2017). The Metropolitan Transportation Authority's (MTA) public bus system serves all New York City neighborhoods "with the express intention that no New Yorker should walk more than a quarter-mile to the closest bus shelter or subway station." (Comptroller 2017) For some, bus service is merely supplementary to subways, but many others living in neighborhoods without subway service rely on the bus every day. Despite its availability throughout the City, bus service is inadequate due to “a product of age-old institutional failures by the City and the MTA to maximize the system’s potential.” (Comptroller 2017) According to a report by City Comptroller Scott Stringer:

> “its routes are often slow, unreliable, long, meandering, confusing, congested, and poorly connected. It’s buses are old, it’s shelters deficient, and access to its stops and separated lanes are under-enforced. Its network is stagnant, changing little in recent decades despite an extraordinary transformation in residential, employment, and commuting patterns throughout the five boroughs.” (Comptroller 2017)

Despite New Yorker’s reliance on buses, speeds average 7.4 mph (Figure 1); slowest in the country “thanks to unprecedented gridlock.” (Transit Center 2016, Gordon 2017) Citywide speeds declined 6% in the last decade and 14 since 2006 despite tourism and population growth (City Council 2016, Maslin Nir, 2018). Ridership of local routes declined 6.3% in the past year and 16% from 2002 to 2016. (Fried 2017, Transit Center 2016) Throughout this decline, subway ridership increased 24.7% since 2002 though is sharply declining due to delays and construction, prompting an increase in for-hire vehicle (FHV) use (Transit Center 2016). Decreased ridership prompts service decreases which propel further ridership decreases, ultimately killing bus service. The decrease in New York City’s bus ridership parallels the pattern of the country. Bus ridership nationwide fell 3.9% from 2015 to 2016 and 13.6% from 1990 to 2016 (APTA, 2017).

Ridership increases and historical public disinvestment in the subway system cause crowding and delays. The MTA is gradually making improvements to the subway system, but even minor adjustments require many years to complete. New Yorkers’ are frustrated with the lackluster subway system. Only 28% of New Yorker’s approve of Governor Andrew Cuomo in relation to his leadership of the subway system (Lavacca 2017). He even declared a state of emergency in June 2017 due to the subway’s failures; dedicating an additional one billion dollars to MTA’s capital plan “so the MTA has the resources they need to get this done.” (Lovett 2017)

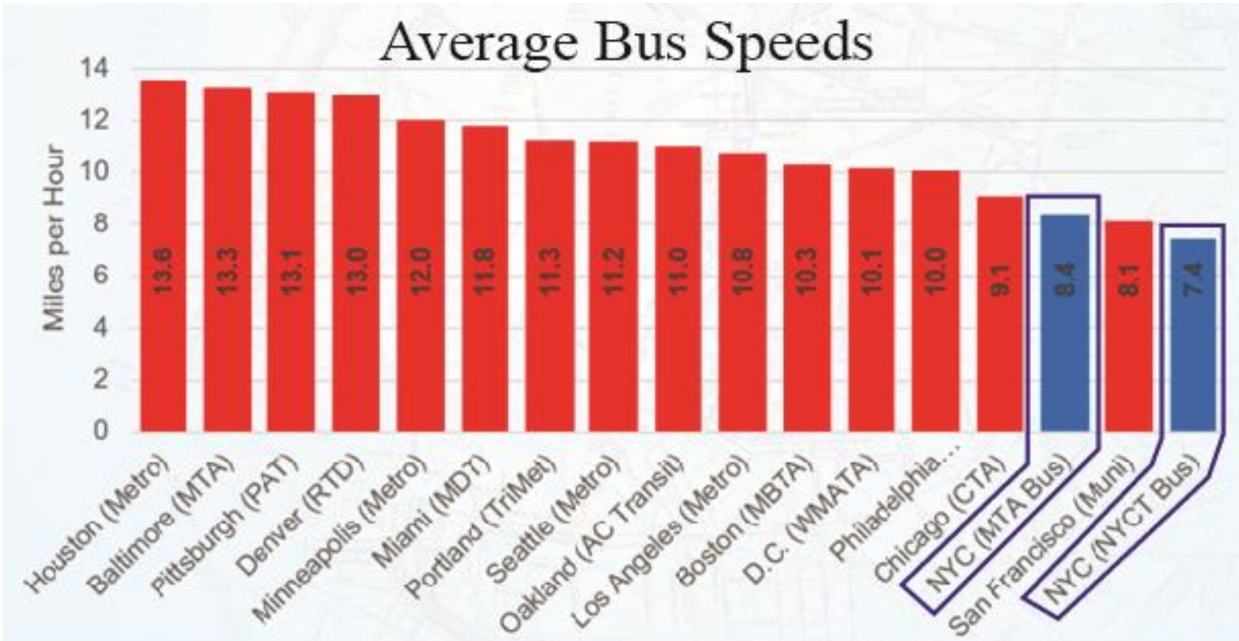

Figure 1 https://comptroller.nyc.gov/reports/the-other-transit-crisis-how-to-improve-the-nyc-bus-system/, Modified by Author

With failing subway service and a dearth of MTA funding, providing adequate bus service is as important as ever. The City has a six thousand mile street network which can easily cater buses. A difficult problem to overcome in other American cities is creating demand for bus service. New York City does not have this issue. Despite poor service, million's of New Yorker's continue to ride the bus daily. The decrease in bus ridership is not due to a lack of demand, but lack of adequate service. The issue is also not due to neighborhoods being too sparsely populated; the vast majority of New York City is adequately dense to cater to frequent bus service. Boris Pushkarev and Jeffrey Zupan determined "densities in the 2-7 dwellings per acre range produced only marginal use of public transportation within major urban areas of the United States…Densities of 7 to 30 dwellings per acre were necessary to sustain significant transit use – in the range of 5 to 40 percent of all trips." (Pritchard 2007) Of New York City's 3.43 million households, only 5.5% live in a census tract with less than 7 dwellings per acre. (See Figure 2). The average size of these less densely populated census tracts is only 0.7 square miles. Therefore, though these tracts may not have sufficient density to support frequent transit, their small size signifies residents may live close enough to a census tract with sufficiently high density. The historical popularity of bus service expresses that plenty of New Yorkers' would ride the bus if adequate service was provided. When the existing system does not satisfy them, they revert to other modes of transit (primarily subway and automobile). Buses are typically viewed as transporting lower class customers compared to fixed rail transit networks with dedicated rights-of-way such as subway, commuter rail and light rail, but this does not need to be the case; other cities have proven bus service can appeal to everyone. Faster and more reliable service will attract more riders. Subway improvements are fairly straightforward requiring technological and infrastructural upgrades, but at great cost and service disruption. Bus improvements are more nuanced covering a range of fields including street design, technology, policy, marketing and transit planning. "Bus transit is less glamorous and sexy than the subways, but it's a vital piece of our infrastructure" said City Council Member Mark D. Levine (Maslin Nir 2018). Though more complicated than subways, bus improvements are much easier to implement due to less infrastructure requirements. Many well-researched measures around the world have been undertaken to improve bus service. New York City has implemented some of these, but has a lot more work to do. This paper analyzes potential bus improvements and introduces the issues of congestion which cripples bus service.

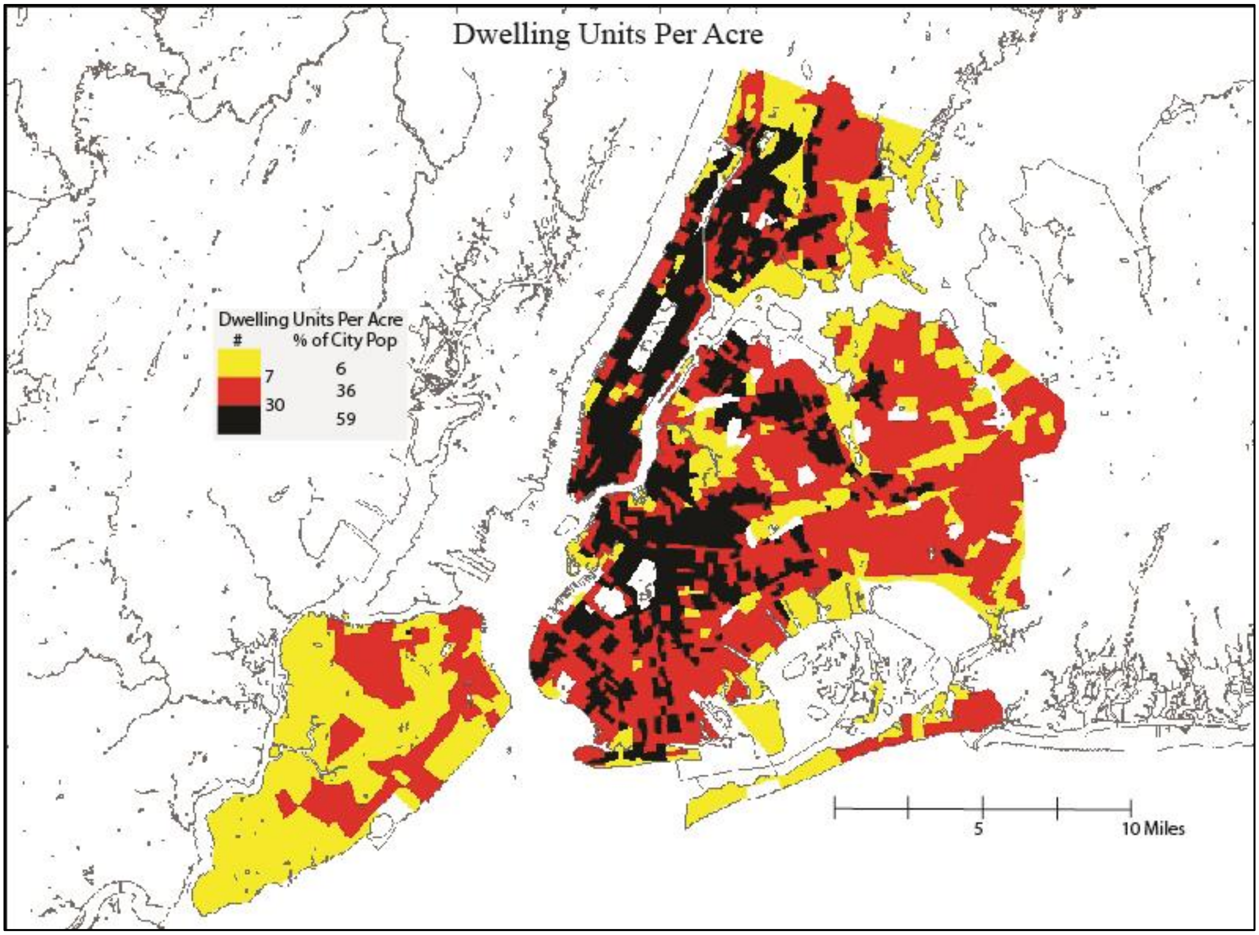

Figure 2 Designed by Author

Agency Responsibility

The MTA is responsible for the operation of New York City's public bus routes. These include local, express and Select Bus Service routes. Local routes operate with frequent stops, express cater to Outer Borough residents during peak times and Select Bus Service represents MTA's venture into Bus Rapid Transit (BRT) providing more frequent, reliable service with fewer stops. Despite all bus service falling under MTA responsibility being within the five boroughs, the MTA is a state agency. The MTA is also responsible for the New York City Subway, Long Island Railroad and Metro North Railroad. MTA's position as a state agency creates many challenges. Funding is a contentious issue as the MTA receives funds from throughout the state, but their work is focused in New York City.

The New York City Department of Transportation (NYCDOT) is responsible for streets and sidewalks (among other things) in New York City. In regards to buses, this includes bus lanes, traffic signals, street design and all amenities placed on sidewalks such as bus shelters and fare machines.

Background

New York City Bus History

Since 1968, the MTA has been responsible for providing public bus service in New York City. Service operates under the MTA Regional Bus Operations and MTA Bus Company subsidiaries. MTA Regional Bus Operations is responsible for most MTA routes while MTA Bus Company is responsible for express bus routes to Manhattan from the Bronx, Brooklyn and Queens and some local routes in Queens (See Figure 3). MTA Bus Company was formed in 2004 as a consolidation of seven private bus lines facing financial distress and is subsidized by the City. Each entity maintains its "own employees, planning groups, depots, capital plans and overhead costs." (City Council 2016) Presently, the City continues to pay all of MTA Bus Company's net operating costs; an amount which has increased 29% since 2011 to 367 million dollars. (City Council 2016)

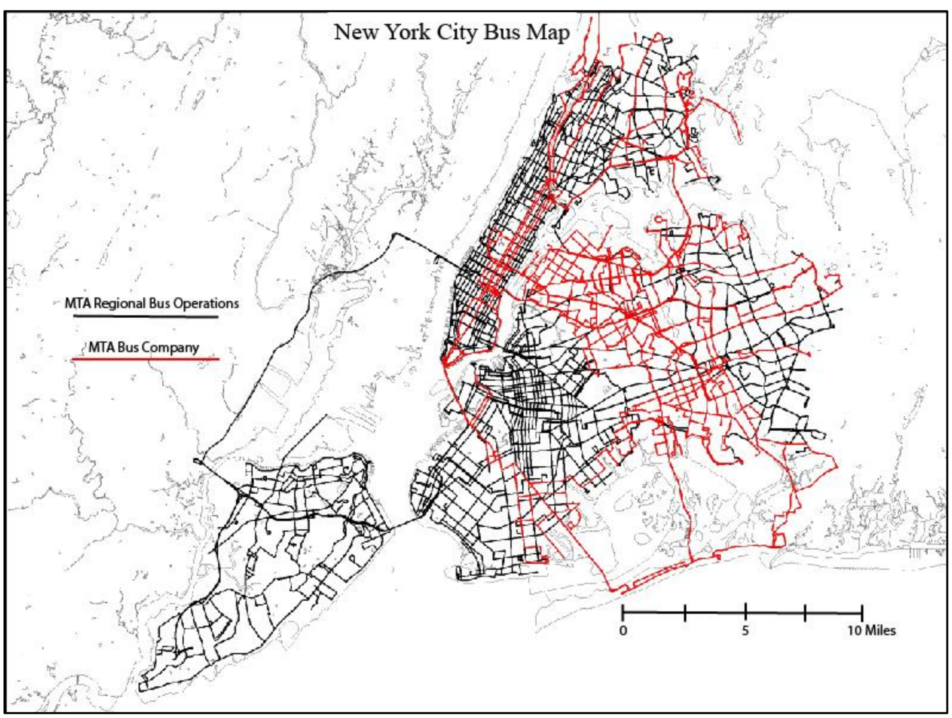

Figure 3 Designed by Author NOTE: along corridors with routes from both entities, MTA Bus Company is given preference

In recent years many technological improvements have been made to buses such as a digital map and screen informing passengers of the next stop though this upgrade has only been implemented on some buses. "Bus Time" was introduced in Staten Island in 2013 and expanded to all routes in 2014. (City Council 2012) The app uses bus GPS to publicize bus wait times via website, text message and countdown clocks installed at stops. Widely used across the New York City Subway, countdown clocks inform waiting passengers how long until the next bus arrives. They were first introduced in 1996, but faced difficulties during a few trial runs. Despite the challenges, the Riders Alliance calls them "an unmitigated success." (Doig 2017) 48 bus countdown clocks were installed on the Upper East Side in 2017 after Mayor de Blasio announced the installation of 350 clocks the previous year. (Barone 2017) In 2017, ten percent of participatory budget votes were cast in favor of allocating greater funding to countdown clocks. (Doig 2017) "Bus Trek" has been used internally by the MTA to monitor buses in real-time and allow dispatchers to prompt drivers to skip stops or avoid congested routes. The MTA will receive 2042 newly designed buses by 2020 with more available USB ports, Wi-Fi access and low-floor boarding. These upgrades improve the passenger experience, but have no effect on the speed of buses which is the primary reason for the system's declining ridership.

The MTA reviews express bus service annually and local, limited and Select Bus Service (SBS) every two years. (City Council) These reviews result in adjustments to service frequency. Only a handful of routes have experienced major changes in route though. A few instances of routes being slightly changed have occurred to accommodate large-scale developments such as Starret City in Brooklyn, Atlas Park Mall in Queens and Co-op City in the Bronx. Routes were elongated in the first two examples and rerouted for simplification in the latter. In January 2017 the M5 route was split into two due to congestion along a portion of the route. The split intends to equalize service across the entire route. The MTA has also expressed interest in decreasing the frequency of bus stops where feasible although doing so would result in public uproar. A “Super Express Service” was launched along the X21 in 2014 which maximizes time spent on the highway, limits the number of turns and more greatly separates stops. The peak hour-only service gained 80% ridership (City Council 2016). Local officials and residents’ recently formed the B71+ Coalition to propose reviving B71 bus service between Red Hook, Brooklyn and Manhattan; discontinued in 2010 (Kings County Politics 2017). The two-mile B39 is the only local or SBS route connecting Brooklyn and Manhattan; it is also has the lowest ridership due to thirty minute headways. With an optimum subway system, bus service between boroughs would be less necessary, but providing such would improve mobility and decrease subway crowding.

A number of dedicated bus lanes have been installed on local and SBS routes. Prior to 2004, 71 miles of bus lanes were installed with plans of expanding to 108 miles by the end of 2017 (Kings County Politics 2017). A major issue of bus lanes is enforcement. Any rider utilizing a bus with a dedicated lane has witnessed the number of double parked vehicles rendering the lane moot. A study of the Livingston Street bus lane in Brooklyn found “not a single bus traveled the length of the street without having to merge out of the lane due to an obstruction.” (Comptroller 2017) Bus lane cameras are utilized on nine routes with plans to expand to 16 routes and have been determined to be incredibly successful with violations declining 33-87% after the installation of cameras. (City Council 2016) A reason more cameras have not been installed is the need for State approval. Camera enforcement is always a contentious issue as people (especially American’s) are highly skeptical of surveillance. A number of queue jump bus lanes have been installed which allow buses to cross the intersection from the bus lane before general traffic.

Select Bus Service

The largest improvement by the MTA has been Select Bus Service (SBS). Since 2008 14 bus routes have upgraded to SBS service (Warerkar 2017) (Figure 4). 21 more are expected to be rolled out by 2027. SBS utilizes aspects of BRT to improve reliability and service through off-board fare payment, longer spacing between stops, kneeling buses, all-door boarding and distinctive branding (Figure 5) Additionally, some routes or portions of routes include bus-only lanes and traffic signal priority (TSP) (Figure 6). SBS represents the first significant partnership between the MTA and NYCDOT. Since the program's inception, communication and cooperation between the agencies have improved and ridership along SBS routes have increased. Traffic signal priority extends a green light signal or shortens a red signal depending on the location of the bus. This is a very important method of improving bus service as "on busy routes, buses spend 21% of their time stopped at traffic lights." (NYCDOT 2017) Implemented on five routes, TSP has reduced travel times between 5% and 30%. By the end of 2017 TSP will be implemented at 496 intersections on five additional corridors and by 2020 will be installed at an additional 886 intersections across ten routes. (NYCDOT 2017) According to the Village Voice, only three of these ten routes are scheduled to utilize dedicated bus lanes. This compares to London's 3200 and Los Angeles' 654 intersections. (NYCDOT 2017) Prior to implementation along the M15 SBS route, TSP was expected to reduce peak travel time by between 7.4 and 14.2% as well as reduce peak hour delay for all corridor traffic by between 11.9 and 14.6%. Side street delay was also expected to be reduced by 3.5 to 10.8% (aimsun). City Council Member Mark Levine recently proposed implementing TSP on ten, rather than five routes per year. The cost of implementation is 1-2 million dollars per route, a relatively small price for assured improvements. (Meyer 2017)   The MTA is currently investigating the use of contactless fare payment to speed up boarding; a system utilized around the world (Gordon 2017). Contactless fare payment allows riders to pay via phone or card. Readers will be installed at 500 subway turnstiles and 600 buses beginning in late 2018. Such a fare payment system will speed bus boarding though it is not certain if it will be used on SBS fare machines. Metrocards are expected to be accepted until 2023.

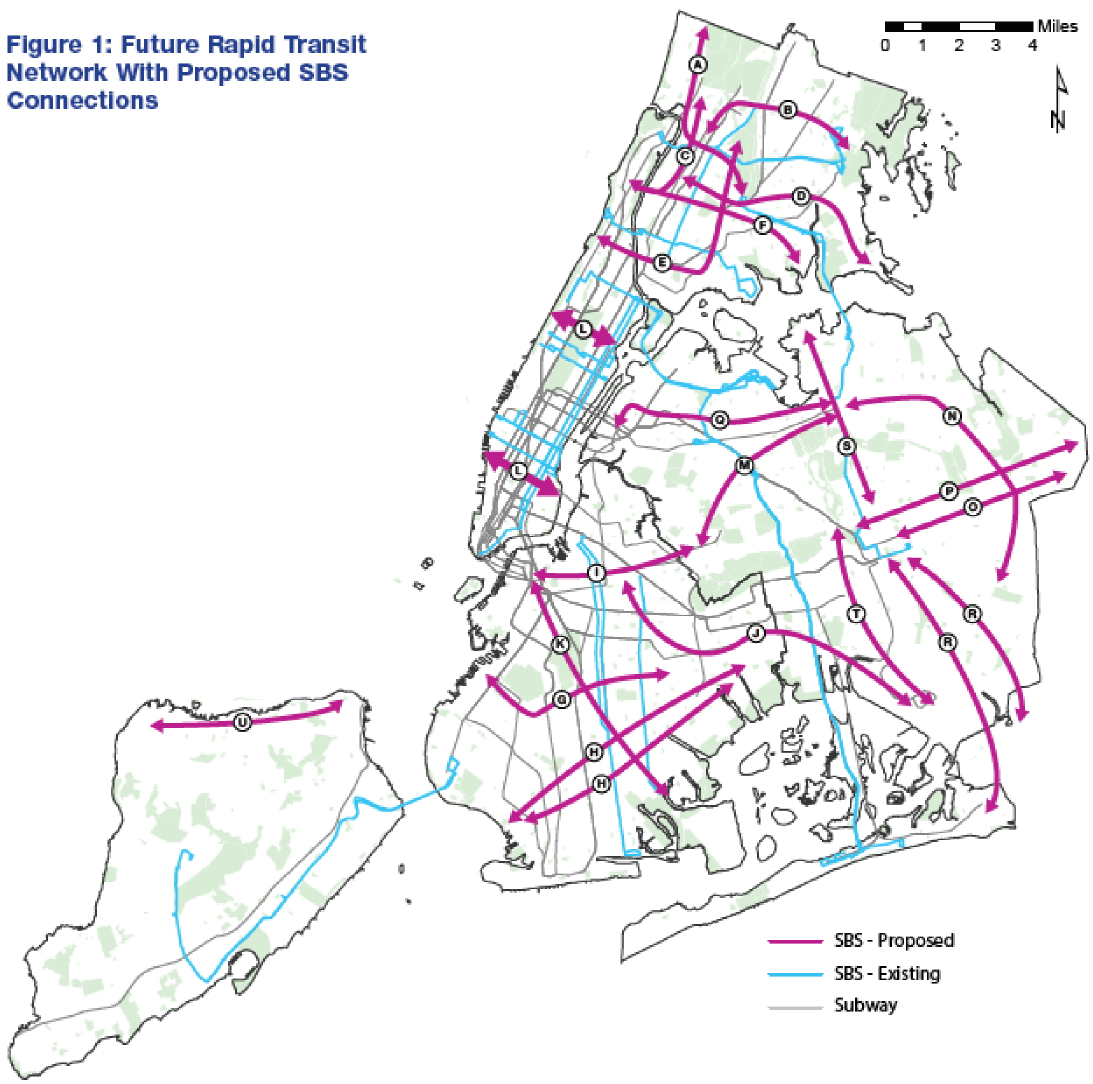

Figure 4https://cdn20.patchcdn.com/users/22965231/20171020/014039/styles/raw/public/processed_images/1508521239-1508521239-3099.jpg

Figure 5 https://untappedcities-wpengine.netdna-ssl.com/wp-content/uploads/2013/07/NYC-MTA-SBS-M15-Select-Bus-Service-BRT.jpg

Figure 6 http://nyc.streetsblog.org/wp-content/uploads/2017/07/TSP_map.jpg

Council Member Mark Levine published a October 2017 *Crain's Magazine* article calling attention to the bus crisis. "Working in concert with the MTA, [NYCDOT] could create dedicated bus lanes backed up by real enforcement, implement a faster payment system, allow for all-door boarding and manage bus spacing to prevent bunching" stated the Council Member. Though all routes upgraded to SBS experienced quantitative improvements, some have criticized SBS for not utilizing all BRT features such as dedicated, separated rights-of-way. (Comptroller 2017) Typically utilized on highly traffic routes, in 2016 12% of the City's bus trips occurred on the 11 SBS corridors. (City Council 2016) Routes have experienced travel time improvements of 13-23% and ridership increases of 10-31% (Transit Center 2016). The Bx12 Fordham Road SBS service experienced a 20% increase in bus speeds, 10% increase in ridership and 71% increase in retail sales along the corridor (Tri-State Transportation Campaign 2017). M5 SBS service along First and Second Avenues (paired with the installation of bike lanes) experienced an 18% increase in bus speeds, 12% in bus ridership, 37% decrease in crashes causing injuries and 47% fewer commercial vacancies. (Tri-State Transportation Campaign 2017) B44 SBS service along Nostrand Avenue experienced improved travel times of 15-31%, a 10% ridership increase and 37% reduction in traffic injuries between 2014 and 2015. (City Council 2016) While the B44 previously spent 20 minutes of each run stopped in traffic, it now does so for only 12.5 minutes in the portion of the route with a bus lane decreasing 7% in the AM peak and 11% in the PM. Bx41 SBS service along Webster Avenue moved 22% faster with 28% more riders (City Council 2016)

The benefits of SBS tactics extend beyond SBS service itself. Local routes Bx15 and M100 utilize the M60 SBS bus lane on 125th Street in Manhattan and have experienced travel time reductions of 7-20%. (City Council 2016) Advocacy group Transportation Alternatives

(TA) have stated “the evidence is clear: dedicated bus lanes improve service, even when a route is not SBS.” (City Council 2016) Though appearing easier to evade the fare on SBS buses which have off-board fare payment, fare evasion constitutes only 3% of trips on off-board fare payment routes compared to 15% on traditional on-board fare buses. (City Council 2016) In addition to the recent implementation of SBS service, safety incidents involving pedestrians and buses decreased 26% between 2013 and 2015. (City Council 2016) Thus far, the City’s SBS foray has cost 300 million dollars; similar subway speed and efficiency improvement would cost many billions. (Gordon 2017) Mayor de Blasio recently announced a 270 million investment in 21 new SBS routes over the next decade; increasing the percentage of the City’s bus rides on SBS to 30%. (Gordon 2017) Tools utilized through SBS can be implemented separate from full SBS service. A representative of TA stated “the city does not need to go through the long process of planning and consulting that precedes designation of SBS routes in order to improve bus service-all it needs is a modest investment in red asphalt, signage and camera enforcement.” (City Council 2016) Jon Orcutt, formerly of NYCDOT and presently of Transit Center argues the “city should expand the most effective aspects of SBS-dedicated bus lanes and transit signal priority-as quickly as possible, which it can do without waiting on the MTA.” (Gordon 2017) Location specific improvements such as bus lanes, bus stop consolidation and TSP should be utilized on non-SBS or pre-SBS routes.

NYCDOT has recently implemented median bus lanes along a portion of East 161st Street in the Bronx for Bx6 SBS and in November 2017 on Woodhaven Boulevard in Queens between Park Lane and Liberty Avenue for Q52/Q53 SBS. (Comptroller 2017) A major concern with offset bus lanes which run between moving traffic and parked vehicles is that double parking often occurs, forcing buses to swerve in and out of the bus lane. Median bus lanes eliminate this conflict. The City's recent brief foray into median bus lanes provide good test cases for more widescale implementation in the future.

BRT

Though SBS is certainly an improvement from typical local bus service, it is far from true BRT service. The Institute of Transportation & Development Policy (ITDP) defines BRT as "a high-quality bus-based transit system that delivers fast, comfortable, and cost effective serves at metro-level capacities." (ITDP, 2018) Figures 7 and 8 are typical BRT stops in Curitiba, Brazil and Bogota, Colombia. ITDP rank various BRT systems on a set of standards, designating Bronze, Silver and Gold rankings. Each tenet of BRT is detailed below, but the fundamentals include paying before boarding, long distances between stops and physically separated routes with conflicting traffic. Each is detailed with how New York City bus service currently fares in each category. A subsequent section of the paper investigates how the City can improve its BRT infrastructure.

BRT Basics

Dedicated Right-of-Way

A key factor of BRT service is a dedicated right-of-way. This requires segregating buses from general traffic. The most effective means of doing so is by physically separating lanes with fences, curbs or bus stations. Such treatment receives the highest score from the ITDP. Lower scores are earned for color-differentiated lanes and lanes separated by paint. The vast majority of New York City bus routes operate in general traffic. The City has 108 miles of bus separated bus lanes. Unfortunately, many of these lanes are rendered moot due to double parking.

Busway Alignment

The ideal place for bus routes is along the median of a street with the bus stop located along the median. New York City does not operate such routes. Buses must contend with other moving and turning vehicles. Issues of turning vehicles is detrimental to bus lanes through which turning vehicles can maneuver.

Off-board Fare Collection

According to the ITDP "off-board fare collection is one of the most important factors in reducing travel time and improving the customer experience." The BRT Standard awards the most points for a barrier-controlled system and second most points for a proof-of-payment system. New York's SBS routes operate with proof-of-payment.

Intersection Treatments

The BRT Standard awards the most points for prohibiting turns across a busway and fewer additional points for TSP. New York does not prohibit turns across busways and has a relatively small portion routes with TSP.

Platform-level Boarding

Having a short distance between the bus and loading platform or curb provides greater accessibility to disabled passengers. New York City has done well in this regard, operating with a fleet of "kneeling buses" which move closer to the curb when prompted by the driver.

Service Planning

Multiple Routes

The BRT Standard awards more points to systems which operate multiple routes along the same corridor. New York City has a number of instances in which portions of multiple routes operate over the same span; notably, four routes operate along a piece of 125th Street in Manhattan.

Express, Limited and Local Services

The ITDP incentivizes providing different types of services along the same route. New York City has express, limited and local bus routes, but not all along the same corridor, except in rare instances (one of which is M15 local and SBS service along First and Second Avenues). Express routes are concentrated in the Outer Boroughs and focus on peak hour travel.

Control Center

Technology has improved to allow the MTA to monitor the locations of buses in order to respond to incidents and control bus spacing though bunching remains a huge issue for the system.

Located in Top Ten Corridors

The ITDP awards more points for BRT routes located along routes with high ridership. Though not fitting with many other BRT qualifications, New York's SBS system has so far concentrated on high ridership routes which have the demand for more frequent and reliable service.

Demand Profile

The BRT Standard awards more points for BRT service in high demand areas. SBS satisfies this as routes lie along the most heavily used corridors.

Hours of Operations

Each MTA route operates at different hours. Some do not run overnight though SBS routes run 24 hours per day.

Multi-corridor Network

The BRT Standard incentivizes operating BRT routes on multiple corridors; ideally on intersecting routes. The City has SBS routes along 15 corridors. Due to the long length and number of corridors, numerous SBS routes intersection with another.

Infrastructure

Passing Lanes at Stations

The ITDP incentivizes allowing local and express service along the same route by having a passing lane. New York City has local and express service along the same corridor although this is only accomplished by having buses run in general traffic.

Minimizing Bus Emissions

In early 2018, the MTA began a three year pilot program with 10 electric buses “with the goal of reducing emissions and modernizing the MTA’s bus fleet.” (MTA, 2018) This is a small test that will not result in large-scale change soon though the MTA is moving in the right direction.

Stations Set Back from Intersections

The ITDP calls for stations “be located at minimum 85 feet, but ideally 130 feet” from intersections to avoid delays. Additionally “if stations are located just before an intersection, the traffic signal can delay buses from moving from the station and thus not allow other buses to pull in.” A standard MTA bus stop is 80 feet long. Typically, buses are not sufficiently separated from intersections. Stops on the near side of an intersection are frequently delayed due to stopping at a red light and allowing additional passengers to board.

Center Stations

The ITDP encourages “having a single station serving both directions of the BRT system mak[ing] transfers between the two directions easier and more convenient.” (ITDP, 2018) MTA bus stops are located on opposite sides of the street, or in cases of one-way streets, on entirely different streets.

Pavement Quality

In general, the pavement quality in New York is of high standard, with frequent inspections and milling and paving conducted based on quality. Additionally, bus pads are installed at highly trafficked bus locations which help prevent damaging asphalt.

Stations

Distances Between Stations

According to the BRT Standard, "in a consistently built-up area, the distance between station stops optimizes at around 450 meters (1476 feet)." (ITDP, 2018) As will be discussed later, New York City bus stops are spaced closer than any other system in the country with a standard minimum of 750 feet which is often not followed.

Safe and Comfortable Stations

The ITDP encourages wide, weather-protected-safe and attractive stations. Some New York City stations provide no amenities while others include a bus shelter protecting from precipitation, but not high and low temperature. No security is provided at bus stops. The BRT Standard asks for a minimum ten foot internal width for bus stops. New York City buses are typically seven feet from the curb, providing insufficient space for waiting passengers and sidewalk users to pass.

Number of Doors on Bus

The ITDP asks for articulated buses to have at least three doors and non-articulated buses two doors. New York City satisfies both though issues arise when passengers are boarding and disembarking from the same door.

Docking Bays and Sub-stops

New York City has no instances of sub-stops which "connect to one another" (ITDP, 2018).

Sliding Doors in BRT Stations

New York City's bus stops have little to no infrastructure and thus no sliding doors.

Communications

Branding

The ITDP incentivizes "all buses, routes, and stations in corridor follow single unifying brand of entire BRT system" (ITDP, 2018). The MTA and NYCDOT have succeeded in this effort of painted SBS differently from other buses and marketing the "SBS" brand.

Passenger Information

The MTA has upgraded SBS buses to show connections to other routes. A number of routes have real time passenger information though the accuracy of this data is frequently questioned.

Access and Integration

All MTA buses are wheelchair accessible though some require the driver to manually rearrange seats to accommodate a passenger in a wheelchair. More modern buses allow the driver to press a button which expands a ramp onto the bus.

Universal Access

Integration with Other Public Transport

All MTA buses and subways have easily accessible fare integration which allows free transfers. Additionally, subway routes and stations include notation and directions to adjacent SBS routes. This is not the case for non-SBS routes though.

Pedestrian Access

All bus stops are accessible to pedestrians though narrow sidewalks prompt crowding.

Secure Bicycle Parking

MTA stops have no bicycle parking.

Bicycle Lanes

There is no concerted effort to integrate SBS or MTA service with bike lanes. Some bus routes have bike lanes on them, but this is merely coincidental. There are presently no bike lanes on the same corridor as bus lanes.

Bicycle-Sharing Integration

Citi Bike bike share stations are located throughout Manhattan south of 130th Street and portions of Queens and Brooklyn located nearest to Manhattan. No comprehensive effort places bike share stations near bus stops.

Point Deductions

In addition to awarding points based on what a bus system includes, points are deducted for neglecting certain items or circumstances which lessen the positive effects of bus improvements.

Commercial Speeds

Bus service that is too popular can result in bus lanes with slow (<12 mph) speeds because of the number of buses using the facility. Bus speeds in New York are slow, but not for this reason.

Minimum Peak Passengers per Hour per Direction Below 1,000

Some bus routes have low ridership, but SBS routes have sufficiently high ridership to not lose points.

Lack of Enforcement of Right-of-Way

A major issue with New York City's bus lanes is double parking and subsequent lack of enforcement. New York loses points for this.

Significant Gap Between Bus Floor and Station Platform

Due to kneeling buses, New York does not have this issue.

Overcrowding

Overcrowding on bus routes vary between routes though some routes are certainly overcrowded.

Poorly Maintained Busway, Buses, Stations, and Technology Systems

Because of a lack of innovations, MTA bus facilities do not require significant maintenance so are relatively well-maintained.

Low Peak Frequency

Peak frequency varies across routes though all SBS routes have frequent service.

Permitting Unsafe Bicycle Use

Cycling often occurs in bus lanes due to lack of adequate bicycle facilities.

Lack of Traffic Safety Data

Traffic safety data is readily available to MTA and NYCDOT employees. This data is frequently reviewed; particularly after an SBS routes is implemented.

Buses Running Parallel to BRT Corridor

Most, if not all SBS corridors have bus routes on parallel spans though due to high demand of bus service, SBS routes still have adequate ridership.

Bus Bunching

Due to congestion and lack of bus lane enforcement, bus bunching occurs constantly in New York.

Figure 7 https://www.google.com/search?q=curitiba+brt&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjsx4G__cTaAhWRm1kKHWcyA4IQ_AUICigB&biw=1920&bih=925#imgrc=l-e2KzMgR55UcM:

Figure 8 https://ggwash.org/images/made/images/posts/_resized/Transmilenio_Main_800_531_90.jpg

Congestion

Traffic congestion is a problem across the country and world as automobile ownership becomes cheaper. The time length of highway congestion in large American cities has increased from 4.5 hours per day in 1982 to 7 hours per day in 2003. In a sense, congestion is good; disincentivizing driving. This becomes a problem when the demand is so high and feasible alternatives are not provided that motorists continue to drive despite the congestion.

The most basic reason for congestion in Manhattan is high demand; people want to be in Manhattan. The vast majority of New Yorker's, 96%, pay to enter Manhattan's central business district (CBD, defined as south of 60th Street). This includes bus and train riders and motorists on tolled bridges. If the non-paying four percent paid closer to their fair share, congestion would decrease and New York would gain a consistent transit funding source. 75% of motorists entering Manhattan's CBD do not pay a toll. Neglecting to charge all crossings encourages "bridge shopping" in which motorists go out of their way to cross over a free bridge. This costs more time, gas, pollution and congestion. A perfect example of this are the thousands of motorists who daily exit the Long Island Expressway and travel north to the free Queensboro Bridge rather than continue through the tolled Queens-Midtown Tunnel worsening congestion on local streets and adding unnecessary vehicle miles traveled.

A January 2018 report by the Tri-State Transportation Campaign lists a number of contributors to congestion including: subway failures, unregulated FHV, population growth, increased freight movement, construction activity and increased tourism and pedestrian volumes.

Subway Failures

A comprehensive New York City transportation system requires multiple modes of transit. A strong subway service supports a strong bus system and vice versa. Subway speeds have declined and delays have increased (Figure 9). Due to the unreliability of the subway, some riders moved to alternate modes; those with more financial means have switched to taking for-hire vehicles which contribute to congestion.

Figure 9 https://penneyvanderbilt.files.wordpress.com/2016/03/subwaycrowded.jpg?w=500&h=287&crop=1

Unregulated FHV

The number of yellow taxi's in New York City has stayed fairly constant over the 60 years due to the Taxi and Limousine Commission's (TLC) medallion system. The advent of transportation network companies (TNC's) like Uber and Lyft have complicated the industry. By not falling under TLC control, FHV's do not have to pay the same surcharges and are thus able to charge lower fares. FHV's are only allowed to pick up passengers who have gone through their phone app; not hailed on the street. This causes increased VMT as FHV drive between customers locations. The most congested areas of the City are Lower/Midtown Manhattan and Downtown Brooklyn which also have the slowest bus speeds and highest demand for FHV. Transportation consultant Bruce Schaller conducted an exhaustive study of TNC's in New York. His 2017 report concluded that TNC's alone accounted for a three to four percent increase in citywide traffic and "a prime cause of the 11 percent slowing of traffic in the Manhattan CBD from 2013 to 2016." (Komanoff 2017) Despite Uber promising "to take 1 million cars off the road in New York City and help eliminate our city's congestion problem for good" TNC's have added 50,000 vehicles to New York's streets. (Schaller 2017) TNC's, yellow cabs, black cars and car services account for 19% of citywide mileage in 2016 compared to only 14 percent in 2013. TNC use has grown despite, or as a result of a decrease in yellow taxi rides. Most troubling is that "for the first time in many years, car-based services, not transit, account for most growth in travel" and "most TNC customers are coming from transit, walking and biking." In October 2017, Uber overtook yellow cabs with 289,000 daily rides versus 277,000 (Warerkar 2017). Much of Uber's growth occurs outside of the central business district, with more than half of all rides beginning outside Manhattan.   The recent increase in congestion provides further evidence that something needs to be done to improve transportation in New York.

On April 1, 2018, New York State lawmakers passed a budget which includes a surcharge on for-hire vehicles; $2.75 per ride for Uber and Lyft, $2.50 fot taxis and $0.75 for group ride services like Via and UberPool (Lumb, 2018). The surcharge will raise 400 million dollars annually for the MTA. These fees are significantly higher than those in other parts of the country. Seattle instituted a $0.24 charge per trip, $0.50 in Portland and $0.65 in Chicago. Congestion expert Charles Komanoff expects a 2.7% decrease in Uber and Lyft and 6.4% in taxis as a result of the added fee (Desai, 2018). These fees were recommended by Governor Cuomo's FixNYC Panel earlier in the year. It is the first stage of implementing road pricing in order to raise funds for the MTA. Unfortunately, while raising funding, the plan does not adequately address the issue of congestion.

In response to rising congestion and transportation costs, the City's Taxi and Limousine Commission could initiate a new program which encourages carpooling (or taxipooling) through its taxi's. Taxipool stations can be setup at high trip locations where multiple people share the same taxi and the cost to travel to nearby locations. This would decrease the number of for-hire vehicles on the road and save passengers money. A potential externality of this would be that rather than discouraging single-ride FHV trips, it further encourages people to switch from bus and subway to the less efficient FHV.

Taxi Carpooling

Population Growth

A fundamental reason for congestion is a lack of regulation of supply and demand. According to Harvey Molotch, cities thrive on growth and endeavors and enterprises conducted within and between city's is in pursuit of this growth. Though already highly dense, New York City's population is expected to grow as more people still wish to live in the City and growth is required for quality of life within the City to improve. Despite having more residents, the City's transportation infrastructure has not expanded, resulting in greater congestion.

Increased Freight Movement

More and more people are receiving deliveries to their home due to technological innovations. These deliveries, such as from Amazon or food deliveries are often conducted by truck. This increased flux of trucks causes more traffic, particularly when trucks double park in order to make deliveries. Though there are more vehicles, there are fewer parking spots, which causes double parking.

Construction Activity

Related to the City's growth is the need for construction and renovation of buildings. These projects often occur in the most desirable areas, which are also the most congested. Construction activities temporarily block streets and remove parking, placing further strain on the system.

Increased Tourism/Pedestrian Volumes

Related to the need for urban growth, more and more tourists are also flocking to New York, causing higher pedestrian volumes. Tourists use of taxi's and FHV clog city streets and the increase in pedestrians slows moving traffic.

The connection between slow bus speeds and congestion is confirmed by New York City Transit Executive Vice President Craig Cipriano who says the main reason for slow bus speeds in New York is congestion; buses can only move as fast as general traffic. (Meyer 2016) Ms. Jenkins also corroborated that congestion is a major contributor to slow bus service (Jenkins 2018). Congestion has always existed in desirable and densely populated New York City, but has increased in recent years.

The regular increase in spaces dedicated to pedestrians and bikes also further stresses road space. Though providing more safety and comfort for alternative transportation modes, the redistribution of roadbed means less space for cars. Despite this, encouraging walking and biking helps discourage driving by improving the conditions for these more efficient modes.

In October 2017, Mayor de Blasio published a set of initiatives toward improving congestion. These include having continuous moving lanes along the curb during peak hours and better enforcing "Don't Block the Box" restrictions (Mayor 2017). Most of the improvements will be tested in Midtown Manhattan with others along congested corridors of the

Outer Boroughs. These initiatives come as travel times in Midtown Manhattan declined 23% since 2010. (Mayor 2017) de Blasio's plan will increase the amount of space dedicated to moving vehicles, thus further incentivizing auto traffic. Congestion pricing expert Charles Komanoff published a response to de Blasio's plan in *Streetsblog* (Komanoff 2017). He notes that almost all de Blasio's plan has been attempted by previous Mayor's and makes no attempt at lessening traffic volumes. Komanoff contrasts de Blasio's proposal with the MoveNY campaign. MoveNY would affect a much larger area and number of people, bring in more money and have a more lasting impact on transit demand.

Overall, the City has taken a number of steps toward improving bus service. Each of these resulted in quantitative improvements. Now that the City knows these tools work successfully, they should implement them on a larger scale on local, express and SBS routes. Tabitha Decker, deputy executive director of Transit Center stated "we're calling for...much more widespread implementation of these solutions and implementation much more quickly than we've been seeing" while NYCDOT Commissioner Polly Trottenberg agreed, calling for more all-door boarding, route evaluations and expediting the installation of TSP technology. (Meyer 2016)

Case Studies

The transportation problems facing New York are not unique. Population growth, industrialization and improving economies have caused car ownership increases worldwide, fueling traffic congestion. Only in recent years have city's begun to comprehensively assess the problem and implement what had been considered drastic solutions. These case studies provide strong insight for New York's attempts at improvements by assessing challenges faced by others and more importantly, the effectiveness of projects. These case studies fall into two not entirely distinct categories; bus and congestion pricing. The American cases and Seoul, South Korea evidence bus service improvements while Singapore, London and Stockholm evidence congestion pricing although the congestion pricing cases include bus service improvements.

Houston

Houston recently streamlined its bus network for faster, more reliable and more user-friendly service. Known as the "New Bus Network" the overhaul of the Metropolitan Transit Authority of Harris County's (METRO) 80 routes and 1200 buses occurred in August 2015 after three years of outreach and planning. This was the "first comprehensive review of its transit system since its inception as an agency in the 1970's (Harris County 2018). Part of the impetus for a redesign was a steady decline in ridership. According to Kurt Luhrsen, Houston METRO's vice president of service planning, "we'd lost 20 percent of ridership in 12 years, at a time when Houston was booming and adding people and jobs and building new light-rail lines."

The purpose of the work was to allow a greater number of Houstonians near a bus stop with frequent service (defined as <15 minute headways) rather than infrequent service across the larger system. This was accomplished in part by replacing the hub-and-spoke system with a grid

(Figure 10). METRO "took a "blank sheet" look at the network, convened a policy discussion on whether to focus resources on ridership or coverage goals, and involved extensive public discussion and consultation." They decided to dedicate 80% of resources toward maximizing ridership 20% to provide adequate coverage as opposed to the previous 50/50. Routes were reconfigured to run more directly, necessitating more transfers, but minimizing difficulty by increase frequencies. Before the redesign, 49% of Houstonians lived within ¼ mile of frequent service; this figure jumps to 73% with the redesign. By rebalancing frequency of routes, the upgrades occurred without raising operating costs. Only three months after the upgrades took place, ridership increased 8%. Increased frequency on weekend's instigated a 13% increase in Saturday ridership and 34% increase for Sunday. The transformation won the 2015 Outstanding Public Transportation System Award from the American Public Transportation Association. (APTA 2015)

New York City can learn from Houston's simplified routes. Scheduled service frequency's in New York are substantially better than Houston's, but are rarely met due to congestion. As will be discussed later, the MTA should take a "blank sheet" approach to entirely and comprehensively replan the City's bus routes rather than making small adjustments to existing routes.

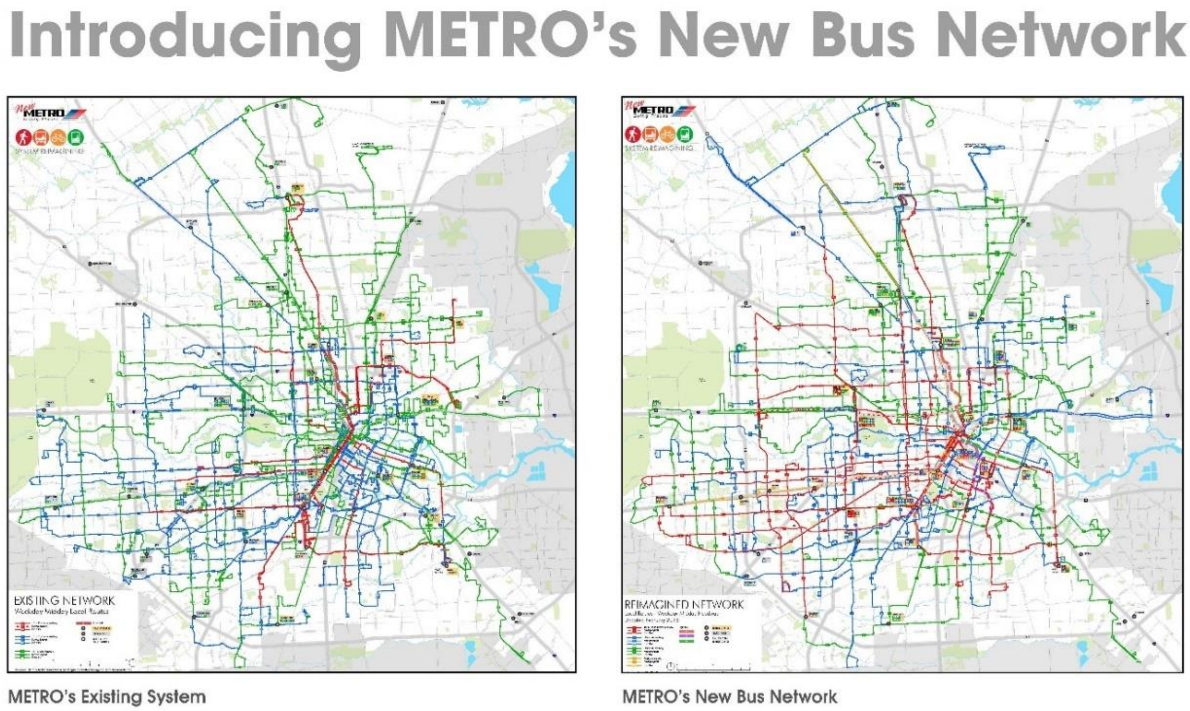

Figure 10 https://kinde r.rice.edu/uploadedImages/Urban_Research_Center/News/Reimagine-Side-By-Side-Maps021115.jpg

Baltimore

In 2017 after 19 months of planning, Baltimore's bus system implemented similar service changes to Houston, though on a smaller scale. Marketed as BaltimoreLink, the process intended to "create a more efficient and reliable bus network by spreading out the routes within the downtown core and creating a grid of high frequency routes serving more downtown locations." Also like Houston, the goal was to "improve frequency and speed of bus service while putting more people within easy reach of transit." BaltimoreLink provides 32% more people ¼ mile access to frequent bus transit service, defined as at most 15 minute headways. Three levels of service were implemented with color coded buses. The first, CityLink, are "BRT ready routes offer[ing] frequent 24 hour service" with 10-15 minute headways. They operate on a grid within Downtown and "radiate out from the city on major streets." LocalLink operates on neighborhood streets and Express BusLink connecting suburban job centers with downtown.

This 135 million dollar plan was initiated by Governor Larry Hogan due to congestion in Downtown Baltimore with the Governor stating “the bottom line is that Baltimore’s current transit system is a mess.” The Maryland Transit Administration would also like to create dedicated transitways for car. As part of the current plan, dedicated bus lanes were refurbished and expanded and a form of transit signal priority was implemented. Reactions to the changes have been mixed. Many riders found the changes confusing, perhaps due to a lack of prior public outreach. Buses now arrive on time 80% of trips, a 9% improvement, but ridership has not increased. The Governor optimistically responded saying “there’s still a lot of ups and downs here and there. I think the dust has yet to settle on the ridership question. Time will tell to see how it increases.”

Portland

TriMet, the public transit provider in Portland implemented a bus stop consolidation program “to improve service reliability and vehicle running times by increasing the spacing between bus stops, while minimizing patronage losses from reductions in stop accessibility.” (Crout 2005) Stops are occasionally eliminated (though more often added) in New York City. One exception is SBS routes though SBS treatment includes a number of changes; the effect of bus stop consolidation alone cannot be determined. A study was conducted of Portland’s bus stop consolidation. European bus services transport a much larger share of the population than America’s though they typically have 3-4 stops per mile compared to America’s 7-10.

The study of Portland cites a similar study in Boston where the average spacing of stops was increased from 200 to 400 meters (~650-1300 feet). Average passenger walking time to a stop increased by 36 seconds though in-vehicle times declined by 108 seconds and vehicle running times declined 4.3 minutes per trip. In Portland’s reassessment of stops a “clean slate” approach was taken rather than modify existing stops. After consolidating stops in Portland, one route experienced a 5.7% decrease in running time with no loss in ridership.

Case Studies Conclusion

New York City can learn from United States case studies of how both small and large-scale improvements can improve bus service without detrimentally impacting too many people. The case studies concerning congestion pricing provide adequate background into the development, implementation and success of congestion pricing schemes in a diverse group of cities. Each city took due diligence to insure their scheme succeeded. The local governments in the case studies have much greater power over their jurisdiction in regards to congestion pricing than New York. Due to widespread public and political opposition, congestion pricing will not be implemented in New York City in the near future, but future legislators and advocates can learn from these cases what steps to take when public opinion has changed. Another facet important for New York with congestion pricing is the major bus overhauls conducted in concert with congestion pricing.

Literature Review

Many reports have been published by the public and non-profit sectors concerning bus service. The most relevant sources are those specific to New York because these provide the most specific evidence and information for what I am looking at.

Scott Stringer's How to Improve NYC Bus System

On November 27, 2017 New York City Comptroller Scott Stringer released "The Other Transit Crisis: How to Improve the NYC Bus System." (Comptroller 2017) The report examines New York City's bus system in-depth and proposes improvements. The research brings up a number of interesting points. The report expands on the issue of social justice in that the average income of bus commuters ($28,455) is significantly lower than of subway commuters and the City ($40,000) (Figure 11). Additionally, a majority of bus commuters are foreign born (55%) and people of color (75%). Though we often think of bus service as being of equally low quality throughout the City, specific circumstances vary widely between routes. For instance, bus speeds in Manhattan, Brooklyn and the Bronx are at least 20% slower than Queens and Staten Island. The majority of residents in the former group utilize transit for commuting. A thematic concern throughout the Comptroller's report is the lack of adjustment to bus routes despite drastic changes in commuting patterns and neighborhood structures. New York City's population is much less Manhattan-centric than it used to be, but the transportation network has not reflected this. Between 2000 and 2015 the number of residents commuting within their home borough increased 48% in the Bronx, 41% in Brooklyn, 34% in Queens and 30% in Staten Island. With the change in work location has come a change in working hours as bus riders "disproportionately employed in industries with "non-traditional work hours"" though bus frequency has not been adjusted to cater to off-peak hour commuting. Employment in such sectors has increased more than twice as fast as City's employment overall between 2006 and 2016. The report also examines bus stop spacing; New York City bus stops are closer than any other major city. MTA's minimum standard spacing is 750 feet, but the average in Manhattan and Brooklyn are barely higher than this minimum at 757 and 778 feet respectively. Stringer also notes 15% of bus passengers' pay in change, slowing the system. Off-board fare payment or a "tap" fare payment system would speed boarding.

The Comptroller's report includes 19 recommendations to improve bus service, many of which have been recommended elsewhere. Most of the suggestions fall under the purview of the MTA rather than NYCDOT (Jenkins 2018). Congestion pricing is not one of these suggestions.

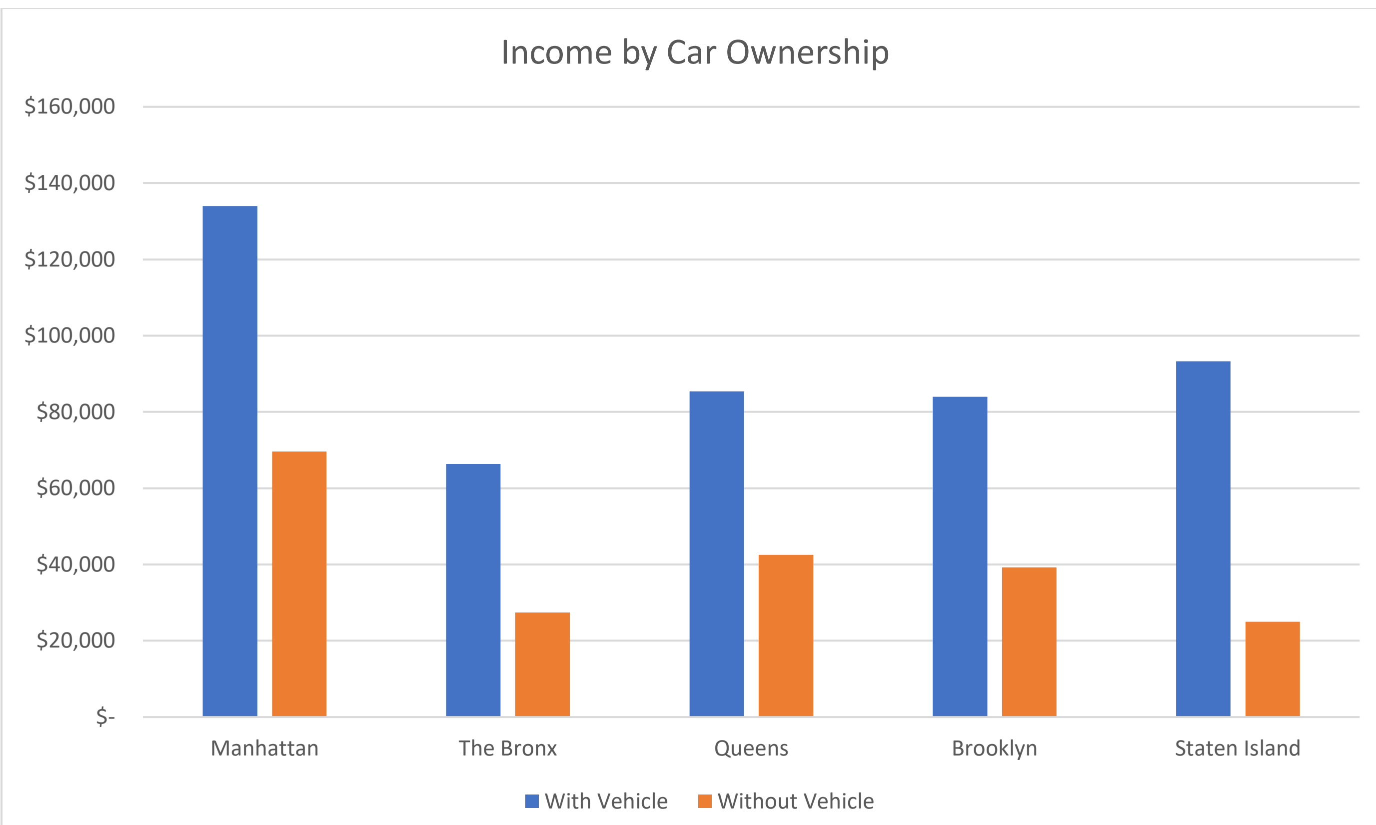

Figure 11

Reports by Non-Profits About Bus in New York City

"Turnaround: Fixing New York City's Buses" was published in 2016 by the Transit Center with cooperation from the Riders Alliance, Tri-State Transportation Campaign and NYPIRG Straphangers Campaign. (Transit Center 2016) The purpose of the report was to recommend reasonable improvements to fixing New York City's bus system with comparisons with and tactics from other cities. The report introduces the history of buses in New York as well as statistical evidence of how the system is failing New Yorkers'. New York's poor quality bus service may seem self-evident, but all statistics supporting this fact are helpful. Some people may also incorrectly assume that all bus service is slow. London and Seoul recently acted to improve bus service. The introduction of these case studies provides relevant comparisons to New York. The bulk of the report discusses general potential design, technological and planning improvements. This provides a helpful foundation of ideas leading to specific implementation locations and strategies for New York City.

A 2017 report by the Tri-State Transportation Campaign titled "How Car-Free is New York City" discusses the prevalence of car use in New York City. (Tri-State Transportation Campaign 2017) 54.5% of households in the City do not own a car; a fact important in emphasizing the need to improve public transit and promote the feasibility of congestion pricing (Figure 12).

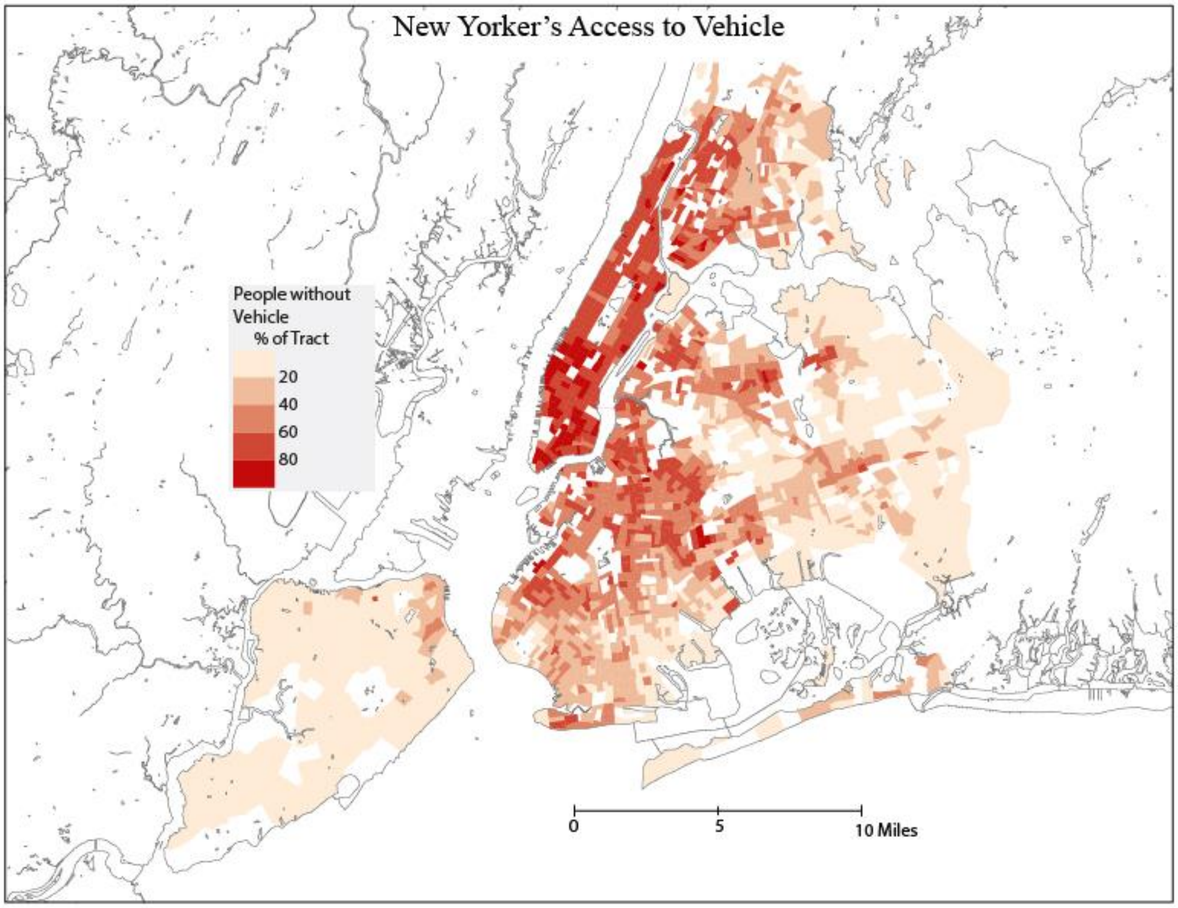

Figure 12

The Riders Alliance published a 2017 report titled "The Woes on the Bus: Frustration and Suffering, All Through the Town." (Riders Alliance 2017) This report includes short anecdotes from bus riders describing their frustrations. This is helpful in showing the real-world impacts poor bus service has on New Yorkers.

The Pratt Center for Community Development published "Mobility and Equity for New York's Transit-Starved Neighborhoods" in December 2013. (Pratt Center 2013) In line with the Pratt Center's ideology, the report looks at the social justice implications of transit; poor people are more likely to take the bus which provides lower service than subways. They recommend implementing true BRT in New York. The report is useful because it points out the strong social justice implications related to poor transit.

Transit Center published an October 2017 article concerning bus stop balancing. (Transit Center 2017) They recommend eliminating underused and closely-located stops to improve speeds as New York City buses spend 22% of time at stops. Some Staten Island express service routes have already undergone this process.

Transit Center released an annual report card of bus service in 2017 in New York. (Walker 2017) Despite the number of improvements made by the City in recent years, Transit Center gave low grades concerning street design, bus network/routing and bus scheduling. The City has slowly tested policy improvements but has yet to implement tools citywide. The Mayor has allocated funds for future SBS implementation, but at the same rate as past improvements.

New York City Reports

In 2017 the New York City Department of Transportation published "Green Means Go: Transit Signal Priority in NYC." (NYCDOT 2017) This report details New York City's use of transit signal priority, where the service has been implemented and what effects it has had. This provides a thorough overview of one proven tactic to improve bus service.

PlaNYC was published in 2007 by then-Mayor Michael Bloomberg's Office. (City of New York 2007) This report was the first official New York City document to propose congestion pricing in the City. The report highlights the worsening congestion and implications and lists the projected traffic benefits for each mode and borough. The report is useful for laying the groundwork which became the Bloomberg congestion pricing proposal ultimately defeated in the State Capitol.

Former Deputy Commissioner for Planner and Sustainability for NYCDOT Bruce Schaller published a 2010 report titled "New York City's Congestion Pricing Experience and Implications for Road Pricing Acceptance in the United States." (Schaller 2010) Schaller focuses on "changing how motorists view the effect of pricing them personally." He elaborates in saying how the debate over Bloomberg's congestion pricing proposal has allowed the conversation to continue to the present.

A number of City Council resolutions and hearings concerning bus service in the past few years shed light on how the City views buses and the future of bus service. Also included in the statements are those of non-profit's in support of the City's. The resolutions include proposing more SBS service, actual BRT service and most recently, asking the State for the City to regain control of the subway and bus systems.

Other Reports Concerning Buses

The Seoul Metropolitan Government published a report detailing the goals and various improvements made in the city's bus service. (Seoul Metropolitan Government 2014) Despite the massive improvements, the most profound and useful of which is the implementation of a hierarchy of routes, the number of daily passengers only increased 5.5%. The type of improvements made are helpful in thinking about how the City's buses can be improved although the minor change in ridership speaks to the differences between cases.

Representatives of Rutgers University and the University of Michigan published an article concerning "Public Transport Reforms in Seoul: Innovations Motivated by Funding Crisis." (Allen 2013) The report details the overhaul of Seoul's bus system with specific emphasis on how "the acute funding crisis of Seoul's public transport system has prompted a complete reexamination of ways to improve service quality while keeping costs and subsidies affordable." (Allen 2013) This brings up the interesting point that New York's strong economic position allows more opportunities to indulge in less efficient transportation means with less urgency such as ferry and streetcar rather than focus on the best options.

An article published in *Smart Cities Dive* by Klaus Philipsen looks at more tactics of improving bus service. (Philipsen 2017) Most of these are similar to the reports specific to New York though include having excess buses available in case of mishaps, creating a service hierarchy of various routes, providing amenities at stops and cutting 25% of bus stops. This furthers the background of ideas of how to improve bus service.

Literature Review Conclusion

Overall, this brief and expedited foray into the literature surrounding bus service provides a broad overview of potential improvements.

Research Methodology

Academic Sources

Much of the data comes directly from government reports and academic pieces concerning bus improvements. In this manner, the literature review and case studies directly connect to the results. The government reports and academic pieces provide examples of successful or bus improvements around the world. This data is used to recommend specific improvements to New York's bus system.

Interviews

I conducted interviews with expert transportation practitioners with a variety of knowledge. They were conducted in an informal format with some general questions to inspire conversation. These introductory questions are included in the appendix. The interviews ground the research in New York and provide detailed information about how improvements can be implemented and how specific challenges can be overcome. Interviews were conducted with Nina Haiman, Director of NYCDOT's School Safety Program and formerly a staff member in the agency's Office of Strategic Planning which was dedicated to studying the transportation chapter of Mayor Bloomberg's PlaNYC, including congestion pricing. I also interviewed Janet Jenkins, Senior Director of NYCDOT's Transit Development Group; the agency's unit dedicated to improving and facilitating bus service and planning and implementing SBS routes. Ms. Jenkins has been with NYCDOT since 2016, but involved with SBS as a consultant and part of the MTA since the program's conception in 2004.

I reached out to the Pratt Center, Transit Center and the office of New York City Council Member and Transportation Committee Chair Ydanis Rodriguez, requesting to meet with them for interviews, but received no response.

Non-Interview Data

The most vital statistical data comes from Transit Center's Bus Turnaround Campaign report cards which provide detailed speed, ridership and bunching data for most bus routes in the City. I entered this data manually into Microsoft Excel and exported it into ArcGIS. I joined the bus data with bus route shapefiles obtained from Baruch College's website. The data directly obtained from Baruch had each direction of route (i.e. one for northbound, one for southbound). I combined each of these matching shapefiles so each route had only one. I also gathered Census Tract data for New York City. This data focused on basic demographic and transportation attributes. I synthesized bus commuting data for each census tract for 2000, 2010 and 2017.

I go into more detail as to the individual data attributes in my data analysis section.

Data/Results

Bus Routes

The purpose of the data analysis is to determine where bus service issues exist and consequently, where improvements should be focused. The first step of the data analysis analyzed each variable separately while the following section combined them; resulting in a comprehensive score. The following sections also include how variables correlate with one another; allowing us to better understand how bus service variables overlap with one another. The full correlation table is included in the appendix as “Bus Route Correlations.”

The variables used are:

1. PerAM

The frequency of buses in the AM Peak (defined as 7-9AM). Data was obtained through MTA bus brochure’s for each borough detailing AM, Noon, PM, Evening and Night headways for each route for each borough.

2. RHPerAM

The number of daily riders per AM peak bus. This is not intended to present accurate statistics as to how many people are on each bus, but rather represents the relative crowding of each bus.

   i. Average

      The average riders per AM peak bus per route.

   ii. Total

      The total riders per AM peak bus per route for each quintile.

3. Speed

The average speed of the bus over the course of it’s route.

4. Bunch

The percentage of buses arriving at a stop while bunching (multiple buses stopping at the same stop at the same time).

5. Riders

The number of daily riders using a route.

6. Change

The percentage change in a route's ridership between 2010 and 2016.

7. Length

The length of a route. If operating on one-way streets, considers the cumulative route length.

8. RPM

The number of riders per mile.

    i. Average

    The number of riders per mile per route.

    ii. Total

    The cumulative total of riders per mile per route for each quintile.

9. Riders Loss

The change in ridership along a route between 2010 and 2016.

    i. Average

    The average change in ridership per route between 2010 and 2016 in a quintile.

    ii. Total

    The average change in ridership along all routes in a quintile between 2010 and 2016.

The full tables for each variable are located in the appendix as “Correlational Analysis.”

Speed

The slowest bus routes are concentrated in Manhattan. The lowest quintile of routes has speeds less than 5.6 mph and the second lowest less than 6.5 mph. Of the 44 bus routes in the lowest quintile speed, 30 are in Manhattan, 8 are in Brooklyn, 5 are in the Bronx and 1 is in Queens. Additionally, each of the slowest 20 routes are in Manhattan. The second slowest quintile of routes are concentrated in the Bronx and Brooklyn. Of the 47 routes, 22 are in Brooklyn, 17 are in the Bronx, 4 are in Manhattan. The slower routes carry a greater proportion of riders. The slowest two quintiles carry 51% of passengers while the fastest two quintiles carry only 28% of passengers. Slower routes have significantly higher rates of bunching and are much more likely to have lost ridership. The slowest quintile alone accounts for 53% of the loss in bus ridership. The fact that the slowest routes have lost the most riders, but still carry a disproportionate number of passengers indicates the importance of improving these routes that are so heavily used despite the slow speeds. The slowest quintile has shorter than average route lengths and the fastest quintile longer than average. This is likely due to the location of the routes with crosstown routes in Manhattan being shorter and those in the Outer Boroughs longer. Consistent with ridership numbers, speed is highly negatively correlated with ridership per mile with the slower routes carrying more riders per mile. Consistent with earlier findings, the low speed/high ridership routes operate more buses per hour and carry more passengers per bus.

Speed has weak positive correlations with length of route and ridership loss as well as negative correlations with number of buses per hour, rider’s per bus per hour, bunching, ridership and ridership per mile.

Bunching

Routes experiencing the highest rates of bus bunching are in Manhattan and Brooklyn. The second lowest quintile of routes are spread throughout Brooklyn, Queens and the Bronx while the lowest rates of bunching are in the East Bronx and Staten Island. Of the routes with the 13 highest rates of bunching, 9 are in Brooklyn, 3 are in Manhattan and 1 is in the Bronx. Routes with low bunching operate at higher speeds, carry fewer passengers, experienced less ridership decline, operate shorter routes and fewer buses per hour and carry fewer riders per hour and per bus.

Bunching has a weak positive correlation with riders per hour per peak bus, and length, weak negative correlation with speed and riders lost, and a strong positive correlation with buses per peak hour, ridership and riders per mile. Routes with the highest rates of bunching are thus found along the most used and critical routes.

Ridership

The highest quintile by ridership is fairly evenly distributed with 11 in Brooklyn, 18 in the Bronx, 7 in Manhattan and 7 in Queens. The lowest quintile by ridership is also fairly evenly distributed though with more in Staten Island. 10 are in Brooklyn, 6 in the Bronx, 8 in Manhattan, 9 in Queens and 9 in Staten Island.

Ridership is weakly negatively correlated with speed and weakly positively correlated with route length as well as moderately positively correlated with buses per peak hour and bunching. It is strongly positively correlated with riders per peak hour bus and riders per mile.

Ridership Change (%)

Routes in Manhattan and Brooklyn had the greatest ridership loss. The majority of routes citywide did not experience a significant increase or decrease in ridership; the decline was fairly evenly distributed in small amounts throughout. Some routes in the South Bronx experienced a ridership increase. The lowest quintile of routes ridership change included 9 routes in Brooklyn, 1 in the Bronx, 23 in Manhattan, 6 in Queens and 4 in Staten Island. Most routes experiencing a ridership increase gained only a small amount. Of those in the highest quintile, 8 are in Brooklyn, 15 are in the Bronx, 3 are in Manhattan, 13 are in Queens and 3 are in Staten Island.

Ridership change by percentage is not correlated with any other variable.

Ridership Change (raw)

Routes in Manhattan and Brooklyn experienced the most dramatic loss in raw ridership numbers.

13 routes gained more than 1000 riders. These are spread between six in the Bronx, three in Brooklyn, two in Queens and two in Staten Island. Though none of these gainers are designated Manhattan routes, 5 of these 6 Bronx routes terminate in Manhattan. A possible explanation for this is that these riders are taking the train into Manhattan in order to transfer to the subway. The prevalence of Outer Borough routes gaining represents the de-Manhattanization of New York City. The City's public transit network was established to serve Manhattan, but has not been adjusted in response to Manhattan's loss of population and the spread of population throughout the Five Boroughs. More should be done to prepare for population growth. The MTA, NYCDOT and New York City Department of City Planning should implement street and transit upgrades in growing and upzoned neighborhoods, similar to how they are preparing for the L train shutdown.

Length

Longer routes are concentrated in South Brooklyn, Eastern Queens, Northern Manhattan and Staten Island.

Route length is weakly positively correlated with speed, bunching and ridership. The high ridership crosstown routes in Manhattan are of short length which is why Q1 routes have slower speeds, higher bunching and more riders per mile. The large areas of the Outer Borough's and their routes, particularly in State Island represent the Q4 and Q5 data.

Riders per Mile

Routes with high ridership per mile are concentrated in South Brooklyn and West/South Bronx. Staten Island has the fewest riders per mile. In the case of South Brooklyn, the area is served by the subway, but is far from the central business district; necessitating more bus travel.

Ridership per mile is weakly negative correlated with speed, moderately positively correlated with buses per peak hour and bunching and strongly positively correlated with ridership and riders per peak hour bus. High ridership directly impacts speed as it takes longer for the greater number of passengers to board. The high number of people boarding per stop and traffic congestion leads to greater bunching. Fortunately, riders per mile is correlated with the number of buses per peak hour; more buses are needed because there are more passengers. High ridership areas also tend to be in high density and thus high trafficked areas with greater congestion.

PerAM

Routes with high peak hour service are spread throughout the city with routes with more than 15 buses per peak hour having 3 in Brooklyn, 5 in the Bronx, 6 in Manhattan and 5 in Queens. This provides a good foundation for providing similar frequency service on others routes throughout the five boroughs.

Buses per peak hour is weakly negatively correlate with speed and moderately positively correlated with bunching, ridership and riders per mile.

Routes with high peak hour service experience slower speeds and higher bunching as a result of congestion. It makes sense that routes with more frequent service would be in more heavily trafficked and transit-desirable areas. It can be assumed that routes with more buses per hour would also assuredly correspond to higher bunching rates as bunching requires closely times buses.

RhRPerAM

Routes with high ridership per peak hour bus are concentrated in Staten Island and Eastern Queens. Of the top 20 routes, 4 are in Brooklyn, 9 are in the Bronx, 4 are in Manhattan and 3 are in Queens.

Ridership per peak hour bus is weakly positively correlated with bunching, weakly negatively correlated with speed and strongly positively correlated with ridership and riders per mile. The presence of these routes throughout the City indicates crowding occurs in both high and lower ridership areas. Bus frequency should be adjusted to maintain roughly similar riders per bus.

Multivariate Ranking

After calculating correlations and deducing conclusions from the raw numbers, a multivariate analysis was conducted to comprehensively determine which routes should receive priority improvements. This was done by replacing the raw numbers with 1-5, depending on which quintile the route was in for each variable. A higher number indicates more urgent need. The following variables were used for the analysis:

1. Buses per AM (5 is more buses because they affect more riders)
2. Riders per Bus per AM (5 is more riders because these buses are more crowded and more ripe for improvement)

3. Speed (5 is slower speeds because these routes should receive treatments to increase speeds)
4. Bunch (5 is higher bunching because bunching slows service)
5. Riders (5 is more riders because they transport more people)
6. Change (5 is more negative change because a large negative change indicates unsatisfied demand for improved service)
7. Riders Loss (5 is more negative loss because a large loss indicates unsatisfied demand for improved service)
8. Length (5 is higher length because longer routes have more potential for delays and impact more neighborhoods)
9. Riders Per Mile (5 is more riders per mile because these routes transport more people)

Speed, bunching and ridership were given twice as much weight as the other variables as they relate more to the issues at stake. The following map shows the quintile of routes (Figure 13). The appendix includes the full chart as "Multivariate Ranking."

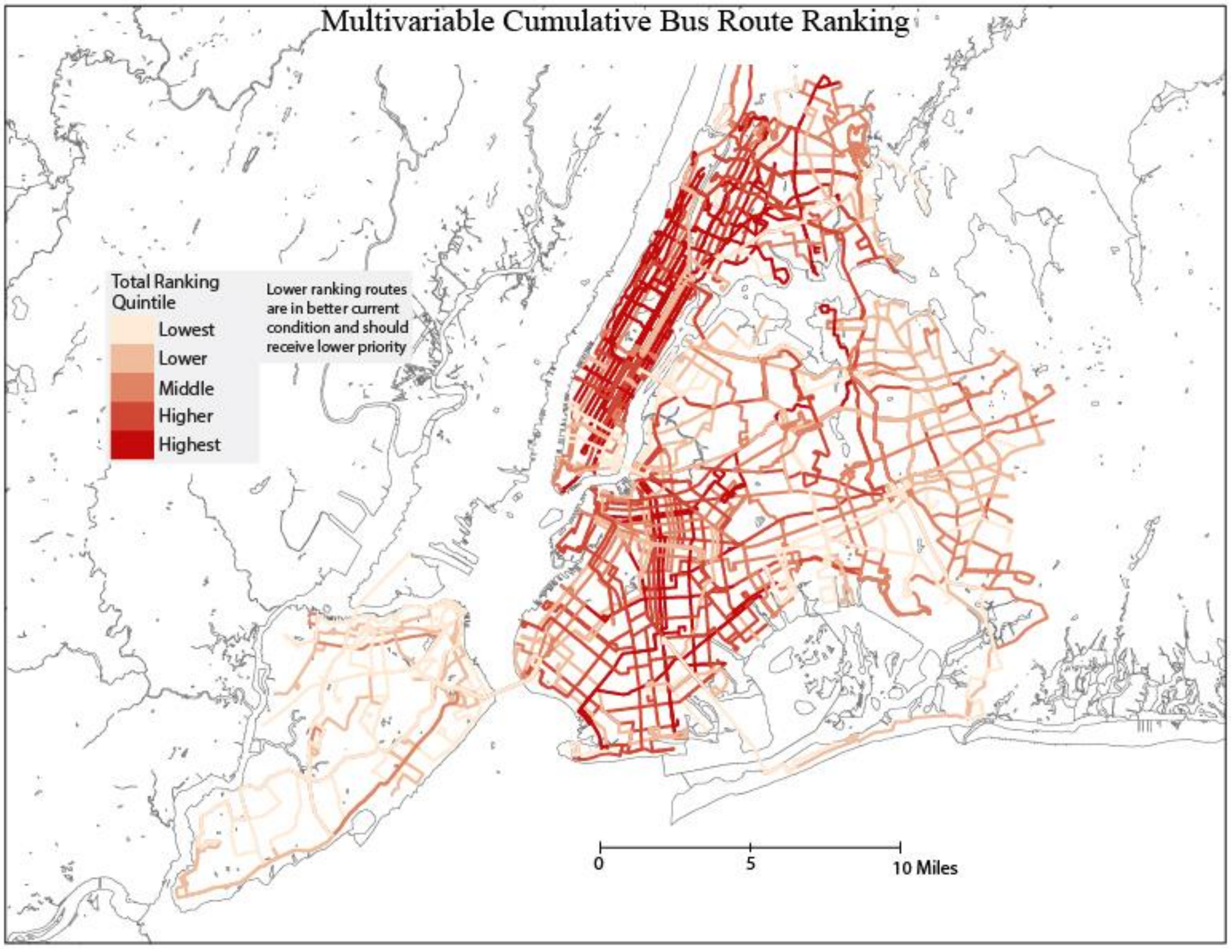

Figure 13

As evidenced by the map and associated data, the routes in greatest need of improvements are concentrated in Manhattan, Downtown Brooklyn and the South Bronx. These are typically high ridership routes with slow speeds and high rates of bunching.

Census Tracts

Variables

The following data was collected for every census tract in New York City and correlations were determined between each. Variables were chosen because of their relevance to transportation and presumed correlations between them. The data is subsequently used to analyze in which areas bus improvements should be concentrated.

The first six variables relate to the portion of resident's commuting by bus. The first two letters of these headings refer to the time period of the data; A is 2000, B is 2010 and C is 2016.

BCChN
- The difference in raw numbers in bus riders between 2010 and 2016

ACChN
- The difference in raw numbers in bus riders between 2000 and 2016

ABChN
- The difference in raw numbers in bus riders between 2000 and 2010

BCChP
- The change in percentage of bus riders between 2010 and 2016

ACChP
- The change in percentage of bus riders between 2000 and 2016

ABChP
- The change in percentage of bus riders between 2000 and 2010

HHChild
- The percentage of households with a child

HHSenior
- The percentage of households with a senior citizen

HHBach
- The percentage of households whose head of household has received a bachelor's degree

HHDisability
- The percentage of households with someone who has a disability

HHForeign
- The percentage of households with someone who is foreign born

HHNotEnglish
- The percentage of households with someone who does not speak English

White
- The percentage of households identifying as White

Black
- The percentage of households identifying as Black or African American

Asian
- The percentage of households identifying as Asian

Hispanic
- The percentage of households identifying as Hispanic or Latino

CarP
- The percentage of households with access to a car

CarDrAlP
- The percentage of households commuting alone in a car

CarpoolP
- The percentage of households commuting by carpool

PubTransP
- The percentage of households commuting by public transit (includes bus and subway)

BusP
- The percentage of households commuting by bus

SubwayP
- The percentage of households commuting by subway

BikeP

- The percentage of households commuting by bike

WalkP

- The percentage of households commuting by walking

WorkHomeP

- The percentage of households working from home

Correlations

Weak correlations were found between many of the variables. Some correlations are insignificant because they directly relate to one another (White and Black, CarP and BusP) so no conclusions can be drawn from their correlations. The full list of correlations is found in the appendix as “Census Tract Correlations.”

Geographic census tract data is less informative than data related to specific routes as the census data only includes commuting trips which are a small portion of all daily trips. Conclusions can be reached for peak hour commuting, but not larger trends. The following is a summary of the most relevant correlations and their impacts.

Households with children, a disabled person and black residents without a bachelor’s degree are more likely to commute by bus. Surprisingly, bus use is positively correlated with commuting by car use and driving alone. This is likely due to high car and bus commuting in portions of the Outer Boroughs without subway service. Expanded adequate subway service would likely decrease auto dependence, but also bus usage.

According to this census data, bus ridership decreased by nearly 28,000 between 2010 and 2016 after increasing by over 130,000 between 2000 and 2010. The City’s overall population increased by nearly 200,000 residents from 2000 and 2010. Caveats of the census tract data is that it does not take into account changes in bus service such as eliminated routes or decreased service. It also only factors in commuting trips; nationally, only 15% of trips are for commuting while 45% are shopping and errands and 27% for social and recreational (Bureau of Transportation Statistics 2002).

The purpose of the data analysis is to determine where improvements should be concentrated. The State and City have finite resources and improvements should be focused in areas where the most people would benefit. These focus locations should also relate to social justice and ensure marginalized and underserved communities receive a proportional set of improvements and attention. The practice of focusing or prioritizing improvements in certain communities is not intended to exclude others; every route can be improved and every neighborhood can benefit from bus service improvements.

Potential improvements implemented across the City include off-board fare payment, all-door boarding and transit signal priority. San Francisco and London presently have all-door boarding and off-board fare payment on all routes. These improvements would need to be implemented simultaneously. Installing fare payment machines on the sidewalk is a costly and labor-intensive task, ensuring electricity is provided beneath the sidewalk and adequate space is provided for passing pedestrians. A frequent complaint of the SBS fare payment system is riders possessing a monthly Metrocard must still purchase their SBS ticket each ride. SBS tickets display the time the ticket was purchased in order to allow ticket enforcers, known as the Eagle Squad to give tickets to lawbreakers. A seemingly simple fix to this is to allow the SBS ticket to vary based on the means of purchase. Using a monthly Metrocard would display the card's expiration ticket on the SBS ticket so the rider could keep that one ticket for the entire month. The same procedure could be done with weekly and daily Metrocards.

An important piece of data is the change in route ridership. Routes with significant losses in ridership likely have demand for increased service, but riders have switched to alternate modes; mostly subway. This is supported by the fact that the vast majority of routes experiencing a significant decrease in ridership are in Manhattan and North/Central Brooklyn where communities are generally well-served by subway and population density is high. It is also likely that bus ridership decreased in Manhattan because of the rising congestion which slows bus service. The present crisis for subway service can be an attraction for bus service; if bus service were improved, riders would switch from subways to buses. These routes with decreased ridership would benefit from all-door boarding, off-board fare payment, transit signal priority and a consolidation of stops. These measures would decrease the time buses are stopped. Bus lanes would be helpful though are particularly difficult in Manhattan where there are high traffic volumes. The implementation of congestion pricing would decrease traffic throughout Manhattan. NYCDOT should use this opportunity to implement bus lanes and other measures to decrease the supply of road space.

Only a handful of routes experienced a ridership increase. These routes have higher ridership than average.

Routes bunching is highly positively correlated with ridership. Despite the presence of bunch busing, these routes still attract riders. This is likely due to the need for the route for the community. The previously mentioned citywide improvements would be helpful toward bunching by decreasing slow downs at signals and stops. Bus stop consolidation would also be helpful.

What Can be Done

The following details potential improvements which can be made to New York City's bus system. Some of these have already been implemented piecemeal in New York while others are inspired by cities around the world. The appendix (What Can be Done) includes a summary of the positives and negatives of each.

BRT Feasibility

New York's Select Bus Service utilizes certain tools of BRT, but neglects others. Greater aspects of BRT can be used on the city's wider streets. The roadbed on wider streets can be reallocated for a dedicated bus lane be located against the curb with physical separation from moving traffic for the majority of the block. Where right turns are allowed (with the bus lane on the right side of the street), egress must be given for right turning vehicles. This poses a frequent impediment to bus traffic, but cannot be avoided in such instances. With proper bus lane camera enforcement, the negatives of this overlap can be minimized. Offset bus lanes in New York are presently parallel to parallel parking; vehicles parking must cross the bus lane to park. This process encourages double parking and impedes bus service. Working off of Mayor de Blasio's "clear lanes" policy, parking can be prohibited in these lanes during peak times to facilitate faster bus speeds. The City is certainly moving in the direction of a higher percentage of routes utilizing pieces of BRT, but is far off from implementing "true" BRT service as began in South America. Additionally, from speaking with Janet Jenkins, Director of NYCDOT's Transit Development Unit, there is little agency interest in focusing all of its resources on a single BRT route, rather than spreading the wealth with small improvements throughout the five boroughs.

Enforcement

A major issue preventing improved bus service is a lack of enforcement. The City can create rules in an effort to improve bus service, but if people disobey them and are not punished, the rules are useless. Foremost among these issues is bus lane enforcement. As previously cited, a study of the Livingston Street bus lane in Brooklyn found "not a single bus traveled the length of the street without having to merge out of the lane due to an obstruction." Needing to frequently merge in and out of moving traffic enhances bus delays. Double parking runs rampant throughout New York City despite "double parking of passenger vehicles [being] illegal at all times, including when street cleaning is occurring, regardless of location, purpose or duration." (NYCDOT, 2018) The City should dedicate more resources to enforcing the rules in place. People break the rules when they do not fear the punishment; in this instance because the punishment is so rarely enforced. More funding can be dedicated to the New York Police Department to enforce moving violations and bus lane violations which slow traffic. Alternatively, NYCDOT can be given greater authority to enforce the rules along infrastructure which they maintain and control.

Transit Signal Priority

According to the New York City Department of Transportation's "BRT Transit Signal Priority" report TSP takes advantage of presently installed GPS technology on all MTA buses as part of their Bus Time vehicle location system. For the past few months, all intersections and traffic signals in New York City are equipped with GPS and advanced signal controllers. (Levine 2017, Jenkins 2018) Due to the availability and relative ease of installing the technology, "TSP is truly low-hanging fruit…the only remaining cost is planning." A 2014 *Streetsblog* article titled "Every Bus Should Get Priority at NYC Traffic Signals" claimed the same in saying "given the relatively low cost of implementing signal priority, the city should aggressively apply the technology to more bus lines city wide, beginning with those with the highest ridership or slowest average speeds." (Petro 2014) The cost of implementing TSP on a route ranges from one to million dollars (Petro, 2014).

A difficulty in implementing TSP is the need for extensive traffic analysis to assure "availability of time to shorten cross-street phases and meet minimum requirements for pedestrian crossing and also the ability to provide TSP without significant adverse effects on cross-street vehicular traffic." (aimsum) A model was developed by Greenman-Pedersen, Inc.

“to simulate all traffic operations in the corridor and to assess and recommend improvements for optimal TSP implementation, which includes changes to geometry, striping, and signal timing.” This model is “now suitable to represent any TSP implementation within New York City.” In addition to the model, traffic volumes are required for an entire corridor and intersecting streets in order to utilize the model to determine what detrimental effect TSP would have. Obtaining and synthesizing these volumes is timely and costly. With such vast improvement potential, TSP should be more widely utilized and more staff should be hired by NYCDOT dedicated to analyzing corridors and intersections for TSP. Traffic analysis for TSP is conducted by NYCDOT’s Signals Unit rather than Transit Development which is devoted to SBS. NYCDOT would need additional funding to speed the pace of TSP implementation. NYCDOT plans to install TSP on 15 additional routes (out of 238) by 2020. Council Member Levine recently “introduced legislation in the City Council to require that 20 lines be upgraded each year for Transit Signal Priority.” Ms. Jenkins stated the MTA and NYCDOT are “looking at faster ways of implementing TSP” (Jenkins 2018) TSP and other improvements are being considered for more “quick and dirty implementation” which would provide smaller, but more immediate improvements.

Due to the amount of time buses spend stopped at traffic signals, citywide use of TSP would vastly improve bus service with little to no detriment to drivers. Presently a lengthy process, TSP implementation should be streamlined and expedited to provide quicker benefits to bus riders. TSP requires the least intervention through signal timing in low traffic areas but routes with the slowest speeds (and thus higher traffic volumes) would benefit most. The MTA and NYCDOT should dedicate more funding for staff to analyze corridors for TSP. All streets would benefit from an analysis of volumes and signal timing even without TSP. The cost spent planning for TSP routes would be offset by higher farebox revenue and lower costs. Highly congested routes cost more money to operate due to less interest in riding them and higher gas costs. High ridership and low speed routes should be first targeted for TSP. Speeding bus service with TSP would allow buses to run their route in less time, allowing higher frequencies, ridership and reliability. TSP should be partnered with congestion pricing. Intersections with prohibitively high traffic volumes will experience lower volumes upon congestion pricing, improving TSP feasibility. TSP should be approached more aggressively for the betterment of the City's transit system. Routes with too high of traffic volumes not receiving TSP will continue to experience poor bus service because of it, further incentivizing the automobile, increasing traffic volumes and diminishing the feasibility of TSP. Contrarily, TSP will improve bus service and lessen the number of automobiles by providing more attractive bus service.

Bus Stop Consolidation

Buses spend 26% of their time stopped at bus stops (NYCDOT 2017). Much of the United States provides far too many bus stops; New York City is a top offender. Transit Center suggests local bus stops be located every quarter mile. (Schmitt 2017) Locating stops frequently allows for a shorter walk, but also slows down service by 30-40 seconds per stop. (Levy 2018) According to *Curbed* "consolidating bus stops could speed up a route that averages 7 mph to 9 mph." Though this may seem like a minor speed change, it would have tangible impact on the effectiveness of the route. Partnered with other changes, this improvement would far-reaching impact. 43% of stops along a bus route in Fairfax, VA were eliminated, resulting in a 23% decrease in travel times and nearly 25% decrease in operating costs. (News 1130 2014) Without off-board fare payment and all-door boarding, buses spend even more time waiting at stops. Subway and commuter rail service spreads stations out to maximize efficiency. Bus service should be seen in a similar vein. Paratransit service should be more available to those who require a short walk or are taking the bus over a short distance.

Similar to TSP, all routes would benefit from bus stop consolidation. Priority should be given to routes experiencing high ridership and rates of bunching as eliminating stops from such routes would allow for less delays and a more normal bus schedule. Similar to night bus service presently, bus operators can stop at any location they deem safe, negating any potential negative night impact of bus stop consolidation. A comprehensive analysis of bus stops should be conducted and a public outreach campaign undertaken to educate the public about the process. Paraphrasing Janet Jenkins of NYCDOT, “all bus stops have a constituency.” Straphangers will not like the possibility of their local bus stop being removed, but if educated upon the larger benefits doing so would accomplish, would be more likely to support the project. Bus stop consolidation has the added benefit of providing additional curb space at removed stops. Community Boards and NYCDOT should be responsible for reallocating this reclaimed public space. Some should be used for curbside loading to decrease double parking while others can be used for bike share stations or street seats (NYCDOT 2018) which “is a citywide program where partners apply to transform underused streets into vibrant, social public spaces” by providing public seating. The reclaimed bus stops should not be converted to general parking as doing so would further incentivize automobile use. The cost of bus stop consolidation is negligible as it only involves removing the parking signs and bus shelters at consolidated stops. Consolidation would ultimately save the MTA money. In San Francisco “every 5 percent of stops eliminated [equates with] a 1 percent reduction in service hours. In order words, eliminating one in ten stops would save $5 million.” (Snyder, 2009)

Route Reconfiguration (small scale and large scale)

Many New York City bus routes stem from streetcar routes. Route configurations have rarely changed since then. Routes frequently take circuitous and unpredictable routes. Additionally, having many turns, particularly left turns, sometimes needlessly forces buses to wait for perpendicular pedestrians and vehicles rather than allowing the bus to continue straight. Though route schedules are updated every 1-2 years, little concern is given to where the routes go. Due to strange routes, passengers often do not know where the bus is going. According to Ms. Jenkins, route restructuring, particularly on a large-scale is a "tremendous lift" though the MTA has taken a first step in their ongoing study of Staten Island Express bus routes (Jenkins 2018). Hopefully, this initial foray into larger-scale analysis will inspire similar studies in other parts of the City. As much effort as possible should be given to simplify routes to operate along straighter paths. This can be difficult given one-way streets, but more can be done in pursuit of this goal. Routes with the most turns should particularly be reconfigured in order to improve speeds. Route reconfiguration would be politically diffiuclt for similar reasons as bus stop consolidation; though speeds would improve, some people would have a more difficult commute. Extensive public outreach should be conducted to educate the public of the benefits of route reconfiguration and to garner feedback as to how routes can be improved. Though some will have a more difficult commute, trips overall will be more consistent. Other helpful fundamental changes would be procuring more buses, particularly those equipped for SBS and constructing more bus depots (Jenkins 2018). As evidenced by the Houston case study, route reconfiguration can be conducted with no change to operating costs.

Interborough Routes

In addition to reconfiguring existing routes, efforts should be made to extend and create new routes between boroughs. A number of routes operate within both Brooklyn and Queens though most of these, such as the B24, B32, B62 terminate soon after arriving in the adjacent borough. Only a limited number of routes operate between boroughs separated by water though these are consequently the most difficult areas to traverse otherwise. The S53 and S93 are the only local routes connecting Staten Island and Brooklyn, terminating in Bay Ridge, Brooklyn near the 86 St-R train stop. The R train is highly crowded; the extension and addition of routes further into Brooklyn would ease crowding as Staten Islanders would have more transit options into Manhattan and the rest of the City. These and other routes should be extended in order to promote more one-seat trips. The longer the route, the more potential for delays, but combined with other bus improvements and congestion pricing, extending routes between multiple boroughs provides more transit opportunities and better connects communities. The Q44 SBS and Q50 connect the Bronx and Queens, extending a fair distance within the borough. Particular attention should be given in improving connections between these boroughs that are otherwise only accessible through a long and circuitous subway trip through Manhattan. A number of routes extend from the Bronx to Manhattan. This is only the case because of the number of free crossings between the two boroughs. I do not recommend extending these routes to further parts of Manhattan as doing so would further complicate the bus network; it is better to transfer to Manhattan routes. Only one route, the B39 connects Manhattan and Brooklyn. Though there are plenty of subway opportunities between the two boroughs, trains are highly crowded. The temporary closure of the L Train will provide an opportunity to deal with more innovative bus solutions in connecting the boroughs. Regardless of the plan for the L train, more routes should connect the two highly populated and desirable boroughs, potentially in future HOV lanes. A challenge of initiating new routes is that it would require purchasing new buses or reallocating buses with existing routes. The storage of buses is also an issue. Purchasing new buses would add to cost, but new service itself would be relatively inexpensive.

Hierarchy of Routes

Another means of simplifying routes for passengers is to implement a hierarchy of routes such as was done in Seoul. In such a situation, routes would be color or number coded based on their frequency and pattern (serving subway stations, crosstown, uptown/downtown, etc.) Such a system would give straphanger's a more intuitive understanding of where the routes operate. Implementing and branding a hierarchy of routes is best accomplished after a system-wide reconfiguration of routes as current routes serve multiple purposes over unintuitive routes. This would improve useability of the bus system and provide a sense of consistency. A hierarchy of routes in and of itself would not improve speeds, but would help passengers better understand the system. Implemented together with other improvements, speeds and ridership could increase. The below map uses existing routes and frequencies to split routes in three groups based on headways. The cost from implementing a hierarchy of routes comes from the public outreach needed for such a large change as well as any change in branding of the bus. This may merely take the form of a new coat of paint. ADD

Bus Lanes

Bus lanes provide a clear benefit to bus service. Their implementation is limited in New York due to high traffic volumes. Their success is further limited by a lack of enforcement wherein vehicles double park with the bus lane. Even one vehicle parked in a bus lane along a block causes major disruption for bus service as the bus must either stay in slower, general traffic for the entire block or merge out and into the dedicated bus lane, slowing bus service and general traffic in the process. A limited number of bus lane cameras are in effect to enforce these, but more needs to be done to allow the lanes to function with their purpose. Without a camera, enforcement of bus lane violations are difficult because police officers must monitor how long the intruding vehicle has idled. According to Ms. Jenkins, a pilot study was conducted in which bus lane enforcement cameras were placed on the bus rather than on a streetlight (Jenkins 2018). Such a mechanism would allow greater authority for the MTA and NYCDOT to implement and monitor their own bus lane cameras. The length of bus lane intrusion would be determined by having cameras on each bus along a route; if a specific vehicle is detected by consecutive bus cameras, a violation would be issued. With proper implementation of congestion pricing, congestion on the City's streets would decrease, allowing more bus lanes to be implemented. General traffic demand would subsequently adjust to the decreased level of available road space, disincentivizing traveling by automobile and with the new bus lanes, incentivizing public transit. Implementation of bus lanes requires extensive traffic analysis to insure overall traffic congestion is not worsened. Traffic volumes along many routes are too high for bus lanes to be feasible. With congestion pricing, volumes would decrease and better allow bus lane implementation. According to ICF International, the cost of a bus lane is 2.7 million dollars per mile (Ang-Olson, 2011). As New York City has in-house crews for such projects, the cost in New York would be much lower.

Bus lanes can be most easily installed on high ridership, low speed routes with many lanes.

Bus Frequency

The frequency of scheduled service does not align with that of actual service due to slow speeds. Routes with high rates of bunching should not receive increased bus frequency until the route is operated the way it was intended/scheduled. In a comprehensive analysis of the City's bus routes, other improvements applicable to the entire city such as TSP, bus stop consolidation, all-door boarding and off-board fare payment should be implemented before any change to frequency. Subsequently, high ridership and crowded routes should see increased frequency. Low ridership routes should not necessarily receive lower frequency's because the attractiveness of bus service would continue to decline. In areas and along routes with decreased ridership, a comprehensive analysis should be conducted to determine the reason for the loss in ridership and what can be done to improve the attractiveness of buses and potentially decrease the feasibility of less efficient modes. The cost of changing the frequency of bus service comes from needing more buses and drivers. If implemented with other improvements, bus speeds may improve to the point at which changing the frequency is not necessary. The cost of a new bus is approximately $900,000 (Metro, 2017). Wages for New York City bus operators are higher than in most cities. The average wage for New York City's 9,390 bus operators is $73,166 plus $16,539 for overtime (Citizens Budget Commission, 2012). Including all compensation such as medical and retirement benefits, the average annual compensation rises to $120,908; more than $20,000 higher than the next most highly paid transit agency in the country.

Increasing bus frequency is difficult to do with heavy traffic causing inconsistent service. Routes with high rates of bus bunching and crowding should first be improved so it can be determined whether scheduled service is adequate.

Redesign of Interior of Buses

The interior of buses can be improved. Pilot efforts have recently been made to reconfigure the layout of New York City Transit subway cars to increase capacity. More space should be created for standing passengers by eliminating seats. This issue is similar to bus stop consolidation. The greatest accessibility options come from more stops allowing for longer walks though with decreased speeds while more seats on the bus allows more passengers to sit, but overall carry fewer passengers. Seats should be lined up on either side of buses, but not with two side-by-side perpendicular seats as presently exists. Having side-by-side seats also causes internal congestion when passengers sitting against the wall must exit, forcing the adjacent passenger to stand in what may already be a crowded area. Nothing can be done to eliminate the need to move for exiting passengers, but more can be done to make the process easier and allow straphanger's to exit the bus as quickly as possible. The cost of redesigning the interior of buses varies based on what improvement is made.

All Door Boarding and Off-Board Fare Payment

All door boarding is paramount to improved bus service. Presently, on all non-SBS buses, passengers must enter and pay through the front door. Departing passengers are supposed to exit in a back door though they often exit out the front door, impeding oncoming passengers. All door boarding should be paired with off-board fare payment. According to Ms. Jenkins, the MTA's new fare payment system which will make the Metrocard obsolete would allow easy fare payment at each door of a bus though off-board payment would still be preferable (Jenkins 2018). Paying through door could be a successful interim solution until citywide off-board fare payment is feasible. With proper all-door boarding, buses will be less crowded because passengers will be able to more equally distribute throughout the entire bus. Additionally, bus speeds will increase by needing wait less for embarking/disembarking passengers. A major source of wait for buses is having passengers pay on the bus. Despite requiring a Metrocard or exact change, having every passenger enter and pay through the front door is time consuming. More lightly used systems with fewer passengers and stops face less negative aspects from paying through the front door. Off-board fare payment as practiced on

SBS mandates passengers purchase their ticket prior to boarding, receiving a receipt they must carry with them on the bus. Roaming fare inspectors occasionally board buses to insure everyone has bought their ticket. Requiring passengers to purchase their ticket prior to boarding saves further time once on the bus. Though best implemented throughout the entire city, all-door boarding and off-board fare payment should be first targeted along high ridership routes as these are most likely to spend the most time waiting for passengers to (dis)embark. COST?

Technological Upgrades

Technological upgrades can be made to buses to allow more widespread dissemination of helpful information. Many subway trains are outfitted with screens displaying the next and/or subsequent stops. With so many stops and unpredictable routes, this system would be even more helpful on the City's buses. Bus operators announce the next stop and connections, but similar to riding the train, these messages can be difficult to hear. Having a digital display or even a printout of the route with stops would help passengers know where they are going and provide ease that they will get there. Reconfiguring routes to be more intuitive would lessen the detriment of not providing bus screens though it would still be helpful.

The suggested bus improvements laid out in this research provide fundamental ideas for how to improve the City's bus service. If due diligence is given, all can benefit the transportation system and the million's using it. But these changes cannot occur overnight. Expansive outreach needs to be conducted to elicit feedback, pinpoint problems and educate the public about how they will benefit.

What Can be Done Conclusion

Each of the previously detailed improvements would improve the experience for bus riders. Some would only improve the experience itself while others would improve speeds as well. The MTA and City should focus on improvements which improve bus speeds and thus attract more riders. Too much attention has been paid to other changes, such as installing USB drives on buses. Improvements which can be systematically be implemented citywide such as all-door boarding and bus stop consolidation would result in the greatest improvements. Additionally, there are opportunities for these improvements everywhere, whereas changes such as bus lanes and transit signal priority are only feasible in certain areas. All improvements such be considered and studied, but those focusing on the entire system should be given priority.

Conclusion

MTA Bus Plan

In April 2018, the MTA's "Bus Plan" was introduced to the public. Their presentation begins with the set of problems facing bus service; slow speeds, unreliable service, decreased ridership, the vast number of people relying on the bus, lack of updates and a trend in shifting to other modes. The MTA's plan includes a number of improved outlined in this paper include redesigning the bus network "from top to bottom based on customer input, demographic changes, and travel demand analysis" as well as improving the network through community engagement to "remov[ing[closely-spaced and underutilized stops and making street design changes on select corridors…" They will also expand off-peak service on some routes, expand TSP, add more bus lanes, advocate for stronger enforcement, install more bus shelters and improve service transparency to riders. Perhaps the biggest improvement will be the introduction of all-door boarding, to be introduced with the Metrocard's successor. This plan sets out to accomplish a number of wonderful tasks that will improve bus service and the overall experience for bus riders. Despite these changes, the narrow focus on bus service itself, rather than the larger transportation network and traffic congestion caps the improvements.

Concluding Thoughts

The crux of my research centers on improving bus service in New York. The success and feasibility of these methods are evidenced by case studies elsewhere. Most of these improvements are minimally invasive and would almost certainly result in quantitative improvements. An effective, well designed system would reduce commute times, improve access to jobs, ease subway overcrowding, alleviate gaps in the subway system, and dramatically improve the lives of all New Yorkers, particularly those with lower incomes" as well as "reduce commuters' needs for private vehicles, allowing many lower-income New Yorkers to forego car ownership and save thousands of dollars" and "improve economic conditions and quality of life of New Yorker." (Comptroller 2017) According to the Regional Plan Association "With the right combination of smart technology, greater availability, faster travel times, and new lines, riding a bus or streetcar would no longer be the last and least desirable option in the region's transit system-it may even be the first" (Maslin Nir 2018). The City's transportation system faces difficulties that may appear to be overwhelming, but can be overcome using a variety of methods proven in other cities. Prior to the Mayor's reelection the Village Voice reported "in all likelihood, de Blasio will have four more years to change his transportation legacy. If he doesn't want to be seen as the Mayor who squandered the best chance to fix the City's transit, he'd better start now." (Gordon 2017) I hope to provide recommendations to advise policymakers, elected officials and planners on how to proceed in improving this network.

Appendix

Correlational Analysis

The following tables relate to the "Bus Routes" subsection of "Data/Results." The top left corner of the table is the variable analyzed. The following five quintiles (Q1 (lowest number) to Q5 (highest number) place each New York City bus route based on the variable analyzed. The subsequent data in the tables display the average figure for the routes in the respective quintiles. These figures portray the different trends and themes across each variable. The body of the paper includes key findings while these tables provide more complete data.

Speed	Range	#	Bunch	Riders (Avg)	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	Length 2 Tot	RPM2 Avg	RPM Tot	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	3.6-5.5	44	11	13737	-11.8	-1751	-73572	442	1559	65492	8.2	190	7770
Q2	5.6-6.4	45	9.58	14949	-4.1	-916	-40300	535	1225	53891	8.3	161	7099
Q3	6.5-7.7	46	7.7	11979	-3.3	-490	-21539	543	980	43130	7.4	139	6134
Q4	7.8-9.5	43	6	9802	5.6	147	5593	502	795	32592	7.7	117	4792
Q5	9.6-15.5	42	4.6	6297	-3.2	-196	-8051	647	410	17205	5.8	67	2759
Average		44	7.8	11400	-3.6		-26137	534	997	42462	7.5	135	5710

Figure 14

Bunching	Range	#	Speed	Riders (Avg)	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	Length 2 Tot	RPM2 Avg	RPM Tot	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	.1-2.7	45	9.1	3710	5.5	13	545	430	390	17567	4.3	94	4134
Q2	2.7+-5.4	45	8.4	7109	-5.1	-369	-16621	518	762	34311	6.6	123	5526
Q3	5.4+-9	44	7.4	11426	-7.6	-576	-23620	535	1089	44631	7.9	147	6015
Q4	9+-12.7	45	6.8	14344	-1.5	-271	-11939	538	1291	56795	9.8	138	5930
Q5	12.7+-20.8	43	6.1	21170	-10.1	-2163	-86537	655	1514	60560	8.9	180	7205
Average		44	7.6	11400	-3.6		-26137	534	997	42462	7.5	135	5710

Figure 15

Ridership	Range	#	Speed	Bunch	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	Length 2 Tot	RPM2 Avg	RPM Tot	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	258-3989	43	8.9	2.3	-.8	-144	-5602	402	264	11358	3.9	68	2908
Q2	3990-7049	43	8.9	5	-4.6	-415	-17846	519	561	24102	6.3	99	4153
Q3	7050-10530	43	7.2	8.3	-5.2	-784	-33700	513	806	34678	7.8	113	4840
Q4	10531-16021	43	6.4	10.6	-7.1	-1237	-53174	528	1319	56735	9.5	154	6635
Q5	16022-48656	43	6.7	12.2	-.7	-648	-27851	650	2023	86992	9.6	245	10274
Average		43	7.6	7.8	-3.6	-655	-26137	534	997	42462	7.5	135	5710

Figure 16

Change	Range	#	Speed	Bunch	Ridership	Rider Lost (Avg)	Riders Lost (Tot)	Length 2 Tot	RPM2 Avg	RPM Tot	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	-59.5--15.5	43	6.6	9.4	8122	-2575	-110733	502	781	33599	6	129	5555
Q2	-15.5--7.6	44	7.1	9	13589	-1575	-69287	520	1240	54577	8.5	137	6038
Q3	-7.7--2.1	44	8.1	7.4	12269	-548	-24092	598	959	42179	7.9	130	5459
Q4	-2.1-4.1	38	8.5	6.6	11579	83	3161	484	1026	38987	7.1	151	5746
Q5	4.1-183.8	42	7.7	6.7	11982	1495	62778	487	1048	44033	8.1	137	5768
Average		43	7.6	7.8	11400	-655	-26137	534	997	42462	7.5	135	5710

Figure 17

Change Raw	Range	#	Speed	Bunch	Ridership	Change (Avg)	Length 2 Tot	RPM2 Avg	RPM Tot	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	-8398.7--1573.73	43	5.7	12.7	16544	-19.8	561	1480	63659	8.6	180	7740
Q2	-1573.729999--611.33	44	6.7	8.3	12775	-12	515	1043.7	45921	7.6	142	6106
Q3	-611.329999--154.91	42	9	5.8	6714	-9.3	543	572	24023	6.5	90	3692
Q4	-154.909999-347.68	39	9.1	4.5	7212	.6	439	721	28131	6.5	107	4164
Q5	347.680001-8736.36	43	7.7	7.4	13803	22	518	1201	51642	8.3	160	6864
Average		43	7.6	7.8	11400	-3.6	534	997	42462	7.5	135	5710

Figure 18

Length	Range	#	Speed	Bunch	Ridership	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	RPM2 Avg	RPM Tot	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	2.39-6.95	42	6.8	4.5	5974	-4	-459	-16965	1238	49527	7.7	152	6065
Q2	6.95-10.51	43	7	7.4	8921	-4.6	-644	-25102	1015	40602	8.1	133	5327
Q3	10.51-13.37	46	7.2	7.9	10946	-.1	-127	-5723	935	42071	6.9	132	5811
Q4	13.37-15.76	48	8.1	8.3	13373	-5.1	-867	-40726	915	42992	6.3	148	6934
Q5	15.76-37	44	8.6	10.6	16651	-5.1	-1155	-49659	899	38674	8.6	111	4673
Average		43	7.6	7.8	11400	-3.6	-655	-26137	997	42462	7.5	135	5710

Figure 19

RpM2	Range	#	Speed	Bunch	Ridership	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	Length	PerAM Avg	RHPerAm Avg	RHPerAm Tot
Q1	26.72-342.56	43	10.4	3	2669	-2.6	-344	-13432	552	4	55	2294
Q2	342.56-638.18	45	8	5.7	5972	-2	-362	-16293	548	6.2	93	4166
Q3	638.18-862	42	7	8.8	9293	-6.3	-852	-35778	514	7.45	117	4929
Q4	862-1414.37	45	6.7	9.9	14513	-5.5	-916	-41209	583	9	141	6218
Q5	1414.37-5712.67	40	5.9	11.3	25150	-2.1	-787	-31461	416	10.7	280	11203
Average		43	7.6	7.8	11400	-3.6	-655	-26137	534	7.5	135	5710

Figure 20

PerAm	Range	#	Speed	Bunch	Ridership	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	Length	RPM2 Avg	RPM2 Tot	RHPerAm Avg	RHPerAm Tot
Q1	2-4	52	9.2	3.4	4690	1.7	-297	-13945	612	395	20133	109	5432
Q2	4-6	51	7.2	7.1	9729	-6.9	-799	-39148	608	863	41811	163	7974
Q3	6-7.5	46	7.1	10.1	13893	-8.2	-1056	-47536	618	1062	47776	150	6750
Q4	7.5-10	36	6.9	9.8	13807	4.6	-763	-25163	449	1114	36776	119	3915
Q5	10-20	37	6.9	10.1	17517	-.21	-335	-12382	407	1821	67370	132	4740
Average		43	7.6	7.8	11400	-3.6	-655	-26137	534	997	42462	135	5710

Figure 21

RHrPerM	Range	#	Speed	Bunch	Ridership	Change (Avg)	Rider Lost (Avg)	Riders Lost (Tot)	Length	RPM2 Avg	RPM2 Tot	PerAM
Q1	13.36-68.84	42	10.2	4.7	4668	1	-150	-5993	579	337	14154	7.1
Q2	68.847-92.74	43	8.4	5.9	7038	-2.63	-432	-17703	543	527	22646	6.8
Q3	92.74-127.63	43	7	8.1	9507	-6.2	-867.4	-37296	482	860	36975	8
Q4	127.63-177/9	42	6.2	10	12175	-7	-1261	-52965	485	1066	44753	7.2
Q5	177.9-667	43	6.3	9.8	23073	-1.6	-538	-23135	494	2179	93697	8.2
Average		43	7.6	7.8	11400	-3.6	-655	-26137	534	997	42462	7.5

Figure 22

Bus Route Correlations

Bus Routes	*PerAM*	*RHrPerAM*	*Speed*	*Bunch*	*RidersB*	*Change*	*Length*	*RpM*	*RidersA*	*RidersLoss*	*Length2*	*RPM2*	*Total*
PerAM	1.00												
RHrPerAM	0.00	1.00											
Speed	-0.23	-0.40	1.00										

Bunch	0.40	0.24	-0.42	1.00									
RidersB	0.43	0.64	-0.30	0.60	1.00								
Change	0.03	0.00	0.16	-0.20	0.01	1.00							
Length	-0.05	-0.16	0.34	0.34	0.27	-0.03	1.00						
RpM	0.55	0.75	-0.44	0.40	0.75	0.00	-0.22	1.00					
RidersA	0.41	0.63	-0.34	0.64	0.98	-0.10	0.28	0.73	1.00				
RidersLoss	0.02	-0.09	0.27	-0.33	-0.12	0.59	-0.11	- 0.07	-0.31	1.00			
Length2	-0.06	-0.14	0.34	0.34	0.28	-0.02	0.99	- 0.21	0.29	-0.09	1.00		
RPM2	0.56	0.73	-0.44	0.41	0.75	0.00	-0.21	0.99	0.74	-0.08	-0.20	1.00	
Total	0.49	0.51	-0.64	0.82	0.75	-0.08	0.14	0.68	0.76	-0.25	0.15	0.68	1.00

Figure 23

Multivariate Ranking

The following table provides data used for the multivariate ranking of bus routes. A higher number indicates more urgent need. Yellow is the lowest quintile, orange the second lowest, green the third, blue the second highest and red the highest. Some routes were excluded from the final ranking because of missing variables.

route_id	PerAM	RHrPerAM	Speed	Bunch	RidersB	Change	RpM	RidersLoss	Length2	RPM2	Total
B39	1	1	#VALUE!	2	2	5	70.62	1	1	1	#VALUE!
B74	3	5	#VALUE!	8	4	3	1475.22	3	1	5	#VALUE!
BX4A	4	X	8	6	#VALUE!	X	X	X	2	X	X
M14A	3	X	10	8	#VALUE!	X	X	X	2	X	X
M14D	5	X	10	10	#VALUE!	X	X	X	1	X	X
Q06	2	X	4	10	#VALUE!	X	X	X	2	X	X
Q07	2	X	4	6	#VALUE!	X	X	X	3	X	X
Q08	4	X	6	10	#VALUE!	X	X	X	4	X	X
Q09	4	X	6	6	#VALUE!	X	X	X	1	X	X
Q114	1	X	#VALUE!	#VALUE!	#VALUE!	X	X	X	5	X	X
BX15	3	5	10	10	10	5	2644.43	5	3	5	56
BX6	5	5	8	10	10	5	2693.74	5	3	5	56
M15	3	5	10	10	10	3	2728.99	5	5	5	56
B44+	5	5	8	10	10	2	2349.72	5	5	5	55
BX36	5	4	8	10	10	4	2282.01	5	4	5	55
M101	3	4	10	10	10	4	1240.43	5	5	4	55
B35	4	5	10	10	10	2	2877.94	5	3	5	54
BX35	5	5	10	8	10	5	2888.83	5	1	5	54
M15+	5	4	8	10	10	2	2854.65	5	5	5	54

B12	5	4	10	10	8	4	2092.3	5	2	5	53
B44	5	3	8	10	10	2	1896.15	5	5	5	53
M4	3	3	10	10	10	4	769.6	5	5	3	53
B41	1	5	8	10	10	4	1899.47	5	4	5	52
BX21	4	4	8	10	10	4	1576.45	4	3	5	52
M7	3	4	10	10	8	4	862.01	5	4	4	52
B46	3	5	6	10	10	3	2987.4	5	4	5	51
Q58	3	5	6	8	10	4	1854	5	5	5	51
BX19	4	5	10	10	10	2	2698.88	2	3	5	51
BX2	3	5	10	10	10	1	2573.46	3	4	5	51
BX39	4	3	8	8	10	5	1246.49	5	4	4	51
M102	2	4	10	10	8	5	851.63	5	4	3	51
M1	2	4	10	10	8	5	593.83	5	5	2	51
B38	4	4	8	10	10	2	1274.01	4	4	4	50
B82	3	5	6	10	10	3	1438.45	4	5	4	50
M42	5	5	10	8	8	4	3127.31	4	1	5	50
BX11	5	4	8	8	8	4	1792.58	5	2	5	49
M3	2	3	10	10	8	4	726.01	4	5	3	49
M66	5	5	10	8	8	3	3301	4	1	5	49
Q25	2	5	6	8	10	5	1342.83	5	4	4	49
B6	3	5	6	10	10	1	2120	3	5	5	48
BX12+	5	5	2	8	10	4	3620.18	5	4	5	48
M104	2	4	10	10	6	5	882.52	5	2	4	48
M11	2	3	10	10	8	4	745.61	4	4	3	48
M5	4	1	8	10	8	4	458.11	5	5	3	48
M86+	5	5	10	6	10	2	5712.67	4	1	5	48
M96	5	5	10	10	8	2	4216.26	2	1	5	48
B25	3	4	10	10	6	3	983.35	4	3	4	47
B68	4	4	6	10	8	3	1096.67	4	4	4	47
BX13	5	3	8	6	8	5	1746.03	5	2	5	47
BX1	4	5	6	8	10	1	2307.19	3	5	5	47
BX9	5	5	8	8	10	2	2863.85	2	2	5	47
M103	2	4	10	8	6	5	682.05	5	4	3	47
M116	5	4	10	6	6	5	2108.89	5	1	5	47
B49	3	2	6	10	8	5	658.2	5	5	2	46
B61	3	4	8	8	6	5	975.32	5	3	4	46
BX22	4	4	8	8	8	3	1357.2	4	3	4	46
M2	3	2	8	10	6	5	482.02	5	5	2	46
M31	5	3	10	8	6	4	1414.37	4	2	4	46
Q17	4	4	6	8	10	2	1238.42	4	4	4	46
Q32	3	3	10	8	6	4	719.8	5	4	3	46
B1	3	5	6	10	10	2	1758.33	1	3	5	45
B3	5	3	8	8	8	3	1324.74	4	2	4	45

BX12	2	5	4	6	10	4	3323.54	5	4	5	45
BX41	2	5	8	6	10	3	2771.1	4	2	5	45
Q27	5	2	4	8	10	3	1413.56	4	5	4	45
B47	3	3	8	10	8	3	816.33	3	3	3	44
B60	3	3	8	8	6	5	705.62	4	4	3	44
BX3	5	5	6	8	8	2	2134.85	3	2	5	44
M60+	4	3	4	8	10	3	902.77	3	5	4	44
B103	5	1	4	8	8	5	763.99	5	5	3	44
B11	4	3	10	8	8	1	1073.13	2	3	4	43
B54	3	5	10	8	8	1	1442.58	2	2	4	43
B57	1	4	8	8	6	5	529.14	5	4	2	43
B8	4	3	8	6	10	1	1164.12	2	5	4	43
B9	2	4	8	8	8	3	884.15	3	4	3	43
Q56	2	4	8	10	6	4	826.04	4	2	3	43
BX17	4	3	8	10	8	2	1163.94	2	2	4	43
BX40	4	5	8	4	10	1	2048.9	3	3	5	43
M34+	2	5	10	4	8	4	4007.91	4	1	5	43
M34A+	2	5	10	4	8	4	3136.07	4	1	5	43
B15	2	4	4	10	10	2	937	1	5	4	42
Q54	4	2	6	10	8	2	760.42	2	5	3	42
Q44+	5	2	4	6	10	3	1143.77	3	5	4	42
Q23	3	5	8	8	8	1	1343.71	2	3	4	42
B17	2	5	6	6	8	3	1037.59	4	3	4	41
B36	5	3	6	6	8	3	1393.25	4	2	4	41
B62	3	3	8	6	6	5	642.46	4	4	2	41
BX10	5	2	6	6	8	4	912.44	4	3	3	41
BX32	3	3	10	8	4	4	818.19	4	2	3	41
BX41+	3	5	4	6	10	3	3815.34	4	1	5	41
BX42	1	5	8	4	10	1	1951.01	3	4	5	41
M57	2	5	10	6	4	5	1073.46	4	1	4	41
B52	4	4	8	8	8	1	1346	1	2	4	40
B63	2	4	10	6	8	1	870.05	2	4	3	40
BX4	4	4	8	4	8	2	1512.29	3	2	5	40
Q111	4	2	4	10	8	2	834.54	3	4	3	40
B43	2	4	10	6	6	2	843.47	3	3	3	39
B45	2	3	10	8	4	4	722.02	3	2	3	39
BX28	2	5	6	4	10	2	980.84	1	5	4	39
BX7	4	4	8	6	8	1	1378.73	2	2	4	39
M100	1	X	10	8	10	1	X	2	3	4	39
M10	3	3	8	6	6	4	797.4	4	2	3	39
M9	3	2	10	8	4	4	616.14	4	2	2	39
Q30	1	4	4	8	6	4	643.97	4	5	3	39
Q46	5	1	2	8	10	2	1098.65	2	5	4	39

BX30	4	2	6	6	6	4	825.4	4	3	3	38
Q20A	1	5	8	4	8	2	916.1	2	4	4	38
Q43	5	2	4	8	8	1	1253.03	3	3	4	38
B26	4	3	8	6	6	1	860.95	2	3	4	37
BX31	4	3	6	8	6	1	950.4	2	3	4	37
S79+	3	1	2	6	8	5	420.52	5	5	2	37
Q10	2	5	2	6	10	1	1233.65	2	5	4	37
Q24	4	1	6	10	6	1	554.59	1	5	2	36
BX27	5	2	6	4	6	4	1374.22	4	1	4	36
BX38	2	5	6	2	10	2	1123.37	1	4	4	36
BX5	5	1	4	6	8	2	821.63	3	4	3	36
M72	3	4	10	6	4	2	1169.43	2	1	4	36
Q12	5	3	4	4	8	3	1152.41	3	2	4	36
Q33	4	4	6	4	6	3	1528.5	3	1	5	36
B20	3	2	8	6	6	2	534.46	2	4	2	35
Q20B	2	5	6	2	8	2	886.51	2	4	4	35
Q4	2	4	4	6	6	3	881.68	3	3	4	35
Q5	3	3	4	8	8	1	761.83	1	4	3	35
Q34	1	5	6	6	6	3	613.8	3	3	2	35
Q37	5	1	4	4	6	5	807.14	5	2	3	35
B83	2	4	6	8	6	1	804.11	1	3	3	34
Q3	3	3	4	6	6	3	754.03	3	3	3	34
B14	2	4	8	6	6	1	808.81	1	2	3	33
B70	2	4	8	4	4	4	638.18	3	2	2	33
BX16	4	2	4	4	6	4	690.73	3	3	3	33
M20	1	2	10	6	2	5	228.68	3	3	1	33
Q85	3	2	2	8	8	1	690.68	1	5	3	33
Q18	3	4	6	4	6	2	948.7	2	2	4	33
Q38	2	4	4	2	6	5	647.51	5	3	2	33
B13	1	3	6	4	4	4	390.3	4	4	2	32
B69	1	2	8	4	2	5	361.77	5	3	2	32
Q55	5	3	6	4	6	1	1132.83	1	2	4	32
Q28	5	3	4	6	6	1	1112.91	1	2	4	32
S48	2	4	4	4	6	3	708.81	3	3	3	32
BX26	4	2	6	4	6	2	758.67	1	3	3	31
BX8	3	2	4	6	6	2	524.63	2	4	2	31
M106	2	3	10	2	2	5	564.18	4	1	2	31
M50	1	4	10	2	2	5	647.46	3	1	3	31
Q88	5	1	2	8	6	1	574.64	1	5	2	31
S44	2	2	2	6	6	3	409.82	3	5	2	31
Q112	3	3	6	8	4	2	712.98	1	1	3	31
Q113	1	2	2	6	4	5	279.56	5	5	1	31
Q22	3	2	2	8	6	2	458.98	2	4	2	31

Q29	3	3	6	4	4	4	784.35	3	1	3	31
B16	1	3	6	6	4	2	461.98	2	4	2	30
B42	5	3	6	4	4	1	1800.42	1	1	5	30
B67	1	3	8	4	4	3	388	2	3	2	30
Q31	4	1	4	6	4	3	390.18	2	4	2	30
Q36	4	1	4	2	4	4	342.56	4	5	2	30
S46	2	2	2	6	6	3	494.24	3	4	2	30
B4	1	2	6	2	4	4	344.72	4	5	1	29
M22	3	1	10	2	2	5	501.13	3	1	2	29
Q15A	1	5	4	2	4	4	730.12	4	2	3	29
Q15	1	5	4	2	4	4	743.95	4	2	3	29
Q110	4	2	4	8	4	2	619.28	1	2	2	29
Q11	3	1	2	4	4	5	299.06	5	4	1	29
M98	3	1	4	6	2	5	134.09	3	3	1	28
Q83	3	3	4	4	6	1	799.95	1	3	3	28
S53	3	2	2	4	6	2	591.08	2	5	2	28
B48	2	2	8	4	2	3	344.87	1	3	2	27
B65	2	1	8	4	2	4	385.61	2	2	2	27
B7	1	3	6	6	4	1	505.85	1	3	2	27
Q59	2	2	6	4	4	2	554.11	2	3	2	27
M8	2	2	10	2	2	4	505.09	2	1	2	27
Q76	4	1	2	6	4	2	333.23	2	5	1	27
S78	2	1	2	10	4	1	165.87	1	5	1	27
Q100	2	3	2	4	4	5	598.17	4	1	2	27
B37	1	2	6	2	2	5	209.47	4	3	1	26
B64	2	2	6	4	4	2	456.5	1	3	2	26
Q13	3	3	4	2	6	1	843.12	1	3	3	26
Q2	2	4	4	4	4	2	789.73	1	2	3	26
Q77	4	1	4	6	4	1	533.47	1	3	2	26
B100	5	1	4	4	4	2	761.99	2	1	3	26
Q104	1	4	8	2	2	3	437.3	3	1	2	26
Q19	1	2	2	4	2	5	270.43	5	3	1	25
B24	1	2	6	4	2	4	210.82	1	3	1	24
BX33	1	4	8	2	2	3	583.51	1	1	2	24
Q16	4	1	2	2	4	4	417.95	3	2	2	24
S61	1	2	2	4	4	3	296.58	3	4	1	24
S74	3	1	2	4	4	2	183.66	2	5	1	24
S76	2	1	2	4	4	3	311.53	3	4	1	24
BX18	1	3	6	2	2	3	462	3	1	2	23
BX34	2	3	6	2	4	1	697.9	1	1	3	23
Q1	1	4	4	2	4	2	468.09	2	2	2	23
S90	1	3	2	2	4	3	408.71	3	3	2	23
S93	1	1	2	2	2	5	213.31	5	4	1	23

BX20	1	1	6	4	2	5	126.44	1	1	1	22
M21	2	1	10	2	2	1	280.32	2	1	1	22
Q84	5	1	2	4	4	1	481.23	1	2	2	22
S40	1	2	2	2	4	3	367.71	3	3	2	22
S52	1	1	2	2	2	5	254.89	4	4	1	22
B2	2	3	6	2	2	1	551.83	2	1	2	21
S42	1	2	2	6	2	5	159.21	1	1	1	21
S55	1	1	2	4	2	5	26.72	1	4	1	21
S56	1	1	2	4	2	5	39.34	1	4	1	21
Q103	1	1	4	2	2	5	229.03	4	1	1	21
M35	2	1	2	4	2	5	252.42	2	1	1	20
Q42	2	1	4	2	2	4	302.84	3	1	1	20
S54	1	1	2	4	2	3	85.25	1	5	1	20
Q102	1	2	4	2	2	3	282.09	3	2	1	20
Q35	2	1	2	2	4	2	284.01	2	4	1	20
Q48	1	1	4	2	2	3	263.98	3	2	1	19
S57	1	1	2	4	2	1	88.05	2	5	1	19
S62	1	2	2	2	4	2	326.71	1	4	1	19
S89	1	1	2	2	2	3	45.68	2	5	1	19
Q101	2	2	6	2	2	1	330.23	1	2	1	19
Q21	1	3	2	2	2	3	188.83	1	4	1	19
B31	2	2	4	2	2	1	524.44	2	1	2	18
S51	1	2	2	2	4	1	320.27	1	4	1	18
S59	1	1	2	4	2	1	144.64	1	5	1	18
Q26	3	1	2	2	2	4	240.63	1	1	1	17
S66	1	1	2	2	2	3	126.37	1	4	1	17
S84	X	X	2	2	4	1	322.73	1	5	1	16
BX29	1	2	2	2	2	1	275.45	2	2	1	15
BX24	1	1	4	2	2	X	97.97	X	2	1	13
BX46	1	2	4	2	2	X	137.73	X	1	1	13
B32	1	1	4	2	2	X	105.64	X	1	1	12
B84	1	2	2	2	2	X	146.99	X	1	1	11

Figure 24

Census Tract Correlations

The following correlations were found using census tract data. This is intended to signify where improvements should be concentrated and what communities are most impacted by poor bus service.

The following weak positive correlations were found:

- ACChN and HHChild
- ACChN and Hispanic
- ABChN and HHChild
- ABChN and BusP
- ACChP and BusP
- HHChild and HHForeign
- HHChild and HHNotEnglish
- HHChild and Black
- HHChild and Hispanic
- HHChild and CarP
- HHChild and CarDrAlP
- HHChild and CarpoolP
- HHChild and BusP
- HHSenior and HHDisability
- HHSenior and HHForeign
- HHSenior and CarpoolP
- HHBach and SubwayP
- HHBach and BikeP
- HHBach and WalkP
- HHBach and WorkHomeP
- HHDisability and Hispanic
- HHDisability and BusP
- HHForeign and CarpoolP
- HHForeign and PubTransP
- HHForeign and SubwayP
- HHNotEnglish and CarpoolP
- HHNotEnglish and PubTransP
- HHNotEnglish and SubwayP
- White and WalkP
- White and WorkHomeP
- Black and PubTransP
- Black and BusP
- Asian and PubTransP
- Hispanic and SubwayP
- CarP and BusP
- CarDrAlP and BusP
- SubwayP and BikeP
- BikeP and Walk P
- WalkP and WorkHomeP

The following weak negative correlations were found:

- BCChN and ABChN
- ACChN and HHBach
- ACChN and White
- ABChN and HHBach
- HHChild and White
- HHChild and WorkHomeP
- HHSenior and Hispanic
- HHSenior and SubwayP
- HHSenior and BikeP
- HHBach and HHDisability
- HHBach and Black
- HHBach and Hispanic
- HHBach and BusP
- HHForegin and White
- HHForeign and WorkHomeP
- White and PubTransP
- White and BusP
- Black and WalkP
- Hispanic and CarP
- Hispanic and CarDrAlP
- CarP and BikeP
- CarP and WorkHomeP
- CarDrAlP and BikeP
- CarDrAlP and WorkHome

The following variables are moderately positively correlated:

- BCChN and ACChN
- ACChn and BusP
- ACChP and ABChP
- HHSenior and CarP

- HHSenior and CarDrAlP
- HHBach and White
- HHForeign and Asian
- HHNotEnglish and Asian
- HHNotEnglish and Hispanic
- Hispanic and PubTransP
- CarDrAlP and CarppolP

The following variables are moderately negatively correlated:

- HHChild and HHBach
- HHNotEnglish and White
- Black and Asian
- CarP and PubTransP
- CarP and WalkP
- CarDrAlP and PubTransP
- CarDrAlP and WalkP

What Can be Done

The following is a summary of the positives and negatives of each proposed bus improvement.

BRT Feasibility

- Pros
    - Results in largest improvements
- Cons
    - Incredibly costly
    - Because of cost, would minimize improvements city could make elsewhere
    - Currently politically infeasible

Improved Enforcement

- Pros
    - No new infrastructure needed
    - Better utilizes existing infrastructure
- Cons

    - Potentially requires reallocation of resources from crime prevention
    - Does not seem to be motivation from NYPD to enforce these rules

Transit Signal Priority

- Pros
    - Infrastructure exists
    - Minimally invasive to day to day; most people wouldn't notice
- Cons
    - Requires greater funding to expedite studies and implementation

Bus Stop Consolidation

- Pros
    - No new infrastructure
    - Provides space for other uses
- Cons
    - Requires vast public outreach
    - Bad public relations from people losing their stop
    - Some people have to walk further to stop

Route Reconfiguration (small scale and large scale)

- Pros
    - No new infrastructure
    - Improves efficiency of existing system
- Cons
    - Some people would be further from stops
    - Nobody likes change

Interborough Routes

- Pros
    - Eases subway crowding
    - Satisfies a latent demand
- Cons
    - Requires more buses in service
    - Buses between boroughs (particularly to/from Manhattan) may face greater crowding on bridges

Hierarchy of Routes

- Pros
    - Better structures existing system
    - Provides better system which will make improvements easier to implement in future
- Cons
    - Requires large investment in new buses and publicity materials
    - MTA rarely conducts large scale changes

Bus Lanes

- Pros
    - With proper enforcement, definitely results in improved bus service
    - By removing road space, disincentivizes driving
- Cons
    - Current lanes aren't enforced
    - Reduces space for general traffic

    - requires extensive traffic study

Bus Frequency

- Pros
    - Improves reliability of bus service
    - No new infrastructure
- Cons
    - Would decrease reliability for some
    - Requires more buses

Redesign of Interior of Buses

- Pros
    - Improves comfort on buses
    - Improves crowding
- Cons
    - Little to no change in bus speeds
    - Costly to implement system-wide

All Door Boarding and Off-Board Fare Payment

- Pros
    - Improves bus service citywide
    - Easier to do this citywide than route by route
- Cons
    - Need to wait for new fare card
    - Creates confusion among long term riders
    - Perception of greater fare beating

Technological Upgrades

- Pros
  - Improves people's perception of bus service by providing more information to passengers
- Cons
  - Doesn't improve bus speeds
  - Potential large investment if conducted citywide
  - Technology constantly changes; may quickly become outdated

Interview Questions

Janet Jenkins

- What's the main impediment to improving bus service?
- Would congestion pricing help bus service?
- Has connection between congestion pricing and bus service been discussed?
- How have tactics changed over time; what prompted them?
- What are the challenges of off-board fare payment/all door boarding?
- What would help transit signal priority progress?
- What caused the decrease in bus ridership?
- Has bus stop consolidation been considered?
- Why haven't there been any citywide plans/methods for improving bus service?

References

“Bus Stop Balancing,” *Transit Center*, Oct. 30, 2017, http://transitcenter.org/2017/10/30/bus-stop-balancing/

“Buses,” *Metropolitan Transportation Authority*, 2017, http://web.mta.info/nyct/facts/ffbus.htm

“Celebrating Excellence in the Public Transportation Industry,” *American Public Transportation Association,* Oct. 6, 2015, http://www.apta.com/members/memberprogramsandservices/awards/Documents/2015_awards_program_final.pdf

“Congestion Pricing-CSS Analysis,” *Community Service Society,* Oct. 24, 2017, http://www.cssny.org/news/entry/congestion-pricing-css-analysis

“Electeds, Local Civic Groups Pressure MTA to Revive B71,” *Kings County Politics*, Nov. 13, 2017, https://www.kingscountypolitics.com/electeds-local-civic-groups-pressure-mta-revive-b71/

“Getting rid of some bus stops can improve service: study,” *News 1130,* Jan. 10, 2014, http://www.news1130.com/2014/01/10/getting-rid-of-some-bus-stops-can-improve-service-study/

“Green Means Go: Transit Signal Priority in NYC,” *New York City Department of Transportation,* Jul. 2017, http://www.nyc.gov/html/brt/downloads/pdf/brt-transit-signal-priority-july2017.pdf

“How Car-Free is New York City?,” *Tri-State Transportation Campaign,* 2017, Tri State Transportation Campaign, http://blog.tstc.org/2017/04/21/car-free-new-york-city/

“M79 Select Bus Service,” *New York City Department of Transportation,* Mar. 1, 2017, http://www.nyc.gov/html/brt/downloads/pdf/brt-m79-cb8-mar2017.pdf

“Mayor de Blasio Announces Initiatives to Help Ease Congestion,” *New York City Office of the Mayor,* Oct. 22, 2017, http://www1.nyc.gov/office-of-the-mayor/news/673-17/mayor-de-blasio-initiatives-help-ease-congestion#/0

“Mobility and Equity for New York’s Transit-Starved Neighborhoods: The Case for Full-Featured Bus Rapid Transit,” *Pratt Center,* Dec. 2013, Mobility and Equity for New York’s Transit Starved Neighborhoods

“Move NY,” *Move NY,* 2016, http://iheartmoveny.org/

“National Household Travel Survey Daily Travel Quick Facts,” *Bureau of Transportation Statistics*, 2002, https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/subject_areas/national_household_travel_survey/daily_travel.html

“New York City Population Projections by Age/Sex & Borough, 2010-2014,” *New York City Department of City Planning*, Dec. 2013, https://www1.nyc.gov/assets/planning/download/pdf/data-maps/nyc-population/projections_report_2010_2040.pdf

"New York: Transit Signal Priority (TSP), *aimsum,* https://www.aimsun.com/new-york-city-transit-signal-priority/

"PlaNYC: A Greener, Greater, New York," *The City of New York,* 2007, http://www.nyc.gov/html/planyc/downloads/pdf/publications/full_report_2007.pdf

"Res 1600-2012," *New York City Council*, Dec. 10, 2012, http://legistar.council.nyc.gov/LegislationDetail.aspx?ID=1254494&GUID=8DBDB95F-2DD3-49D1-96DA-B522E7FE9329&Options=&Search=

"Ridership Report," *American Public Transportation Association,* 2017, http://www.apta.com/resources/statistics/Pages/ridershipreport.aspx

"Seoul Public Transportation," *Seoul Metropolitan Government,* Jun. 2014, http://citynet-ap.org/wp-content/uploads/2014/06/Seoul-Public-Transportation-English.pdf

"Street Seats," *New York City Department of Transportation,* 2018, http://www.nyc.gov/html/dot/html/pedestrians/streetseats.shtml

"System Reimaging FAQs," *Metropolitan Transit Authority of Harris County, Texas,* 2018, https://www.ridemetro.org/Pages/Reimagining-FAQs.aspx

"T2016-4900" *New York City Council*, Oct. 6, 2016, http://legistar.council.nyc.gov/LegislationDetail.aspx?ID=2824428&GUID=ED6825CF-9408-49D2-9EB3-2A64C7BAA196&FullText=1

“The Other Transit Crisis: How to Improve the NYC Bus System,” *New York City Comptroller’s Office*, Nov. 27, 2017, https://comptroller.nyc.gov/reports/the-other-transit-crisis-how-to-improve-the-nyc-bus-system/

“The Woes on the Bus: Frustration and Suffering, All Through the Town,” *Riders Alliance,* Sep. 2017, http://www.ridersny.org/wp-content/uploads/2017/09/RA_BusWoes_v4.compressed-1.pdf

“Turnaround: Fixing New York City’s Buses,” *Transit Center,* 2016, http://transitcenter.org/wp-content/uploads/2016/07/Turnaround_Fixing-NYCs-Buses-20July2016.pdf

Allen, Heather, “Bus reform in Seoul, Republic of Korea,” *Global Report on Human Settlements,* 2013, https://unhabitat.org/wp-content/uploads/2013/06/GRHS.2013.Case_.Study_.Seoul_.Korea_.pdf

Ang-Olson, Jeffrey and Mahendra, Anjali, “Cost Benefit Analysis of Converting a Lane for Bus Rapid Transit-Phase II Evaluation and Methodology,” *ICF International,* 2011, https://www.nap.edu/read/14518/chapter/1

Associated Press, “De Blasio announces five-point plan to ease congestion,” *Crain’s New York,* http://www.crainsnewyork.com/article/20171023/POLITICS/171029977/mayor-bill-de-blasio-announces-five-point-plan-to-ease-congestion

Barone, Vincent, “Countdown clocks coming to bus stops on Manhattan’s East Side,” *AMNY,* Jun. 20, 2017, https://www.amny.com/transit/countdown-clocks-coming-to-bus-stops-on-manhattan-s-east-side-1.13751019

Citizens Budget Commission, “MTA-TWU Wage Negotiations: A “Fair Increase” Will Not Increase Fares,” Jan. 2012, https://cbcny.org/sites/default/files/REPORT_TWU_01302012.pdf

Colon, David, “Cuomo’s ‘Fix NYC’ Panel Is Devoid Of Anyone Who Governs NYC,” *Gothamist,* Oct. 5, 2017, http://gothamist.com/2017/10/05/the_fix_is_inyc.php

Crout, David T., El-Geneidy, Ahmed M., Kimpel, Thomas J., Strathman, James G., “Effects of Bus Stop Consolidation on Passenger Activity and Transit Operations,” *Transportation Research Record Journal of the Transportation Research Board,* Nov. 2005, https://www.researchgate.net/publication/228760415_Effects_of_Bus_Stop_Consolidation_on_Passenger_Activity_and_Transit_Operations

Desai, Rajvi, “Uber, Lyft and taxi surcharge falls far short of congestion pricing traffic relief, New Yorkers Say,” *AMNY,* April 6, 2018, https://www.amny.com/news/for-hire-surcharge-nyc-traffic-1.17896902

Doig, Will, “New Yorkers Clamor for Countdown Clocks at Bus Stops,” *Next City,* Jun. 6, 2017, https://nextcity.org/daily/entry/nyc-participatory-budget-votes-winners-bus-stop-countdown-clocks

Eliasson, Jonas, “Lessons from the Stockholm Congestion Charging Trial,” *Center for Transport Studies, Royal Institute of Technology,* 2008 http://vianordica2008.vegagerdin.is/vetenskapligt_webb/Tisdag/Session3_sal3A/Eliasson2.pdf

FHWA, “Welcome to the FHWA Congestion Pricing Web Site,” *FHWA,* April 11, 2018, https://ops.fhwa.dot.gov/congestionpricing/index.htm

Fried, Ben, “Never Mind the BQX, Fix the Bus System,” *Streetsblog*, Nov. 16, 2017, https://nyc.streetsblog.org/2017/11/16/never-mind-the-bqx-fix-the-bus-system/

Givoni, Moshe, “Re-Examining the Results of the London Congestion Charging Scheme-A Critical Review,” *University of Oxford,* Jul. 2010, http://www.wctrs-society.com/wp/wp-content/uploads/abstracts/lisbon/selected/03201.pdf

Goldman, Henry, “De Blasio Says He Hasn’t Seen a ‘Fair’ Congestion-Pricing Plan From Cuomo,” *Bloomberg Politics,* Oct. 23, 2017, https://www.bloomberg.com/news/articles/2017-10-23/de-blasio-derides-cuomo-traffic-tax-while-pitching-alternatives

Gordon, Aaron, “Five Ways de Blasio Could Fix Transit, But Won’t,” *Village Voice*, Oct. 30, 2017, https://www.villagevoice.com/2017/10/30/five-ways-de-blasio-could-fix-transit-but-wont

Haiman, Nina. Personal interview. Feb. 5, 2018

Hu, Winnie, “If Your Uber Ride Cost an Extra $50, Would You Still Take It?,” *The New York Times*, Mar. 7, 2018, https://www.nytimes.com/2018/03/07/nyregion/congestion-pricing-uber-lyft-taxi-nyc.html

ITDP, “The Scorecard,” 2018, https://www.itdp.org/library/standards-and-guides/the-bus-rapid-transit-standard/the-scorecard/

Jenkins, Janet. Personal interview. Mar. 2, 2018

Komanoff, Charles, “It’s Settled: Uber is Making NYC Gridlock Worse,” *Streetsblog*, Feb. 27, 2017, https://nyc.streetsblog.org/2017/02/27/its-settled-uber-is-making-nyc-gridlock-worse/

Lavacca, Katherine, "Gov. Cuomo's Approval Ratings Plunge as Subway Frustration Grows, Poll Says," *DNAInfo*, Jul. 12, 2017, https://www.dnainfo.com/new-york/20170712/midtown/cuomos-ratings-drop-mta-commuters-frustration

Levine, Mark, "Buses can ease New York City's transit crisis. Yes, buses," *Crain's New York,* Oct. 11, 2017, http://www.crainsnewyork.com/article/20171011/opinion/171019988/transit-signal-priority-can-speed-mta-buses-through-new-york-city-and-ease-your-commute

Levy, Alon, "New York City bus operating costs: an analysis," *Curbed New York,* Jan. 30, 2018, https://ny.curbed.com/2018/1/30/16946476/mta-new-york-city-bus-operating-costs-analysis

Litman, Todd, "London Congestion Pricing: Implications for Other Cities," *Victoria Transport Policy Institute,* Nov. 24, 2011, https://www.vtpi.org/london.pdf

Lovett, Kennet, Gabrielli, Sarah, McShane, Larry, "Cuomo announces $1 billion infusion of state funds to repair MTA," *New York Daily News*, Jun. 29, 2017, *http*://www.nydailynews.com/new-york/cuomo-announces-1-billion-infusion-state-funds-repair-mta-article-1.3287974

Lumb, David "New York approves surcharge for Uber and Lyft rides in Manhattan," *Engadget*, April 2, 2018, https://www.engadget.com/2018/04/02/new-york-surcharge-uber-lyft-manhattan/

Maslin Nir, Sarah, "As Subway Crisis Takes Up 'So Much Oxygen,' the Buses Drag Along, *The New York Times,* Mar. 8, 2018, https://www.nytimes.com/2018/03/08/nyregion/new-york-city-bus-troubles.html

Metro, "NYC to add 180 new articulated buses to fleet," Oct. 25, 2017, http://www.metro-magazine.com/bus/news/725992/nyc-to-add-180-new-state-of-the-art-articulated-buses-to-fleet

Meyer, David, “Bucking de Blasio, Speaker Candidates Support Congestion Pricing,” *Streetsblog,* Nov. 1, 2017, https://nyc.streetsblog.org/2017/11/01/bucking-de-blasio-speaker-candidates-support-congestion-pricing/

Meyer, David, “Levine Introduces Bill to Speed Up Installation of Signal Priority for Buses,” *Streetsblog,* Nov. 16, 2017, https://nyc.streetsblog.org/2017/11/16/levine-introduces-bill-to-speed-up-installation-of-signal-priority-for-buses/

MTA, “MTA Testing 10 New, All-Electric Buses to Reduce Emissions & Modernize Public Transit Fleet,” Jan. 8, 2018, http://www.mta.info/news/2018/01/08/mta-testing-10-new-all-electric-buses-reduce-emissions-modernize-public-transit

NYCDOT, “Parking Regulations,” *New York City Department of Transportation,* 2018, http://www.nyc.gov/html/dot/html/motorist/parking-regulations.shtml

Peirson, John and Vickerman, Roger, “The London Congestion Charging Scheme: The Evidence,” *University of Kent,* http://www.regscience.hu:88/record/404/files/978-3-540-77150-0.pdf?version=1#page=94

Petro, John, “Every Bus Should Get Priority at NYC Traffic Signals,” *Streetsblog,* Jun. 19, 2014, https://nyc.streetsblog.org/2014/06/19/every-bus-should-get-priority-at-nyc-traffic-signals/

Philipsen, Klaus, “Ten Ways to Improve Bus Transit Use and Experience,” *Smart Cities,* 2017, http://www.smartcitiesdive.com/ex/sustainablecitiescollective/ten-ways-improve-bus-transit/1074286/

Pritchard, David “Notes on Pushkarev and Zupan, Public Transportation and Land Use Policy,” *David Pritchard,* 2007, http://davidpritchard.org/sustrans/PusZup77/

Santos, Georgina and Shaffer, Blake, “Preliminary Results of the London Congestion Charging Scheme,” Oct. 2004, http://journals.sagepub.com/doi/pdf/10.1177/1087724X04268569

Schaller, Bruce, “New York City’s Congestion Pricing Experience and Implications for Road Pricing Acceptance in the United States,” *New York City Department of Transportation,* August 2010, http://www.nyc.gov/html/dot/downloads/pdf/schaller_paper_2010trb.pdf

Schaller, Bruce, “Unsustainable?: The Growth of App-Based Ride Services and Traffic, Travel and the Future of New York City,” *Schaller Consulting,* 2017, http://schallerconsult.com/rideservices/unsustainable.htm

Schmitt, Angie, “America’s Bus Stops Are Too Close Together,” *Streetsblog,* Oct. 30, 2017, https://usa.streetsblog.org/2017/10/30/americas-bus-stops-are-too-close-together/

Snyder, Dave, “Bus Stop Consolidation: The Times Have Changed,” *Streetsblog,* July 2, 2009, https://sf.streetsblog.org/2009/07/02/bus-stop-consolidation-the-times-have-changed/

Vickrey, William, “Principles of Efficient Congestion Pricing,” *Columbia University,* June 1992, http://www.cleanairinstitute.org/cops/bd/file/gdt/92-Principles-of-Efficient-Congestion-Pricing.pdf

Walker, Ameena, “MTA, DOT efforts to improve bus service receive poor marks from advocates,” *Curbed,* Aug. 15, 2017, https://ny.curbed.com/2017/8/15/16147296/nyc-transportation-mta-dot-bus-service-report-card

Warerkar, Tanay, “NYC Select Bus Service will come to 21 new routes in the next decade,” *Curbed,* Oct. 20, 2017, https://ny.curbed.com/2017/10/20/16508426/select-bus-service-expansion-nyc

Warerkar, Tanya, “Uber surpasses yellow cabs in average daily ridership in NYC,” *Curbed,* Oct. 13, 2017, https://ny.curbed.com/2017/10/13/16468716/uber-yellow-cab-nyc-surpass-ridership