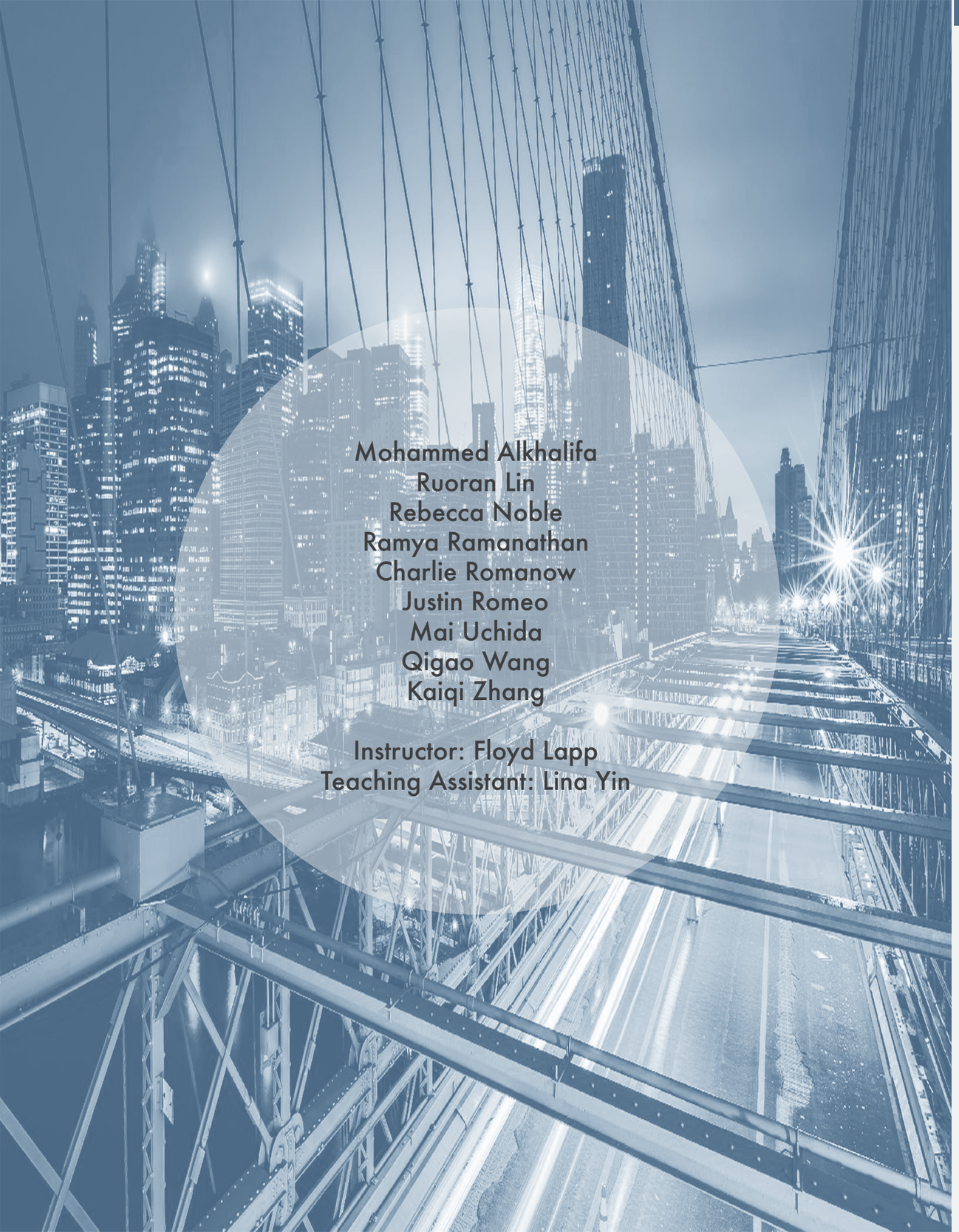
Responding to Climate Change at LaGuardia & Teterboro Airports and Improving Ground Access to JFK

Airport Improvement Studio
Client: Regional Plan Association
Columbia GSAPP | May 2017



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Executive Summary

The New York City metropolitan area's airports are vital to the transportation and economy of the region. The future operations of some of these airports are vulnerable due to unsustainable planning decisions of the past. Two of the main challenges our airports face are risks associated with the effects of climate change and limited ground connections between the central business district and the airports. These issues will continue to worsen as climate change progresses and traffic congestion increases due to population growth and greater tourist demand. While some visionary proposals for resolving these challenges have been put forth, there have been few if any practicable actions taken toward improving the main resiliency and connectivity challenges the airports face.

This report summarizes realistic strategies to adapt to the dynamic transportation landscape of a 21st century city. We propose context-appropriate solutions for climate change adaptation at LaGuardia and Teterboro Airports and innovative ground access improvements for John F. Kennedy Airport. We have consulted with professionals from relevant agencies such as the Port Authority of New York and New Jersey and the New York City Department of Transportation and drawn on the research of a number of primary and secondary sources to inform our decision making.

Ultimately, the goal of this report is to summarize key actionable changes that should be adopted to enhance the overall functionality of our airports and transportation network.

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Introduction

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1.1 Client

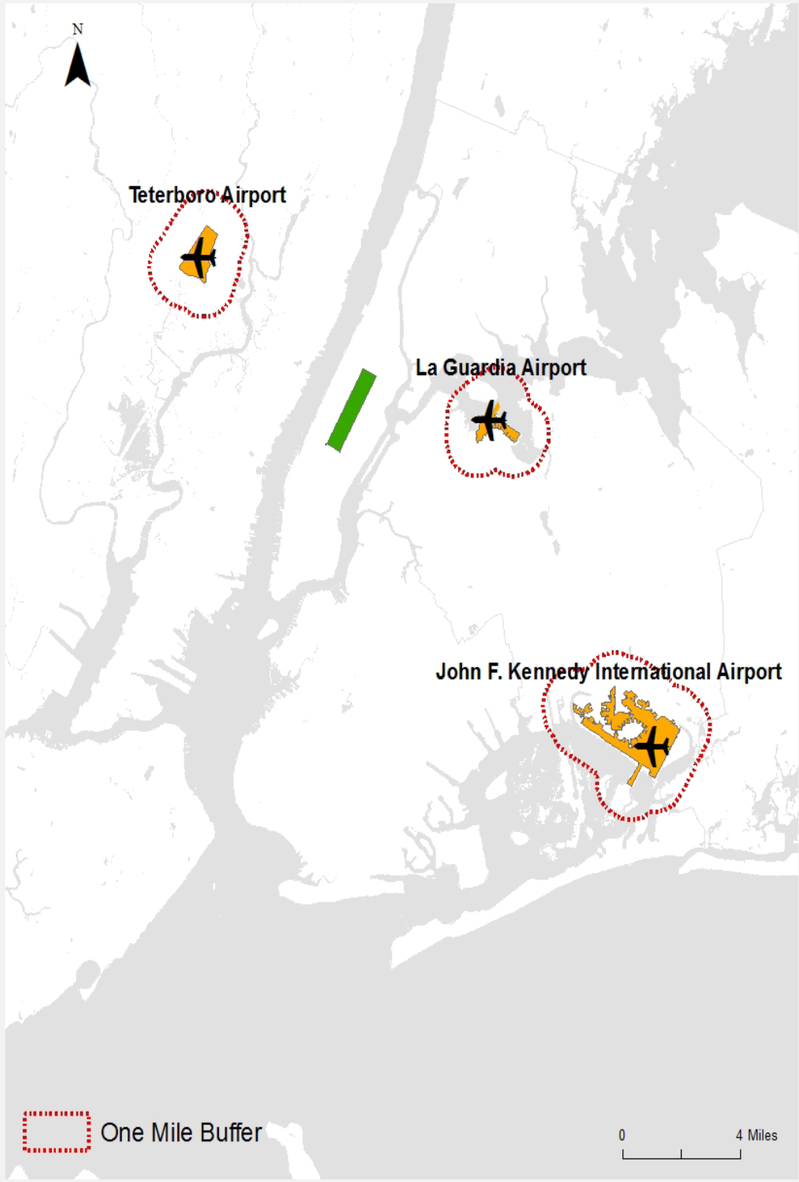
The Regional Plan Association (RPA) is a non-profit research and advocacy organization that has held a prominent presence in the New York metropolitan area since 1922.

The organization publishes reports regarding urban planning issues throughout its 31 counties in New York, New Jersey and Connecticut. The most widely regarded work undertaken by the RPA are its regional plans, each of which are long range guides to the growth of the metropolitan area.

Three influential regional plans have been published since the organization's founding and work is currently underway to release a fourth regional plan in 2017. The purpose of our report is to communicate research that can supplement the creation of RPA's Fourth Regional Plan..

1.2 General Purpose of Studio

Our studio was tasked with investigating how climate change will affect Teterboro and LaGuardia Airports, how to improve ground access at John F. Kennedy International Airport, and how JFK can cater to the needs of future autonomous vehicle users.



Map of Three Airports of Our Interest

1.3 Who Governs?

Port Authority of New York and New Jersey

The Port Authority of New York and New Jersey (PA, PANYNJ) is operated by New York and New Jersey and was initially made responsible for operating and facilitating trade through the Port. Their services have expanded to include real estate and transportation matters.

The Port Authority operates:

•Port Newark-Elizabeth Marine Terminal which is the largest on the East Coast

•All three New York City crossings of the Hudson River; Holland Tunnel, Lincoln Tunnel and George Washington Bridge

•All three crossings between New Jersey and Staten Island
Port Authority and George Washington Bridge Bus Terminals
PATH Trains between New Jersey and Manhattan

•John F. Kennedy International Airport (JFK), LaGuardia Airport (LGA), Newark Liberty International Airport (EWR),

•Teterboro Airport (TEB), Stewart International Airport (SWF) and Atlantic City International Airport (ACY)

Though the PA operates both airports within New York City, the land is leased to them by the City of New York. The current lease is valid until 2050.

Metropolitan Transportation Authority

The Metropolitan Transportation Authority (MTA) is an agency of the State of New York and is responsible for commuter rail in New York City and its suburbs and subway and bus public transit within the five boroughs.

Under the MTA, the subways and buses are operated by New York City Transit (NYCT) while commuter rail functions are through the Long Island Rail Road (LIRR) in Brooklyn, Queens and Long Island and Metro-North Railroad (MNR) in the Bronx, Connecticut and New York's northern suburbs.

New York State Department of Transportation

In New York City, the New York State Department of Transportation (NYSDOT) is responsible for numerous major highways.

New York City Department of Transportation

The New York City Department of Transportation (NYCDOT) is responsible for the City's streets and sidewalks among other infrastructure. The City does not operate any public transportation, but is responsible for the maintenance of streets on which public transit operates.

1.4 Land Use

We were tasked by the RPA to investigate environmental conditions at Teterboro and LaGuardia Airports and ground access at JFK Airport.

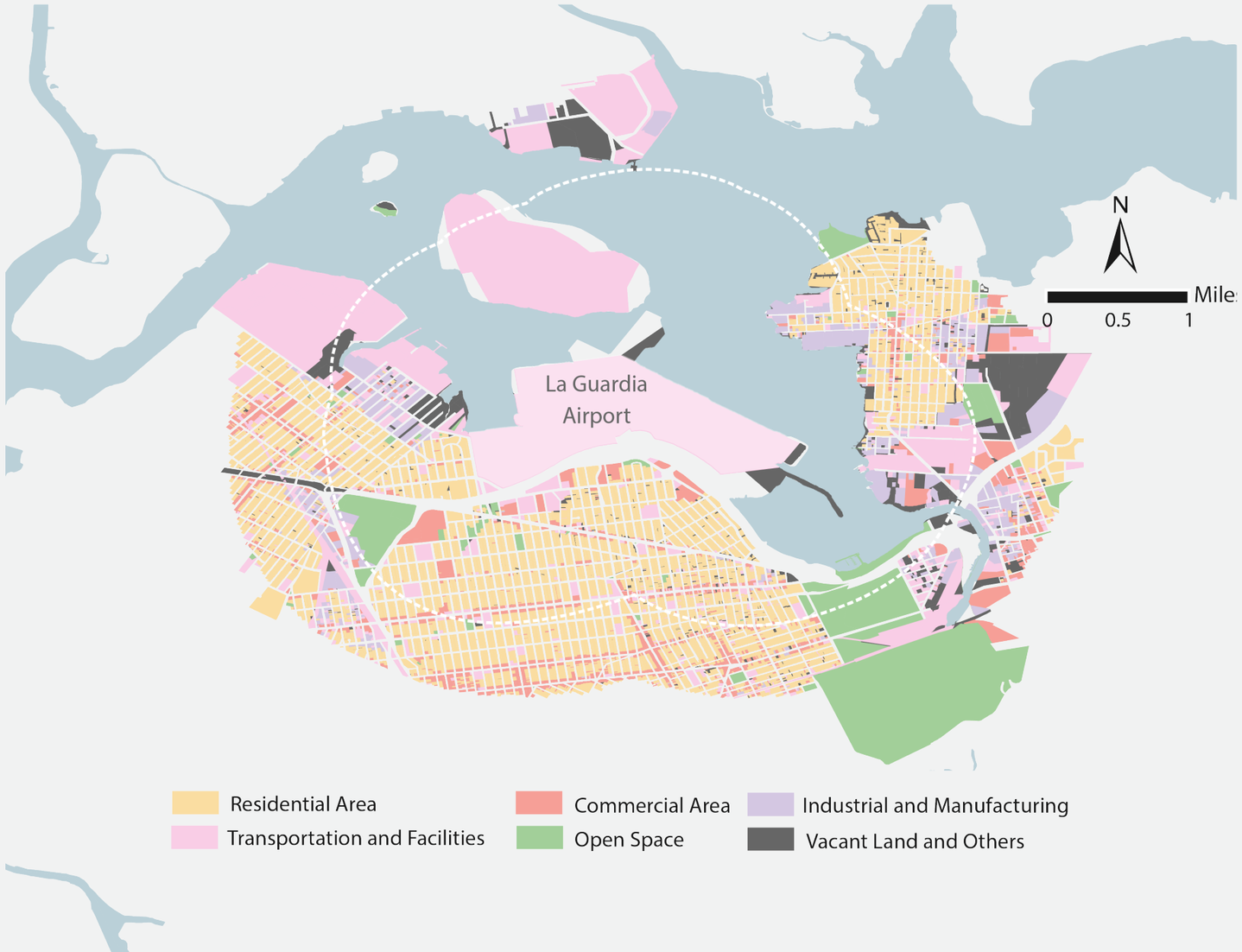
The areas surrounding these airports comprise high densities of low-rise residential and industrial uses. This lack of open space makes it difficult to construct infrastructure to improve environmental conditions or ground access.

JFK

JFK Airport is bordered to the south and east by Jamaica Bay and to the west and north by residential neighborhoods.

A small enclave of industrial and manufacturing uses border a portion of the north and a public wildlife sanctuary borders the northeast.

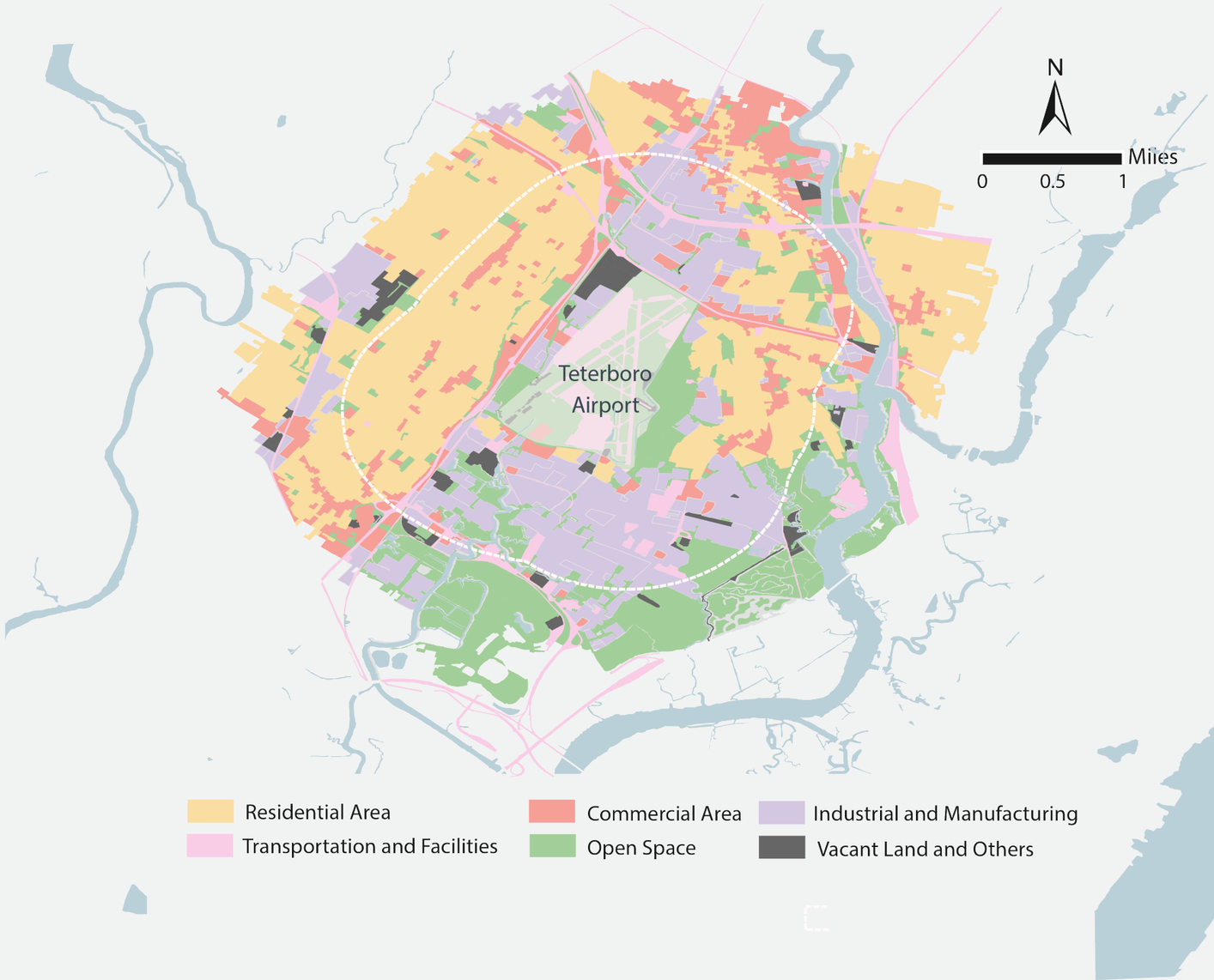
The surrounding residential areas increase in density as one moves further from the airport. The predominant categories of land use surrounding JFK are residential areas and open space.



LGA

LGA is bordered by the East River and Flushing Bay to the west, north and east. As shown in the map, to the south is a low-rise residential neighborhood. An industrial community exists to the west as well.

The predominant categories of land use surrounding LGA are residential, industrial and manufacturing, and transportation and facilities.



TEB

Teterboro Airport is located in the towns of Teterboro and Moonachie, New Jersey. The airport is bordered by residential neighborhoods to the west and east and large industrial communities to the north and south.

The predominant categories of land use surrounding TEB are residential areas, industrial and manufacturing areas, and open space including forest and agricultural areas.

Chapter 2:
Environmental Section

2.1 Goals for Addressing Climate Change at LGA and TEB

Our studio explored options for increased climate change resiliency at LGA and TEB. Using historical and predictive climatological data, we evaluated the risks that climate change poses for these airports.

The effects of storm surges and sea level rise on these airports' runways and facilities were considered in context of each airport's different operational function and capacity in order to make recommendations for the near- and long-term planning for each airport.

2.2 Climate Change in Coastal Areas

In the 20th Century, sea level rose one foot (RPA 2016). Scientists now claim that human activities have greatly escalated the process of climate change. Even if humans immediately ceased producing greenhouse gas emissions, climate change is expected to continue. Coastal areas are particularly vulnerable to the effects of climate change.

Some of the expected and indeed already apparent climate changes include more extreme temperatures, sea level rise, increased precipitation and flooding events, and increased storm intensity and frequency.

Scientists struggle to predict exactly when these changes will take place, and the uncertainty about the timelines of these estimates makes infrastructure planning more complex.

2.3 Importance of Climate Change Projections

Climate change projections are the foundation of climate change adaptation planning and preparedness. Uncertainty among climate change experts about the rate of temperature increase and the amount of arctic ice melt account for some of the range of discrepancies in climate change estimates. Therefore, while these climate change projections are crucial to long-range planning endeavors, they should primarily serve as guides.

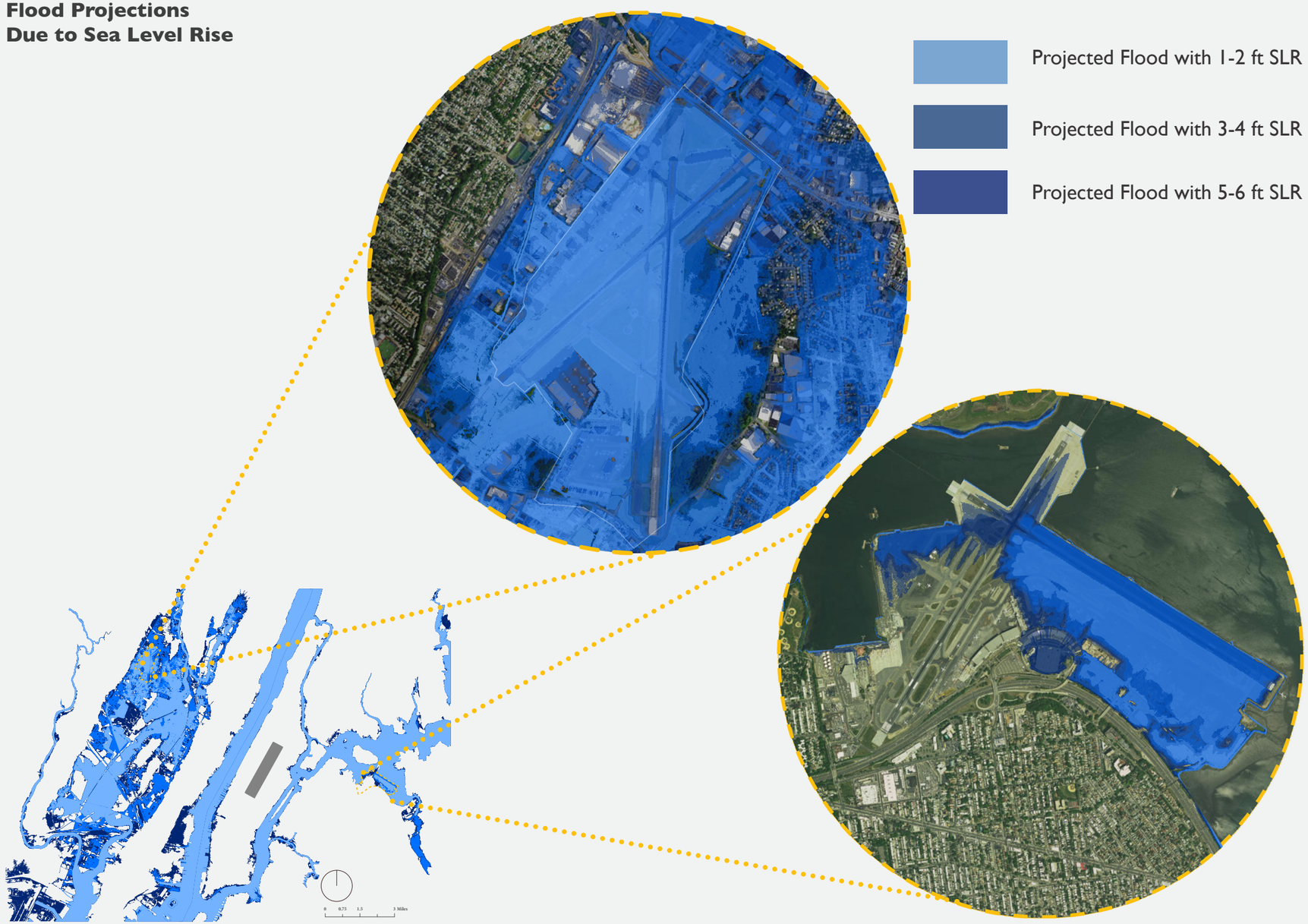
Monitoring climate change as it progresses and incorporating new findings and projections as they become available is crucial to improving the planning process and outcomes.

The RPA's own climate change projections (from their report, "Under Water: How Sea Level Rise Threatens the Tri-state Region,") are based on a 10-square-meter resolution, which has led some local planning professionals to doubt these maps' suitability for conducting facility-inundation analysis (RPA 2016).

We advise that the RPA redo their analysis with a finer grain resolution (preferably 1-square-meter or finer) to strengthen the accuracy and increase the persuasiveness of these visual and analytical tools.

		2020s		2050s		2080s	
	Baseline	Mid-range Estimate	High Estimate	Mid-range Estimate	High Estimate	Mid-range Estimate	High Estimate
Precipitation	50.1" (1971-2000)	+1 - 8%	+11%	+4 - 11%	+13%	+5 - 13%	+19%
Sea Level Rise	2000-2004	+4"- 8"	+10"	+11"- 21"	+30"	+18"- 39"	+58"

Flood Projections Due to Sea Level Rise



2.4 Adaptation Challenges in NYC Region

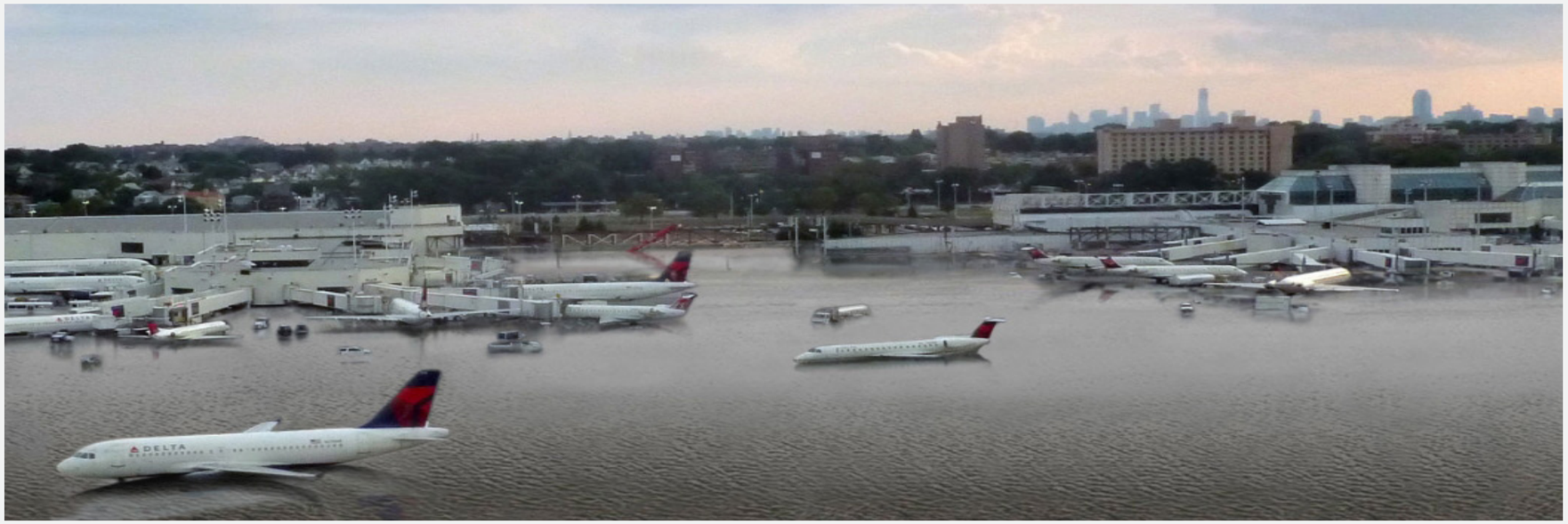


Image 1: What LaGuardia Airport could look like at high tide with 5 feet of sea level rise, an amount that could occur by 2100, according to some estimates

In addition to the general uncertainty about the swiftness with which climate change projections will materialize, New York City faces other adaptation challenges.

Like some similar coastal areas, the New York metropolitan region's situation is complicated by the fact that the land mass is also sinking, so the net influence of sea level rise is potentially much greater here than the figures indicate (DeMatto 2012).

There are also critical size and cost restraints to adaptation. While this is true no matter where planning projects are implemented, the effects of these restraints can be remarkably confining in an area as densely built up as New York City.

The size constraints of LaGuardia limit the feasibility of some adaptation strategies. While Teterboro Airport has much more land area available, alleviating its flooding risk by altering its current topography would be prohibitively expensive.

Political and developmental pressures also factor into the future of the airports. Waterfront development cannot be entirely banned in New York City due to political and private commercial interests in developing those sites. Nor can low-lying areas, like the Hackensack Meadowlands surrounding Teterboro be completely evacuated in anticipation of future flooding.

Abandoning LaGuardia's site is infeasible, especially given its recent infusion of airport improvement funds. Together these factors all influence the viability of adaptation strategies to cope with climate change at our region's airports.

2.5 Responding to Climate Change

Image 2: LGA airport post Hurricane Sandy

Climate Change at LaGuardia Airport

Both Teterboro and LaGuardia Airports are at great risk of flooding. Some portions of LaGuardia will be affected by one foot of sea level rise and more than half of LaGuardia Airport could be permanently underwater with just three feet of sea level rise (RPA 2016).

Storm surges are also a cause for concern at LaGuardia Airport, since storms' impacts will increase in severity with any amount of sea level rise.

Image 3: Flooding closed Teterboro airport for 36 hours after Hurricane Sandy

Climate Change at Teterboro Airport

With just one to two feet of sea level rise Teterboro could be permanently flooded (RPA 2016).

The Hackensack Meadowlands is also vulnerable to sea level rise. Attempting to elevate the airport or improve its perimeter protection could increase the vulnerability of the surrounding area. Prohibiting water from entering the airport's premises would cause that water to flow into nearby homes and surroundings.

Even if these protective measures are not taken at the airport, the Meadowlands area will still be incredibly vulnerable to flooding because of its low elevation and lack of natural barriers.

2.6 Port Authority's Sea Level Rise Design Response

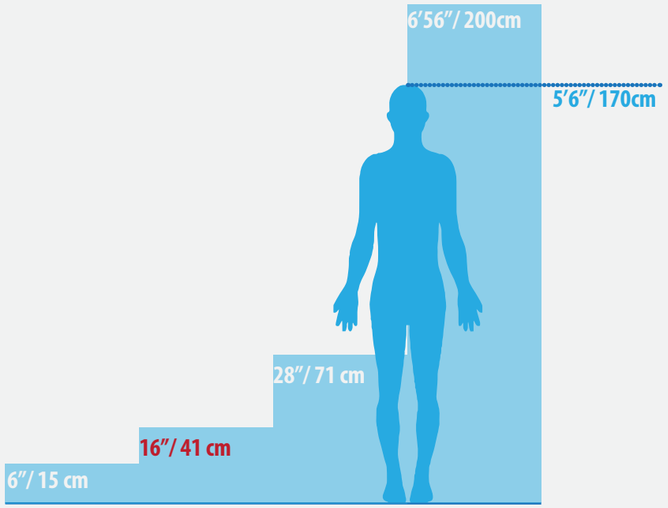
The PANYNJ which operates both Teterboro and LaGuardia Airports, uses a sea level rise estimate of 16" in their current designs, meaning that all critical infrastructure such as electrical equipment is elevated to this height in order to protect PANYNJ's existing assets (PANYNJ 2015).

PANYNJ considers this a conservative estimate, meaning that they believe their current designs allow for a certain amount of continued climate change.

The current elevation of critical infrastructure, at a height of only 16", however, protects these assets only until 2055, by the Port Authority's own predictions.

If sea level rise increases more swiftly than this predicted rate these assets may need additional protection sooner than expected.

Image 4: An artist's conception of what New York City would look like if underwater



	2004	2025	2055	2085
Mean Sea Level Rise	Baseline	+6"	+16"	+28"

2.7 Current Protections at LaGuardia Airport

LaGuardia Airport currently has a perimeter berm that protects the runways from minor water infiltration. Existing rainwater pumps can extract 4,000 gallons of water per minute at full capacity, according to an engineer from the Port Authority.

Although Governor Cuomo proposed the recent extensive redevelopment of LaGuardia in order to make it a world-class airport, there has been very little focus on the impacts and consequences of sea level rise or storm surges. The ongoing renovations at LaGuardia Airport include $30 million in federal funding to construct new floodwalls and improve drainage systems like rainwater pumps; strategies which are approved by the PANYNJ, but will do very little to protect LaGuardia beyond the near-term (New York State 2015).

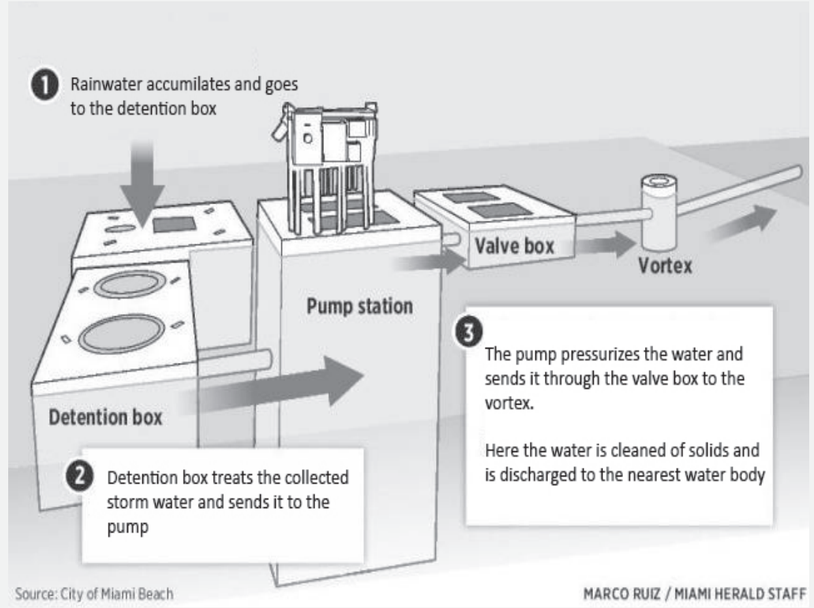


Image 5: **Mechanism of Rainwater Pumps**

Rainwater pumps can help in the immediate removal of (often toxic-filled) rainwater from airports. The collected water is ultimately released into the nearest water body.

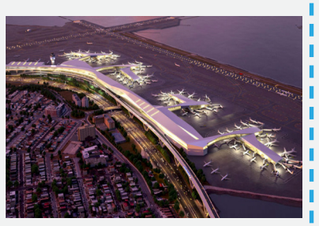
This is a common strategy for floodwater removal and can be used in conjunction with other devices and strategies to protect assets during water-related weather events.

Existing Permiter Berm Wall

New floodwalls and rainwater pumps

Gravity Drainage System

Upgrates to Electrical Systems and Generators



Elevating Critical Infrastructure

Image 6
Image 7
Image 8
Image 9
Image 10

2.8 Current Protections at Teterboro Airport

The only way for water to leave Teterboro Airport is for it to be pumped out (Gazette Newspaper 2008). The Industrial Avenue stormwater pump station conveys water from the airport to Berry's Creek (NJ DEP 2014).

During heavy rains, floodwaters from Teterboro are pumped downstream. This runoff, polluted with sediments from the airport, creates soil contamination in adjacent areas.

Image 11: Aerial view of the Meadowlands and the Hackensack River

Image 12: Teterboro Airport, a 'reliever' airport in New York for smaller and slower aircraft was also flooded after Sandy

2.9 Potential Mitigation and Adaptation Strategies

Improve Greenhouse Gas Emissions Standards

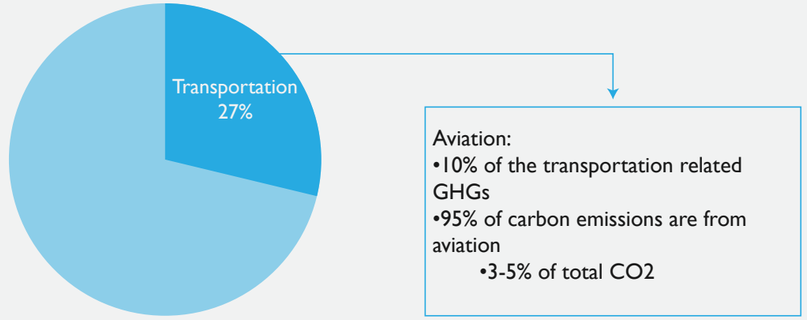
Improve Greenhouse Gas Emissions Standards
Mitigation and adaptation strategies need to be implemented simultaneously and immediately at our study airports. Mitigation strategies focus on sources of climate change by decreasing atmospheric greenhouse gases.

Adaptation strategies attempt to address the impacts of climate change through systematic adjustments to current or expected climatic shifts in order to minimize harm or harness benefits from those changes.

Worldwide reductions in greenhouse gas (GHG) emissions are absolutely necessary to minimize the harmful effects of climate change. Regional airports will be a vital part of reducing the New York City area's GHG emissions as a whole. The airports in this study do not currently have strict GHG emissions standards, but adopting and enforcing such standards are key components of any effective climate change management strategy.

Research shows that the transportation sector accounts for 27% of greenhouse gas emissions. Although airport takeoffs account for the majority of CO2 emissions in airport operation, which is hard to control, the agencies can still take some action to reduce energy consumption, especially from buildings(Monsalud et al 2016).

The potential implementation measures are: creating and/ or continuing to create greenhouse gases inventory, adopting efficient lighting systems, improving fuel efficiency, and adding building regulations.



GHGs Inventory

Efficient Lighting Systems
- •PV
- •LED

Fuel Efficiency
- •Electric vehicles
- •Compressed natural gas

Buildings
- •LEED certified buildings
- •Geothermal heating/ cooling systems
- •Green roofs

Rain Gardens and Green Stormwater Infrastructure

Green stormwater infrastructure is one possible strategy for mitigating flood risk at LGA. This type of infrastructure can mitigate not only flood risk, but also CO2 emissions. Rain gardens are just one example of green stormwater infrastructure. The strengths of the system are that they can be scaled up or down to suit the site or site section.

They are also sustainable because they do not require electricity or heavy maintenance. Rain gardens filter some toxins from the runoff water which improves water and soil quality. However, planting rain gardens may attract birds or other animals and lead to higher numbers of wildlife strikes (when a bird or other animal comes into contact with a plane).

If installed at our study sites, they would additionally require salt-resistant plantings since there is a high potential that they could be inundated with ocean water during a storm or flood. Finally, there are land use constraints that likely limit their suitability in large sections of the airport's site.

While there may be some opportunity to implement this strategy in some sections of the airports, clearly there are other areas where these would be unsuitable.

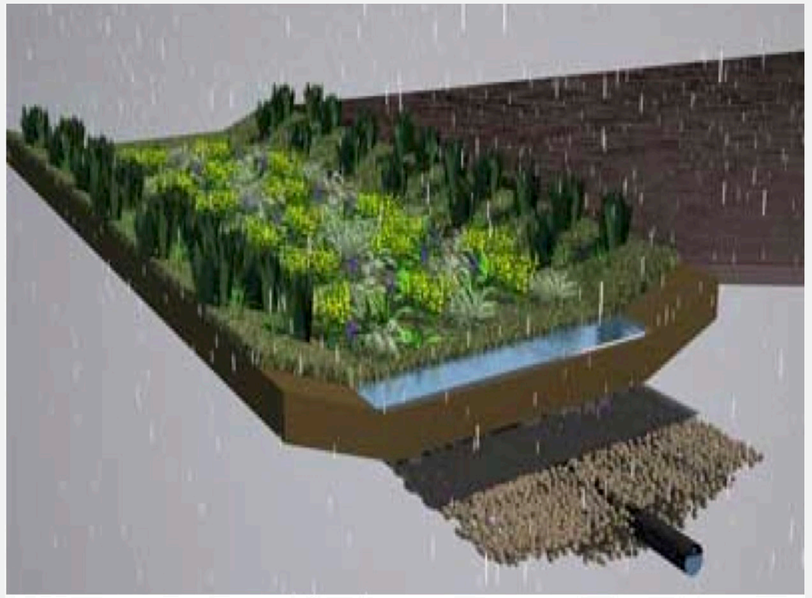


Image 13: **Boston Logan International Airport**

We selected Boston's Logan International Airport as a comparison with LGA. Both airports use some of the same flood management systems such as flood barriers, coastal management, and portable pumps, but Boston does not currently have the perimeter flood protection that LaGuardia does.

However, aggressive strategies to curb carbon emissions have been adopted at Logan that LGA does not currently use. A 2016 Massport study, for example, set a target to reduce GHG emissions 40% per passenger at Logan Airport by 2020 and 80% by 2050 (based on a 2002 baseline) (Massport 2016).

Massport attributes some of its success in GHG emission reduction to their energy efficiency improvements and greater use of renewable energy sources. We can use Logan as a guide for future regulations to reduce greenhouse gas emissions.

Image 14: Example of Rain Garden

Levees

Levees are a flood mitigation strategy often employed near wide river embankments to protect an area from flooding. They are used internationally, including places such as the Netherlands, Japan, and Singapore. Because levees are extremely expensive to construct, require careful engineering, and necessitate a large area for construction and permanent installation, they are considered a fairly extreme solution.

However, in areas that are at high risk of flooding and where flooding would prove irremediably devastating, they are sometimes a good option.

Image 15: **New Orleans**

After Hurricane Katrina, New Orleans created rainwater drainage parks to serve as quick and effective drainage outlets for large quantities of stormwater from a considerable area. This mechanism has been employed in 25 acres of land in New Orleans. Replicating a similar strategy over a portion of the undeveloped 330 acres at TEB and neighboring low-lying areas could be a partial solution to stormwater flooding.

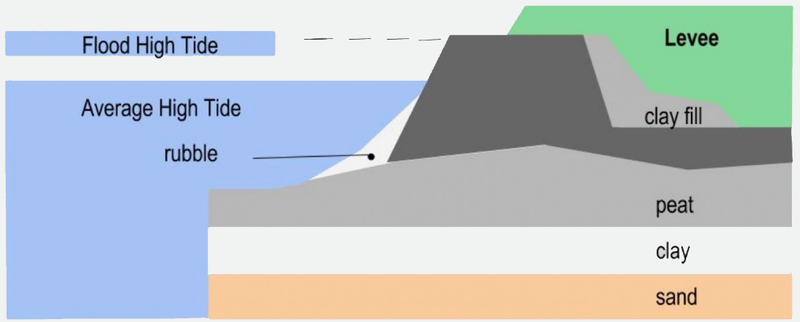


Image 16: Mechanism o f Levee

Integrated Flood Protection System

The existing perimeter berm at LGA needs bolstering. A flip-up flood barrier could be added to the perimeter system at LGA. The flip-up barrier would be manually deployed during an extreme weather event when flooding is anticipated to protect the airport until the storm passes.

This barrier can rise up to a defense height of 6.5 feet, and multiple lengths can be linked to create defenses of almost any width. Due to this height, flight operations would need to cease during deployment. In conjunction with existing pumps, which can extract up to 4,000 gallons of water per minute, this barrier could mitigate the storm's negative impact on the airport and ensure that operations return to normal as soon as possible following the rain event.

After the storm, the barrier would again be lowered, keeping it out of the Federal Aviation Administration's (FAA) object free zone, and normal airport operations would resume.

The problem with this strategy is that it only protects the airport against storm surges and does nothing to protect it during daily flooding at high tide or against long-term sea level rise.

A comprehensive long-term solution would require such substantial investment that foregoing the intermediate improvement of an integrated flood barrier system in order to devote more funding to a long-term solution makes the most sense, given the long-term predictions for sea level rise in the NYC metropolitan area.

Image 17: Flip-up flood barrier

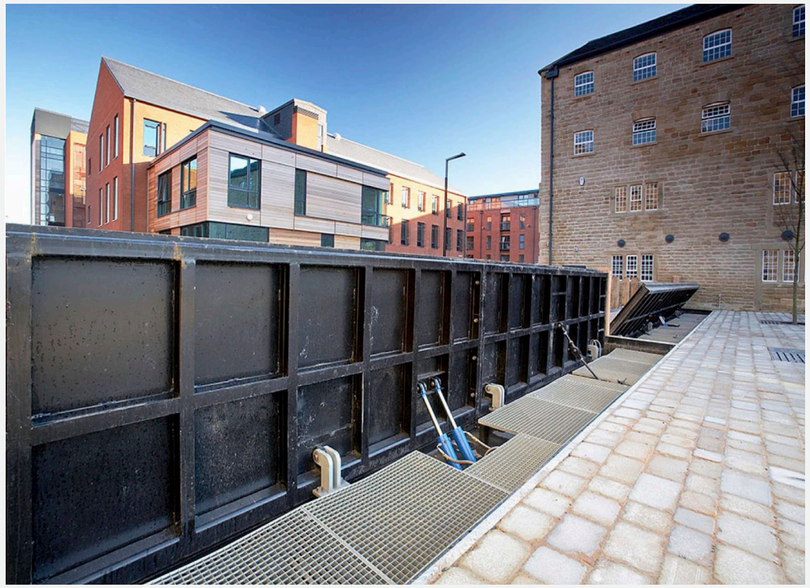


Image 18: **Oakland International Airport**

Oakland's airport has a perimeter berm similar to that at LaGuardia. Recently, Oakland increased the height of this barrier by one foot in anticipation of sea level rise.

Protecting our airports for continued sea level rise requires that we acknowledge these changes and act in the face of our knowledge. Oakland is an example of a city that is proactively addressing the certainty of sea level rise and LGA should do the same, even if the form that our protection takes differs.

2.10 Rikers Island

A report from the Independent Commission on New York City Criminal Justice and Incarceration Reform proposed to shut down New York City's campus of prisons on Rikers Island (Corasaniti 2017).

The Island offers an unusual opportunity in a dense, highly-populated City: more than 400 acres to redevelop. According to the report, Rikers Island is uniquely positioned to accommodate an expanded LaGuardia Airport that would reduce delays and could serve as many as 12 million more passengers annually.

Some believe that the island's position adjacent to LaGuardia presents a rare opportunity to improve operations at one of the nation's most physically challenged airports and to meet the region's need for additional flight capacity (Mutzabaugh 2017).

Incorporating Rikers into LaGuardia could expand flight capacity by 40%. Despite the potential benefits of expansion, after speaking to a representative of the Port Authority, we believe that an expansion of an LGA runway onto Rikers Island is untenable. The island's extant ground pollution would require extensive rehabilitation and the expansion of the runway and thus the flight patterns would infringe upon EWR's airspace.

Given these feasibility constraints, we do not recommend the expansion of the runway onto the Island. If the Island is to be used for airport activities, suitable uses would be limited to the creation of additional hangars or storage space.

Image 19: Aerial View of Rikers Island with LaGuardia Airport in the Foreground

Image 20: Riker's Island

2.11 Short-, Mid-, and Long-term Planning Options for LaGuardia and Teterboro

	Near-Term	Mid-Term	Long-Term
TEB	Mitigation Strategies for GHGs Reduction	Plan for Operational Relocation	Relocate Operations
LGA	Mitigation Strategies for GHGs Reduction	Implement Flood Barrier System	Implement Levee(s)
	Green Stormwater Infrastructure	Explore Site Expansion	Possible Site Expansion

In the short-term, we recommend that both airports implement strategies to minimize greenhouse gas emissions and increase green stormwater infrastructure.

In the short- and mid-term, storm surges are the primary concern at LaGuardia Airport. Deployable flood barriers, such as the integrated flood barrier system, should be installed to protect the airport during extreme weather events. In the long-term, when sea level rise is so great that the facility would be permanently flooded if left unprotected during high tides, the integrated flood barrier system would need to be deployed regularly or constantly to prevent inundation of the airport's runways and buildings.

However, since the barrier would occupy the FAA's object-free-zone, this means that flight operations would be severely limited if not completely halted. In order to protect the airport and retain its functionality, therefore, more aggressive long-term solutions, such as the creation of levee or berms, are necessary. These interventions are incredibly costly, but will be vital to protect the airport's utility and its important role in the in the regional economy into the future.

Without substantial interventions, Teterboro will have to relocate its operations or transition its flights to other airports. Passengers who currently use Teterboro could either take flights from other area airports or, depending on their destinations, take alternate forms of transportation such as commuter rail, Amtrak, intercity bus or personal vehicles. A number of small reliever airports operate in the New York metropolitan area. Essex County, Linden and Morristown Airports are in New Jersey, Brookhaven and Republic Airports are on Long Island and Danbury and Sikorsky are in Connecticut. Though not as close to Manhattan's central business district, these airports could cumulatively absorb some or most of the corporate flights that Teterboro currently offers.

If Teterboro is to remain operational, it will have to implement a levee or berm system to prevent flooding from interfering with operations and protect the surrounding areas, especially those that provide access to the airport.

Chapter 3:
Ground Access Section

3.1 Goals for Improving Ground Access at JFK

Our studio was tasked by the RPA to improve ground access by providing a one-seat ride to John F. Kennedy International Airport (JFK) with specific attention given to the business community of New York City in Midtown Manhattan.

The Partnership for New York City determined that 71% of business travelers would use public mass transit if a direct Manhattan rail link to New York airports existed (PFNYC 2016).

3.2 What We Are Looking For

We set out to formulate ideas for transportation options that would provide a one-seat ride from the central business district to JFK Airport.

We considered both public and private transit options, but all possibilities that would improve the efficiency of the greater transportation system were considerd.

From the onset we took a multi-modal approach to insure that we covered all of our bases and did not neglect any opportunities.

Our multi-modal approach demonstrates not only that we considered a variety of modes, but that we believe it is best to implement multiple modes simultaneously in order to maximize options for users and create valuable redundancies in the transportation network.

3.3 Geographic Context

JFK Airport is located in southeastern Queens, approximately 12 miles from Midtown Manhattan. Though this distance may seem to be small, the areas between the airport and Manhattan are highly developed which creates challenges for transit service.

Due to the evolution of New York City's transportation infrastructure, there is no direct highway or rail route from Midtown or Lower Manhattan to JFK. Attempts have been made to improve ground access to JFK although only less than one fifth of JFK travelers utilize public transit to reach the region's busiest airport (PANYNJ 2016).

Image 21: Plane landing at JFK Airport

3.4 Current Airport Conditions

The history of JFK Airport coincides with the broader histories of New York City, air travel and ground access. What began as the relatively small Idlewild Airport in 1948 has become one of the busiest airports in the nation.

As the city and region have grown, the Airport has had to grow as well. Air travel trends have increased beyond expectations nationwide.

The number of passengers utilizing JFK Airport grew by 38% from 2000 to 2014, with 7% growth between 2014 to 2015 (Port Authority 2017). This increased usage poses a burden on the airport's New York City airports are infamous for delays.

The Partnership for New York City found that 52% of business travelers avoided flying to the New York region at least once during 2015 due to expected flight delays and 29% avoided the area's airports altogether due to to delays (PFNYC 2016).

One third of business travelers had to miss, reschedule or cancel a meeting in the region due to a delay. In 2017 Governor Andrew Cuomo proposed ten billion dollars in renovations to improve infrastructure on the Airport grounds related to circulation, security and amenities (McGeehan 2017).

The New York State Department of Transportation plans on widening the VWE from three to four lanes and adding a managed lane for high occupancy vehicles (New York State 2017).

The Port Authority has dedicated funding into the capital budget to investigate lengthening the AirTrain from two to four vehicles (Port Authority, 2017). There are no proposals in the works to provide new ground access opportunities to the airport though.

Rising incomes and strong national economy

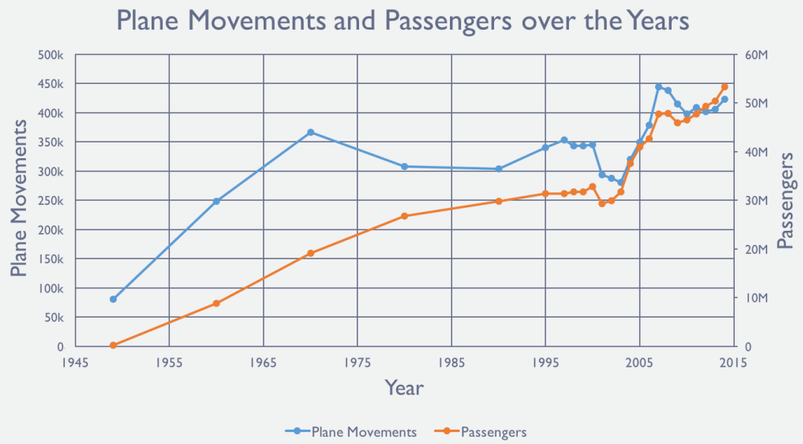
Slow increase of air fares due partly to deregulation of the

Improvements in technology to allow for planes to travel

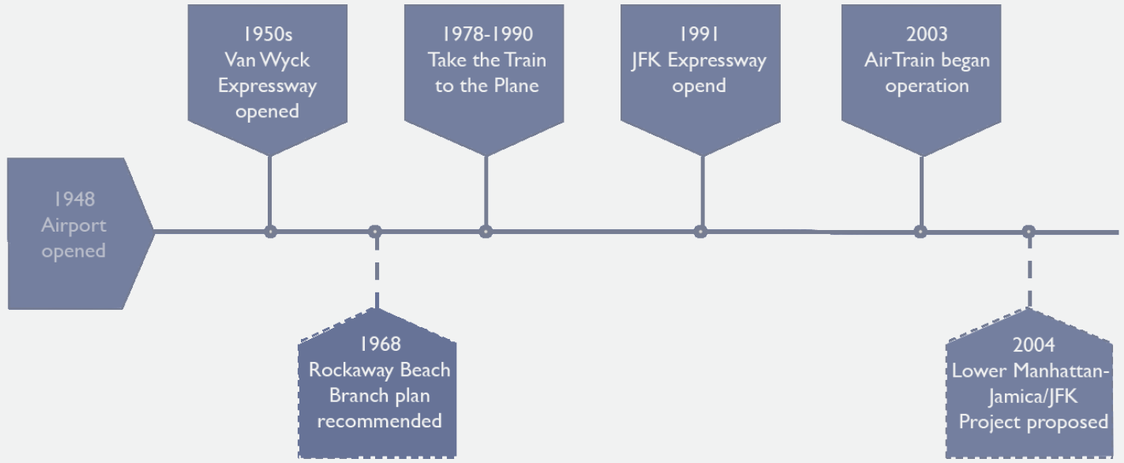
Growing immigrant population who retain ties to family and

Development of more comfortable planes

Globalization of the world's economy



3.5 History



Though located only 12 miles from Midtown Manhattan, it is not easy to travel to/from Midtown and JFK Airport. Development of residential communities quickly spread beyond the central business districts, making it very difficult to construct transit infrastructure between the two points. Ground access to JFK Airport was an afterthought as neighborhoods expanded outward and it was assumed that people would travel to and from JFK by automobile.

As of 2015 82% of JFK passengers reach the airport by motor vehicle, placing an enormous burden on the road network (Port Authority 2015). This dependency on inefficient modes of travel is the result of a nationwide love affair with the automobile and past failures at improving ground transit access.

The first piece of transportation designed specifically with the airport in mind was the Van Wyck Expressway (VWE) which runs from the Grand Central Parkway in Queens to JFK Airport.

The roadway was built in the 1950s and continues to provide the most direct access from the CBD of the City to JFK which results in congestion. The expressway is routinely named as one of the most congested highways in the country. Its location also provides a route from much of New York City to Long Island, contributing to further congestion. The VWE's construction occurred during the craze of roadbuilding that swept the nation in an effort to provide a feeling of independence through the automobile.

It was not until years later that planners realized that building roads exacerbates rather than eases congestion and that public transit is a more effective way of moving large numbers of people. The first effort at public transit to the airport occurred in the 1960s with the proposal to reactivate the Rockaway Beach Branch (RBB) tracks in Queens which had been used for commuter service years earlier. This plan was not implemented.

A further initiative for public transit occurred in 1978 with the "Take the Train to the Plane" program which consisted of a JFK Express subway train traveling to Howard Beach in Queens before passengers transferred to a bus that took them to the airport's terminals. This service operated between 1978 and 1990 when it was discontinued due to a budget deficit, high fares, cleaner less dangerous subways, and the lack of a one-seat ride, according to a former senior staff member of New York City Transit's Office of the President.

Image 22: JFK Airport showing original airport name "New York International Airport"

Image 23: Aerial view of Van Wyck Expressway in 1950

The Transportation Research Board publishes the Highway Capacity Manual to provide a standardized measure of traffic service. Grades range from A to F with A signifying "free flow" where "the average spacing between vehicles is about 550 ft or 27 car lengths. E signifies "unstable flow, operating at capacity" and F indicates "forced or breakdown flow." (Transportation Research Board, 2010)

Further action was taken in favor of the automobile in 1991 with the opening of the JFK Expressway which provided an additional highway from the airport to the Belt Parkway in order to improve circulation and reduce congestion on the VWE.

The Port Authority began construction of the JFK AirTrain in 1998 before opening in 2003. This fixed rail route continues to operate from Jamaica, Queens, where it connects to the E and J subway lines, the Long Island Rail Road and a number of bus routes and the Howard Beach A train station. The service is used by over seven million passengers per year and ridership has grown since the routes inception. Despite this relative success, the AirTrain requires passengers to transfer at one of its two termini before traveling to the Airport, not solving the issue of a one-seat ride.

Though the AirTrain provides a fixed right-of-way onto the airport grounds, it does not provide a one-seat ride and due to the need to transfer from another mode, many travelers instead opt for a taxi or for-hire vehicle to reach the airport. This attitude causes massive congestion on the highways approaching JFK. The VWE experiences an F level of service for most of the day and the Belt Parkway which travels around the borders of Brooklyn and Queens most often experiences an E level of service.

In 1999 the RPA proposed an extension of the Second Avenue Subway that would have provided service to JFK from Grand Central Terminal (GCT) to Atlantic Terminal in Brooklyn and to Jamaica before continuing along the AirTrain tracks (RPA 1999). The proposal was known as the Lower Manhattan-Jamaica/ JFK Transportation Project. The MTA and PANYNJ conducted a feasibility study in 2004 and determined that the construction of a new tunnel below the East River would be necessary for this project (RPA, 1999).

Governor Pataki supported the idea, but could not obtain the appropriate funding before leaving office. Subsequent governors have prioritized other transportation infrastructure projects over ground access to JFK.

Image 24: The Whitepot Underjump during the 1950s

The availability of a one-seat ride from a CBD to the airport is a standard provision in many cities across the country and world.

Many of the world's busiest airports such as Hartsfield-Jackson Atlanta International Airport, O'Hare International Airport (Chicago), Heathrow Airport (London), Pudong International Airport (Shanghai), and Logan International Airport (Boston) provide a one-seat ride through either subway or commuter rail from the CBD directly to the airport.

In this world of greater connectivity and competition, JFK needs to improve ground access in order to stay competitive.

Image 25: Express Airport Subway during the 1990s

Image 26: JFK Airtrain

3.6 Current Access to LGA and JFK

Map of current transit routes to JFK Airport

Current LGA Access

Similar to JFK Airport, LGA passenger traffic has increased steadily in recent years.

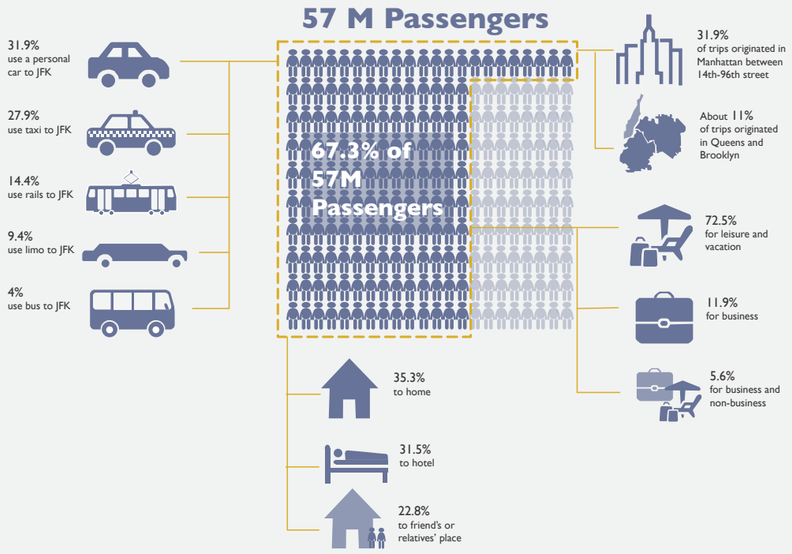
From 2002 to 2015 LGA experienced a 29% increase in passengers, 70% of which was in commuter traffic (Port Authority 2016). Of the 87% of LGA passengers that depart from the airport without connecting from a flight, 44% come to the airport from a hotel, 26% from home, 20% from staying with friends/relatives and 7% from work. Many of these trips (46%) originate in Manhattan between 14th and 96th Streets. An additional 12% are from Queens. 46% reach the airport by taxi, 16% were dropped off as a passenger, 10% by bus, 9% by limousine and 8% by the for-hire vehicle (FHV) services Uber and Lyft. Due to larger trends it is likely that the FHV share has increased since this time.

There are presently no rail connections to LGA although Governor Cuomo has proposed a $450 million LGA AirTrain that would operate from the Mets-Willets Point 7 Train and LIRR station in Queens to LGA (Walker 2017).

LGA is located along the north of Queens and has no dedicated rail service. The M60 SBS, Q47, Q48, Q70 SBS and Q72 buses connect to LGA terminals. Bus service headways vary based on route and day but range from every seven to thirty minutes. LGA Airport offers 5600 public parking spaces (Port Authority, 2016).

NYC Airporter offers a shuttle service between Grand Central Terminal, Penn Station and the Port Authority Bus Terminal in Midtown Manhattan and JFK Airport for $28 round trip or $15 one-way (NYC Airporter 2017). Service operates seven days per week between 6am and 11:30pm. Travel time for the entire route is approximately 60 minutes. This is the official LGA Airport bus service for PANYNJ and NYCDOT. Taxi service to LGA is conducted through the typical metered procedure (NYC Airporter 2017).

Image 27: Select Bus Service to



Current JFK Access

Of the nearly 57 million passengers that utilized JFK Airport in 2016, 67.3% were departing from the airport while the remainder were connecting from another flight (Port Authority 2016).

Of those departing from JFK 35.3% traveled to the airport from home, 31.5% from a hotel and 22.8% were staying with friends or relatives. 31.9% of departing passengers' trips originated in Midtown Manhattan between 14th and 96th Streets. Approximately 10% came from Queens and 5% from Brooklyn. 72.5% of JFK passengers were traveling for leisure or vacation, 11.9% for business and 5.6% for business and nonbusiness purposes. 17.5% of passengers traveling for at least partial business purposes amounts to nearly ten million passengers annually or 27,000 per day.

Despite 31.9% of passengers traveling from Midtown, only 2.6% of passengers' reported primary residence was there. 36.9% of passengers primary residence was in the United States outside of the New York Metropolitan Area and 36.8% primarily reside outside of the United States. The mean household income of travelers was $86,300; significantly higher than the $55,775 national average although this figure was even higher for LGA and EWR passengers than JFK. 31.2% of JFK passengers accessed the airport by personal car, most of whom were dropped off at the airport.

27.9% arrived by taxi, 14.4% by rail, 9.4% by limo and 4% by bus. 3.3% arrived by for-hire vehicle (FHV) services such as Uber and Lyft. Due to the increased popularity and availability of these services it is likely that the FHV share has increased since this time.

Being located in the far southeastern corner of New York City, JFK Airport has minimal public transit access. Its primary means of public transit is the AirTrain which is operated by the Port Authority and costs $5 per ride, compared to $2.75 for a subway ride.

There is no free transfer between the AirTrain and other modes. The B15, Q3 and Q10 local buses each have a stop on the airport grounds. Their frequency varies based on route and day but ranges from six to 20 minutes. The Jamaica AirTrain connects to 18 local Queens bus routes and the Long Island Rail Road. The Howard Beach AirTrain connects to one local bus route. JFK Airport offers more than 15,000 public parkings spaces on the airport's property (Port Authority 2016).

NYC Airporter offers a shuttle service between Grand Central Terminal, Penn Station and the Port Authority Bus Terminal in Midtown Manhattan and JFK Airport for $34 round trip or $18 one way (NYC Airporter 2017). Service operates seven days per week between 6am and 11:30pm. Travel time for the entire route is approximately 90 minutes. This service is the official JFK Airport bus operator for the PANYNJ and NYCDOT. Taxi service is also available that costs approximately $60 each way depending on tolls and whether or not the trip is made during rush hour.

Image 28: JFK Expressway

Image 29: Image of a private airport-to-city

PRESENT INFRASTRUCTURE

A major factor in determining which options to recommend is the cost of construction. Expected costs of infrastructure projects in New York regularly run far above anticipated. The City is densely populated and developed which makes new infrastructure incredibly costly and difficult to construct.

It is for this reason that we wanted to give greater emphasis to projects that would utilize existing infrastructure. To do this, we first had to analyze what infrastructure is present and what the limitations of each are. In regards to our work, existing infrastructure can be broken down into road access and rail access.

3.7 Current Road Access to JFK

Road access map

The history of JFK Airport and much of its surrounding infrastrucure is characterized by automobile travel. Despite this, there are a limited number of entries to the airport by road.

Both the Van Wyck and JFK Expressways enter the airport grounds; connecting to the Belt Parkway north of the airport. The Belt Parkway runs east to the Long Island border where it splits north as the Cross Island Parkway toward the Throgs Neck Bridge and east onto Long Island as the Southern State Parkway.

The VWE continues north through Queens to the Whitestone Bridge, intersecting with the west-east running Jackie Robinson Parkway, Long Island Expressway and Whitestone Expressway from south to north. The Belt Parkway continues southwest around Brooklyn, making for a long ride from the central business district, particularly considering congestion.

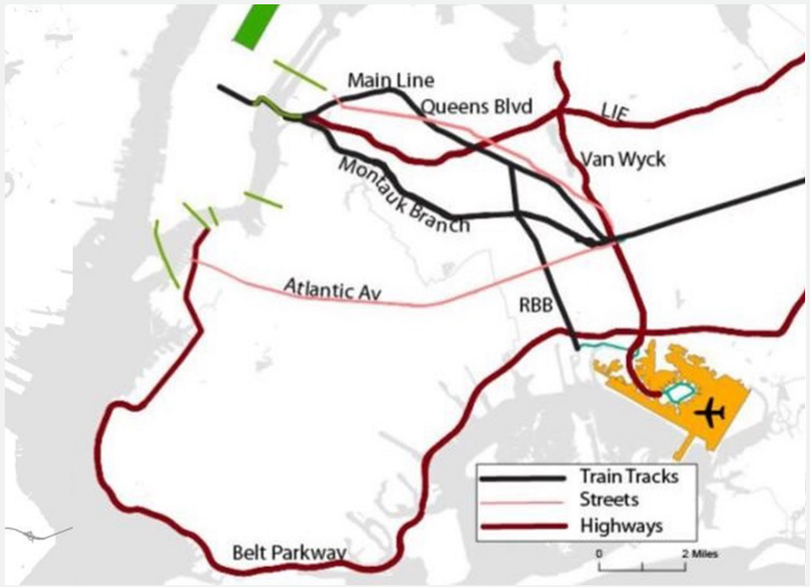
The Jackie Robinson Parkway continues west before becoming a surface road near Bushwick in Brooklyn. The Long Island Expressway continues west into Manhattan, intersecting the Brooklyn-Queens Expressway which continues south to Downtown Brooklyn and Lower Manhattan via the Williamsburg, Manhattan and Brooklyn Bridges.

The Whitestone Expressway becomes the Grand Central Parkway, granting access to LaGuardia Airport and continuing northwest onto the Triboro Bridge which connects Queens with the Bronx and Upper Manhattan.

Due to these conditions, the Long Island Expressway and the VWE are the primary means of accessing JFK Airport by road. Therefore, our proposals that utilize roads will be primarily directed toward the LIE and VWE.

Image 30: Van Wyck Expressway during heavy traffic

3.8 Current Rail Access to JFK



New York has a number of rail lines running through it. 23 subway routes operate frequent service and the Long Island Rail Road and Metro North Railroad provide service from New York's suburbs to Manhattan through the Bronx and Queens respectively.

Though much of the region's subway and commuter rail lines are at or near capacity, there still leaves some room for utilization of these rights-of-way for airport service. We specifically looked at at or above-grade tracks that would be easier to connect to other rails than subterranean tracks. New below grade tracks would be very expensive to construct and extend to the airport and would receive much greater public opposition than above-ground tracks.

The LIRR's Main Line runs west from Long Island to Jamaica where it connects to the AirTrain station and continues northwest before running underground after Woodside and terminating at Penn Station. The LIRR runs service along the Main Line in as frequent intervals as three minutes.

Perpendicular to the Main Line is the Rockaway Beach Branch which served commuter trains between 1880 and 1962 when service was terminated due to low ridership and increasing maintenance costs.

The right-of-way has been deactivated although most the tracks remain; some portions have been covered by pavement or become overgrown with shrubbery.

The southern portion of the branch caters to A Train subway service with trains running as frequently as every ten minutes.

Since 2011, residents of Queens have partnered with The Trust for Public Land to convert the disused stretch of the Rockaway Beach Branch into a linear park akin to the High Line to be known as the Queensway.

A number of city and state public officials have supported the Queensway, rather than a reactivation of the line (Friends of the Queensway 2017).

A representative of the Port Authority revealed that they had attempted to reactivate the Rockaway Beach Branch to be

Image 31: Long Island Railroad at Sutphin/JFK Airport Station

Image 32: MTA Subway at Howard Beach Station

used by the AirTrain, but did not gain any traction because of local opposition. Queens College conducted a study comparing the public support of reactivation vs. the Queensway. The results were inconclusive due to low statistical significance, but support was generally split between the two, with a notable portion of residents favoring leaving the line as is so as to avoid noise and increased visitors.

The public and political support for the Queensway is a consideration in any of our proposals that utilize reactivating the branch.

The Montauk Branch runs west from Jamaica to Long Island City. Passenger service operated over this span until 1998 when freight service took over. The tracks do not connect to the Main Line and due to the density of tracks and development in Long Island City it would be very expensive to improve connections.

33: Commuters at LIRR Sutphin/JFK Station

3.9 Funding Mechanisms

Airport and Airway Trust Fund (AATF)

82% of the Federal Aviation Administration's total funding comes from the Airport and Airway Revenue Act of 1970 (AATF).

AATF funding comes from aviation related excise taxes and collections related to passenger tickets, passenger flight segments, international arrivals/departures, cargo waybills, aviation fuels, and frequent flyer mile awards from non-airline sources like credit cards.

The AATF was established to help in the development of a nationwide airport and airway system as well as to fund investments in air traffic control facilities (University Transportation Center for Mobility 2007).

44.8% of the AATF budget goes toward operating expenses. 27.3% is allocated for the Airport Improvement Program which provides grants for airport construction and safety projects. 22.7% is directed toward facilities and equipment to fund technological improvements to air traffic control systems. 1.2% is used to research issues related to aviation safety, mobility and environment. We propose that a greater portion of funding be allocated toward environmental mitigation efforts.

Airport Improvement Program (AIP) eligible projects must enhance the airport's safety, capacity, or security, or address environmental concerns. AIP funds can be used for most airfield rehabilitation projects and capital improvements.

Examples of eligible projects include rehabilitation of a runway, taxi or apron, improvement of airport lighting, signage or drainage, land acquisition, construction or improvement of weather observation stations, planning or environmental studies and safety area improvements. According to the Federal Aviation Administration, airport developments can be funded with AIP monies, provided that "a current airport layout plan that depicts the proposed project and which has FAA approval from the standpoint of safety, utility and efficiency of the airport shall be required before a development project is approved" (Federal Aviation Administration 2013).

To pay for our proposed environmental improvements, the Port Authority can reallocate some of its Airport Improvement Program funds.

The United States Department of Transportation's Federal Transit Administration lays out a number of other funding mechanisms as well(U.S. Department of Transportation) :

Capital Leasing
A capital lease is when a vendor or financial institution leases a capital asset to a transit agency in lieu of selling it to them. All federal funding for capital investments can be used to lease rather than purchase transit equipment.

Revenue Bonds
Revenue Bonds are issued by state or local governments and repaid by the transit authority to whom the bonds were issued.

Grant Anticipation Notes
Grant anticipation notes (GANs) are a type of revenue bond. These are repaid by Federal Transit Administration funding. Over $3.2 billion GANs have been issued. Alaska Railroad and Chicago Transit Authority are examples of agencies that use GANs.

Debt Service Reserve (DSR)
These are provisions to allow transit agencies to be reimbursed for up to 80% of deposits in debt service reserves, which were established to finance transit capital projects.

Public Private Partnerships
There is potential for private investors to fund improvements in airports' infrastructure, but these public-private partnerships (P3) have yet to be utilized for climatological improvements to airports.

There has been a trend toward these investments in the construction of roads and bridges, but these models have not yet expanded to include the types of long-term sea level rise adaptations needed at LGA. P3's can be utilized to improve ground access by private entities helping to fund transportation improvements in exchange for advertising or a share of any revenues. Public transit rarely earns a profit though the influx of private capital would subsidize fares and lead to a more economically sustainable system.

Public-private partnerships are in common practice across the country, but can face difficulties in the divide between earning profit and providing for the public as publicly operated entities and projects have a clear and explicit mandate to serve the public that is less present in public private partnerships.

Transport Infrastructure Finance and Innovation Act (TIFIA)

These are administered by USDOT to provide loans and credits to fund transit projects.

State Infrastructure Banks

States administered-funding mechanism, which offers a wide variety of credit and loan options for transit infrastructure development.

Passenger Fare Charges (PFC)

Airports use Passenger Fare Charges (PFC) to fund FAA-approved projects that enhance safety, security, or capacity; reduce noise; or increase air carrier competition. The PFC Program allows for passengers to be charged $4.50 per leg of a trip, with a maximum of two charges for a one-way trip and a maximum of four for a round trip, for a total maximum charge of $18.

PFC funds can be used to pay for all or part of the allowable cost of an FAA approved project or to pay debt service and financing costs associated with bond issuance. PFC funds can also be combined with Federal Grant funds, such as AIP to complete an approved project. They can also be used to meet the non-federal share of the cost of projects funded under the Federal Airport Grant Program.

We suggest that a portion of this fixed charge should be be allocated for environmental mitigation improvements.

Combining AIP + PFC

PFC funds can be combined with Federal Grants, such as AIP funds, to complete approved projects. Whenever these funds are commingled, though, the Federal statutory and regulatory requirements of the AIP applies to all funds within the project. Also, if a PFC is imposed at an airport, the AIP funding amount that airport receives is reduced.

A major concern in regards to completing transportation infrastructure projects is funding. It is for this reason that we investigated how our proposals could be funded.

The most prominent transportation funding source nationwide is the Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grant Program through the United States Department of Transportation (USDOT). There is currently 500 million dollars available under this program through September 2019 (USDOT 2016).

Grants are available to local governments, transit agencies, port authorities, metropolitan planning organizations and other government subdivisions.

Funds are available for highway and bridge projects, public transportation, passenger and freight rail, port infrastructure and intermodal projects. The federal government also allocates two billion dollars annually to the

New Starts program which is for projects whose total cost exceeds 300 million dollars (US DOT, 2016). Applicable projects include those with a new fixed guideway, extension to an existing right-of-way or a fixed guide bus rapid transit project. The Small Starts program is for smaller projects that include those with a new fixed guideway, extension of existing right-of-way or a fixed or corridor-based bus rapid transit. The Core Capacity program is for projects located in a corridor that is at or over capacity within the next five years. The proposed project must increase the capacity by at least 10%.

President Trump has proposed eliminating the TIGER program and cutting USDOT expenditures by 13% in favor of promoting investment by the private sector (Tabuchi 2017).

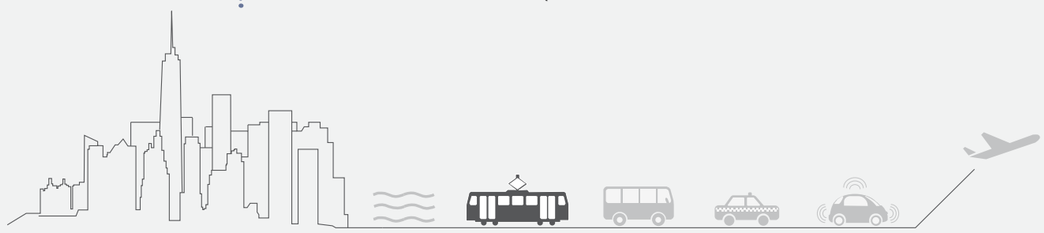
The two major players in public transit in the New York metropolitan area are the MTA and PANYNJ. We analyzed funding for these two organizations in order to understand how they receive their money and how our proposals may affect and be affected by their present financial situation.

The MTA receives funds from a number of sources. 29 billion dollars is dedicated to their 2015-2019 capital plan (MTA, 2016). 28% of this is from bonds and the State of New York respectively. 23% comes from federal sources and 9% from the City. 54% of capital funds are spent through New York City Transit which includes the City's subway and local bus network. 17% goes to network expansion, 10% to bridges and tunnels, and 9% and 8% to the Long Island Rail Road and Metro-North Railroad respectively. Three high cost long-term projects currently undertaken by the MTA are the Second Avenue Subway, East Side Access and the rehabilitation of the L Train.

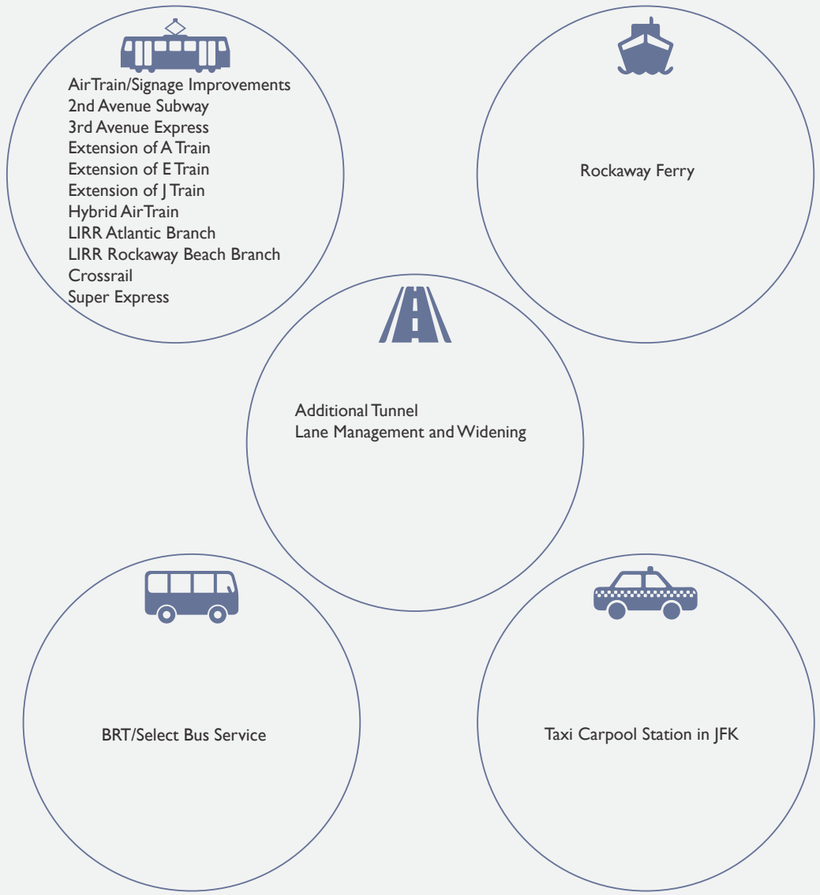
The Port Authority's funding mechanisms are significantly different from the MTA. It's funding is self sustaining as they must raise the necessary funds to operate its facilities and provide services to the public through tolls, fares, rentals and other user charges. Funds are raised on the basis of the Port Authority's credit rating.

Two major projects currently undertaken by the Port Authority are the planning and reconstruction of the Port Authority Bus Terminal which is allocated 3.5 billion dollars and the rehabilitation of the George Washington Bridge which costs 2 billion dollars (Port Authority 2017). The Port Authority's capital and operating budget for 2016 is 7.9 billion dollars. 71% of the Port Authority's budget comes from operating revenues.

An additional 12% is from bond issuances and 5% from grants. 49% of their income is from contributions in aid of construction, 28% from passenger facility charges and 11% from 4 World Trade Center associated payments. 37% of their operating revenues are the result of tolls and fares, 31% from rental fees, 22% from aviation and 7% from parking. Approximately 70% of rental and parking revenues comes from the Port Authority's airports.



3.10 Options



3.10.1 Criteria

In assessing different means and routes of improving ground access to JFK we wanted to have a structure of how to assess and differentiate each idea from one another. It is for this reason that we created a set of criteria to provide a basis for judging each option.

Passenger Fare
The cost for the passenger of the mode

Construction Cost
The infrastructure cost of constructing the project

Construction Time
The length of time required for the project to be implemented and service begun

Trip Time
The length of time for passengers to reach the Airport from the central business district

Political Feasibility
How realistic the project is based on the political actors required and the potential public controversy

Carrying Capacity
The amount of people that the project could transport considering any shared usage of right-of-way and maximum demand.

Equity
What population groups and communities does the proposal serve and not serve

Access to CBD
Whether the route provides a direct connection from Midtown or Lower Manhattan

Geographic Scope
What affect the project will have on commuters from outside of the CBD

Image 34: Planes taxiing on the tarmac at JFK Airport

We discussed and analyzed each of our options holistically, accounting for each piece of criteria. We believe that it is best to not tabulate exact figures for the criteria because there are so many factors that contribute to these points that it would be misleading to believe that we have a conclusive answer.

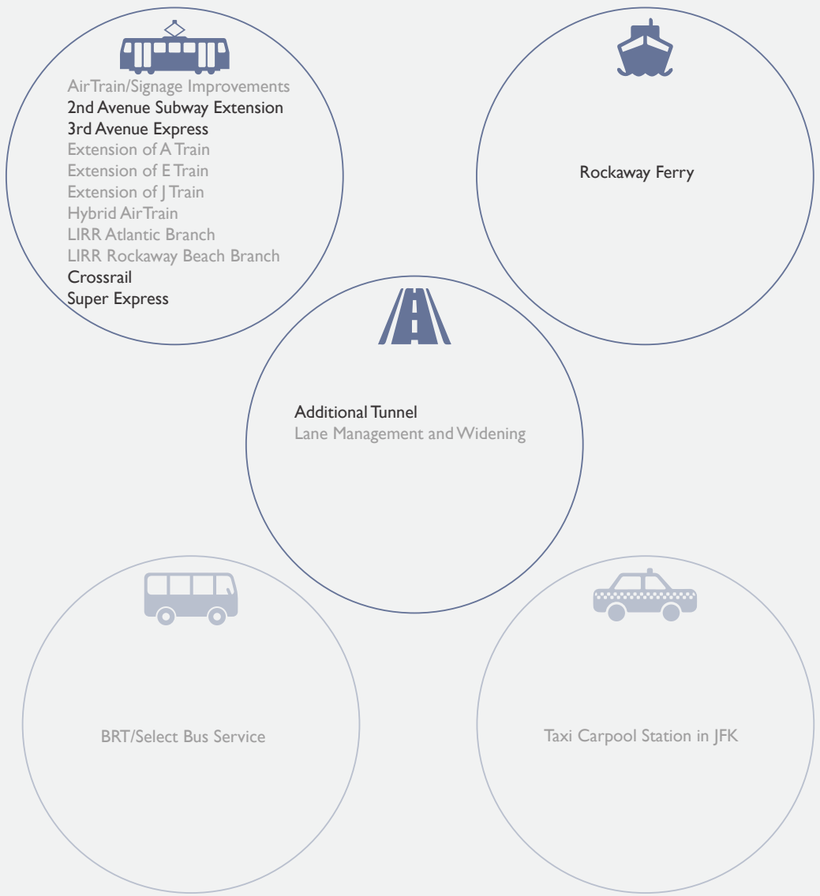
To better compare positives and drawbacks of options we separated projects into near and long-term in order to determine how the construction process' of each may overlap with one another. This is necessary in taking a multi-modal approach whose best outcome will include multiple infrastructure projects complementing one another.

Image 35: Historical aerial view of JFK Airport

Alongside descriptions of each ground access improvement option is a graphic illustrating how the option fits with each criterion. They have been ranked either low, mid or high. Due to the different uses of criterion, "high" does not always translate into a positive quality. For example, scoring high in political feasibility is positive for a project, but high in construction cost is not. It is for this reason that each graphic is color coded to better signify the positives and negatives of each option. Green bars communicate a positive trait while red corresponds to something that would challenge the project's attractiveness.

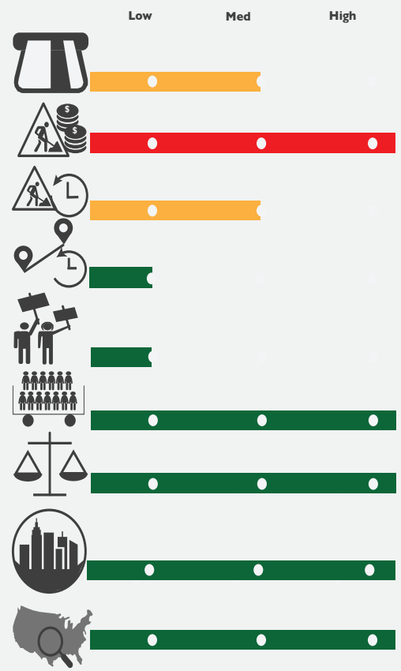
3.10.2 Eliminated Options

We scoured sources for past and contemporary proposed improvements to JFK ground access as well as formulating our own ideas. We will go into further detail into options that we believe are feasible, but will first delve into those which we eliminated from consideration due to their overwhelming negative constraints, particularly considering the availability of better options. We assessed each eliminated option holistically and did not go into as great of detail in relating each piece of criteria to them.



Crossrail

A University of Pennsylvania School of Design studio presented a proposal for a rail system that would connect the LIRR, MNR and New Jersey Transit through a system known as Crossrail (RPA 2017). The proposal also includes passenger train routes to connect all major transportation hubs; Penn Station, Grand Central Station, Newark-Liberty Airport, LaGuardia Airport and JFK Airport.



It would take advantage of the pending East Side Access and Amtrak Gateway Projects which will improve interoperability between agencies infrastructure. The idea was inspired by London's Crossrail project, later deemed the Elizabeth Line which includes 73 miles of new rail that will connect routes below the center of London.

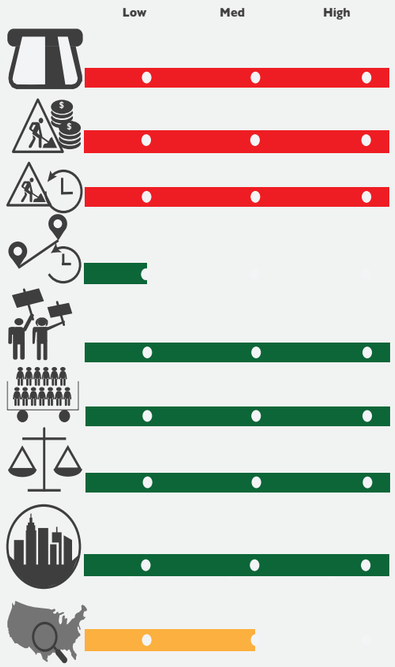
The passenger fare for this option would likely be high due to high construction costs. Our estimates are based on the need for new tunnels, bridges, and rail infrastructure. The construction time would also be long for these sames reasons. It would provide a highly accessible mode from Midtown and provide improved transit service. Though the trip would be fast and the mode's carrying capacity would be high, the project's feasibility is low because construction would be highly disruptive to communities and require numerous agencies' cooperation.

Super Express

The RPA proposed a "Super Express" train that would connect Midtown Manhattan with the Airport via a newly constructed tunnel in their January 2017 report "Creating a One-Seat Ride to JFK" (RPA 2017). The report was not clear as to where exactly the tunnel would be.

Though the Super Express would provide a fast, high-capacity mode, passenger fare is likely high due to high construction costs of new tunnels, bridges, and rail infrastructure. The Super Express could improve transit service for non-airport travelers as well.

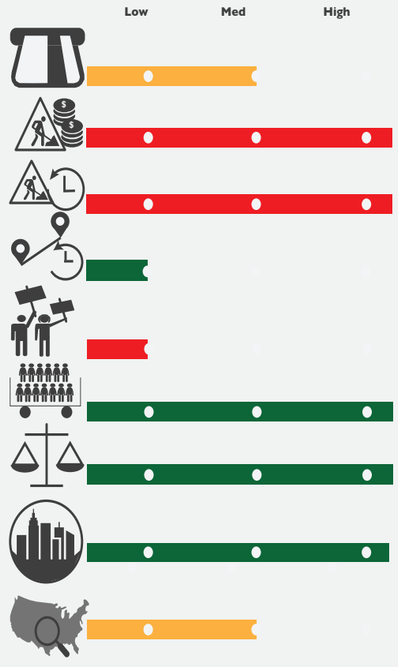
Ultimately, the Super Express is not feasible because of its extreme financial cost, lengthy construction time, lack of funding, its negative effect on local communities due to the need for property takings, and the difficulty of coordinating multiple agencies.



Third Avenue Express

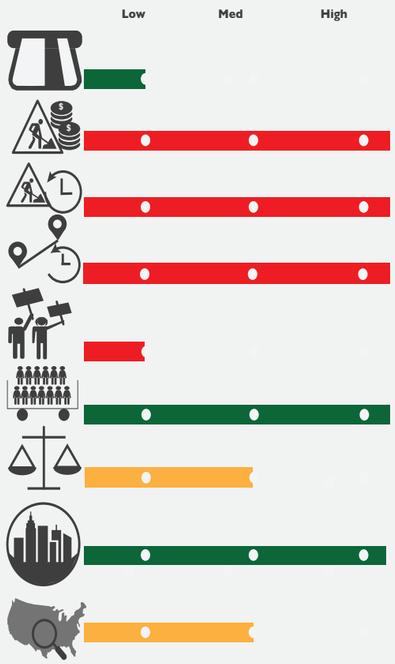
The same RPA report suggested a new Third Avenue Express service (RPA 2017). This would be a subterranean train that operated from Grand Central Terminal south along Third Avenue through Midtown and Lower Manhattan, connecting to the Atlantic Avenue LIRR station in Brooklyn and along the Atlantic and Rockaway Beach Branches in Brooklyn and Queens before traveling along the present AirTrain right-of-way onto the Airport grounds. The RPA was unclear as to the excise types of trains used though stated that it would be different from a typical express subway route such as the A train.

The additional tunnels required for this new rail service to access Manhattan would make the project very expensive and time consuming. Judging based upon the extension of the 2nd Ave subway recently completed, there would also be significant political debate. The fare would likely be similar to the current transit fare, low in comparison to other modes. Being a train the carrying capacity is quite high. The 3rd Ave Express would connect many communities and therefore is quite equitable and it meets the goal of creating a one seat ride to Manhattan.



The project is reliant upon the construction of the remainder of the Second Avenue Subway which has no expected completion date. Phase 2 (of 4) is expected to be completed by 2029, although based on the delays of Phase 1, future construction is likely to take longer than expected.. Phases 3 and 4 have no funding or current plans for service to continue past Lower Manhattan. A route to JFK would require construction of two new tunnels below the East River.

Second Ave Subway Extension

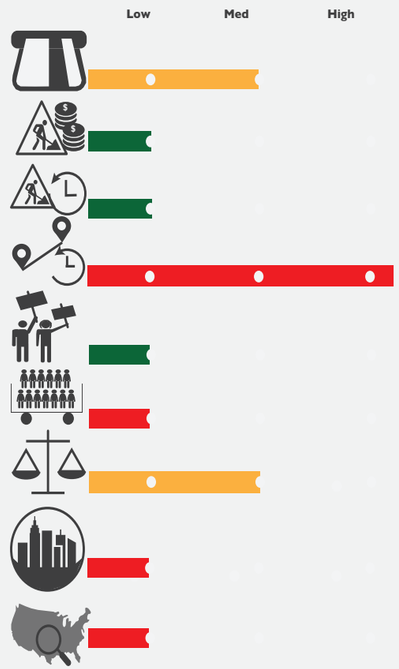


In the same report as the Third Avenue Express, the RPA proposed a Second Avenue Subway Extension to JFK Airport (RPA, 2017). This would run along the proposed Second Avenue Subway route in Manhattan, across the East River, connect to Atlantic Terminal and Brooklyn and travel over the Atlantic and Rockaway Beach Branches before connecting to the existing AirTrain right-of-way.

Though the mode provides a one-seat ride from the CBD, the passenger trip time could be long because of local stops. This mode could also offer a low passenger fare and high carrying capacity. Based on the cost and construction time for the 2nd Ave subway extension that recently opened, a new subway in lower Manhattan along 2nd ave would be very expensive and would take a long time to construct.

The option could help to improve transit in underserved neighborhoods by providing local service along the Atlantic Branch, but doing so would require competition with LIRR Atlantic Branch. Additionally this mode would allow additional connections between the Metro North Rail and LIRR Atlantic Branch.

Rockaway Ferry



This proposal is for ferry service to operate from piers in Midtown and Lower Manhattan to JFK Airport.

The passenger fare for this mode could be fairly reasonable, but the trip time would be slow and carrying capacity would be low due to slow speeds and lengthy boarding/disembarking time.

The New York City Economic Development Corporation recently launched new ferry service between Brooklyn, Queens and Manhattan. A route between Lower Manhattan and the Rockaways is expected to be launched in the future. Passenger air terminals are located far from where the ferry would need to dock.

Considering that passengers will have luggage; this mode would require a supplementary means of transportation which would negate the one-seat ride. The ferry would likely have to depart Manhattan from an area far removed from subway stations.

The low crossings of Cross Bay Boulevard and the A Train over Jamaica Bay would require costly alterations, leading to high construction costs.

A Train over Jamaica Bay would require costly alterations, leading to high construction costs.

3.10.3 Remaining Options

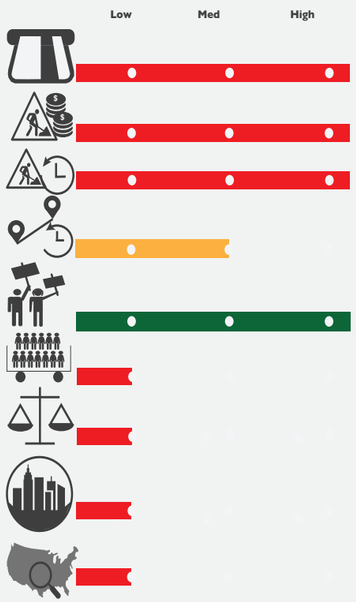
Additional Tunnel

The Clearview Expressway currently operates in Queens between the Throgs Neck Bridge and Cross Island Parkway to the north and the Grand Central Parkway to the south. The original intent for this portion of highway was that it would connect southwest to what is now the JFK Expressway and the airport.

The creation of a new roadway tunnel would be extremely expensive and would require a great deal of time for construction. The tunnel would require many property takings and would have a very high cost. Because of the high costs there would likely be a lot of political tension around the implementation of this optio. This route also does not enable a one-seat ride to Manhattan from JFK.

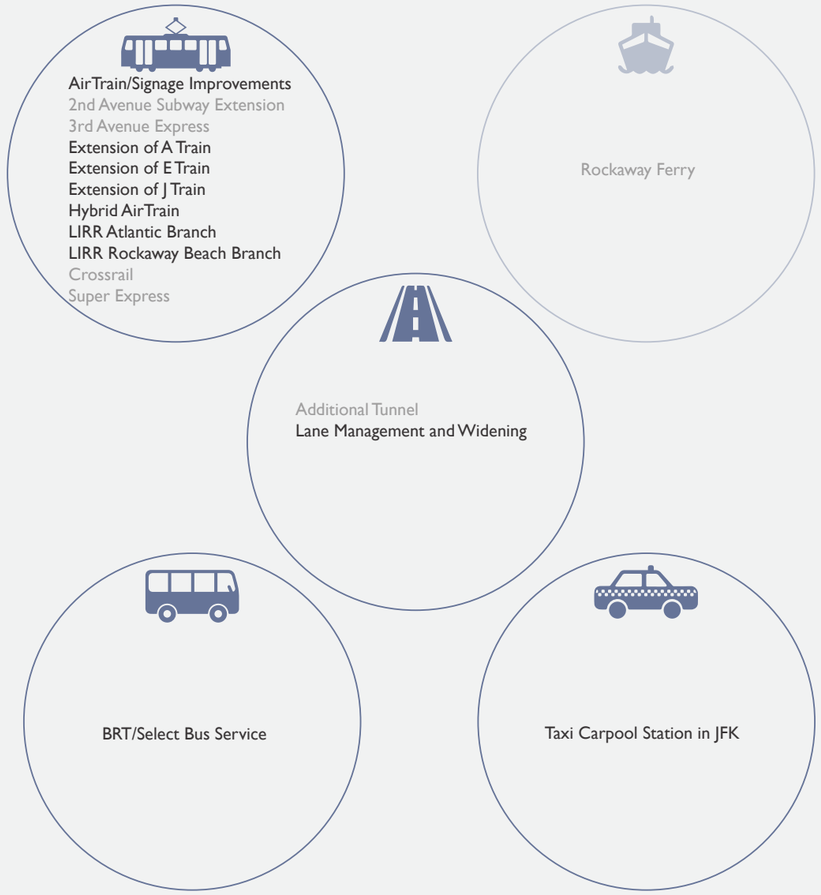
The trip time would be lowered due to a reduction in roadway congestion, although demand may increase when the road opens. There is limited equity because the tunnel would really help the Long Island, the Bronx and Westchester County residents but not those in Manhattan, Brooklyn or Queens

All options above were eliminated



in our first round of evaluation based on cost of construction, lack of political feasibility, time of construction or some combination of these flaws.

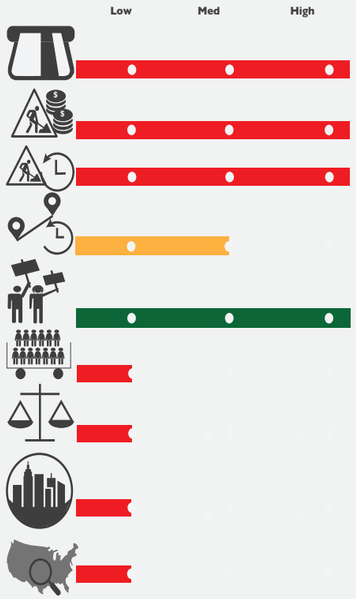
At the advisement of our client we considered both near and long term options. We continue to believe that implementing multiple options simultaneously is the best course of action of ensuring adequate ground access to JFK; this is specifically true when considering that some options may take many years for their political, infrastructural and financial capabilities to come to fruition. The following options are those that we seriously considered, but believe are not part of the best course of action to take.

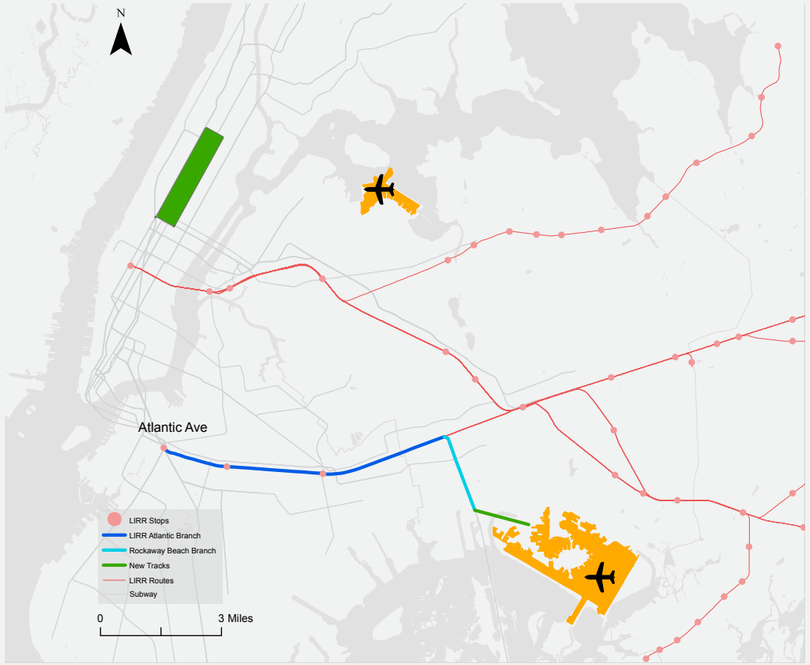


Atlantic Branch

The LIRR's Atlantic Branch exists between Atlantic Terminal in Brooklyn east to Queens before connecting to Jamaica and continuing into Long Island. Commuter service operates along the line. The branch intersects with the deactivated Rockaway Beach Branch which continues south where it overlaps with the route of current A train service. This commuter rail line could be utilized for a new service to JFK along the Rockaway Beach Branch and AirTrain.

We consider the service to have a fairly high construction cost due to the extent of new track that will be required. In order to make this route a true one-seat ride some modifications will need to be made along the AirTrain right of way and a new connection would be required between Manhattan and Brooklyn. The AirTrain tracks and stations were designed to accommodate LIRR and MTA trains but currently can not do so. Additionally, there would be a need to connect the AirTrain to LIRR through a bridge. While no new right of way will be required there is still extensive work that would prohibit the project from being able to be completed quickly. We would design the system to have minimal stops between JFK and the Atlantic Terminal. The project would require cooperation between the Port Authority and the MTA, which has not been very successful in the past. The option, as we designed it, does not present a one seat ride between JFK and the Central Business but it does increase access to the airport for communities along Atlantic Ave.





Map of Atlantic Branch Route

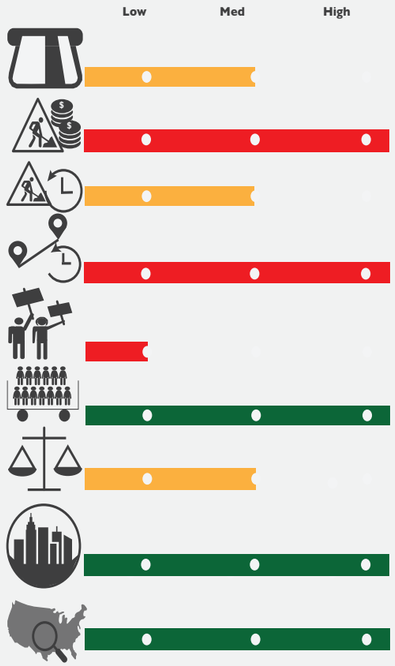
Image 36: LIRR Atlantic Branch

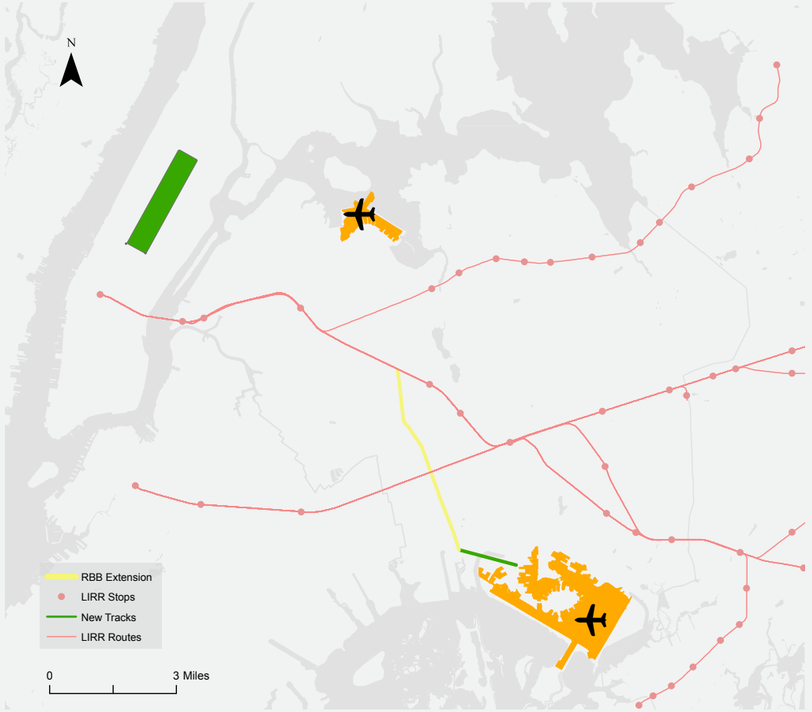
Rockaway Beach Branch

The Rockaway Beach Branch once catered to regular commuter service in Queens. It extended through Forest Park south through Broad Channel and east along the Rockaways. Service was suspended nearly 50 years ago due to low ridership. We propose operating service from Midtown along LIRR's Main Line before connecting to the Rockaway Beach Branch and continue south through Forest Park onto the A Train and AirTrain rights-of-way.

We anticipate the RBB fare to be similar to other commuter rail lines, so somewhat high per user, and the trip time would be fast. The carrying capacity could be quite high, depending on the length of the train. The line has been abandoned for over 50 years therefore there is a lot of overgrowth. The construction cost, would be high in order to reactive and rehabilitate many miles of track.

New vehicles would also need to be purchased to cover the route. It also requires new rail connections between AirTrain and RBB, RBB and Atlantic, or AirTrain and Main Line at Jamaica/Suchpib. Due to this extensive construction and the intense political landscape around working with the PA, MTA and NYC we anticipate the construction time as high as well. Depending on routing equity may be high or low because the route may be able to serve non-airport traffic if designed with stops in Queens. The option does offer a clear ride to midtown Manhattan and GCT so it scores highly in geographic scope.



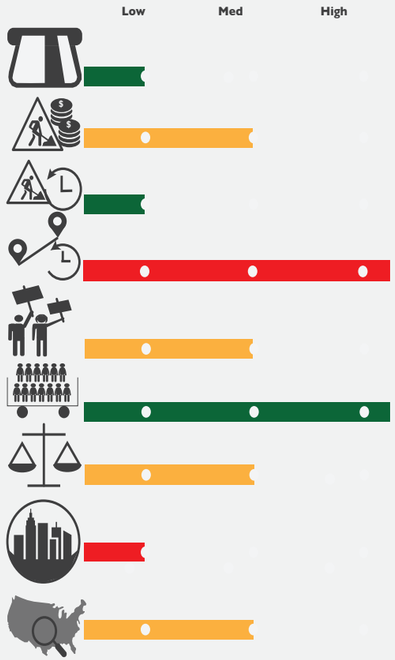


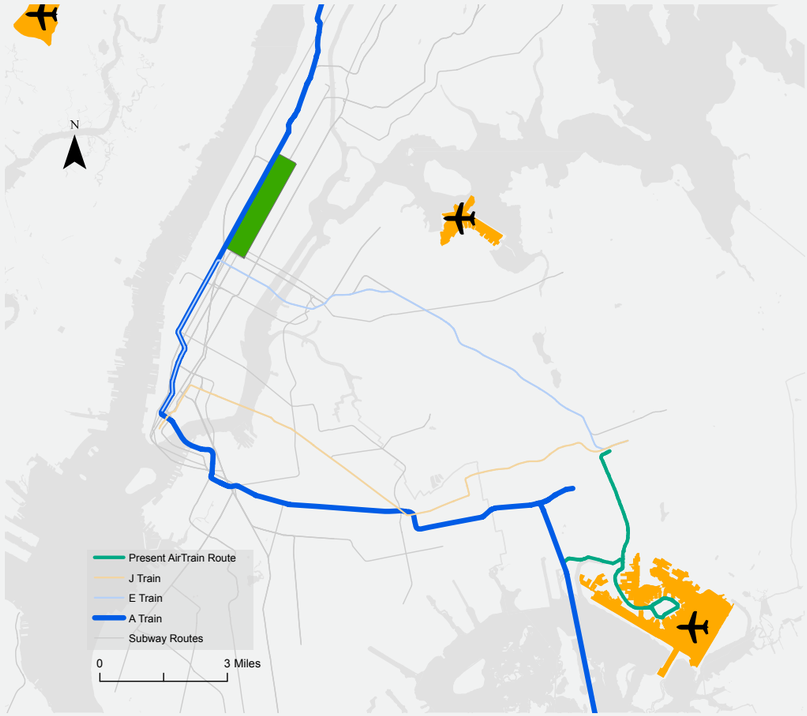
Map highlighting Rockaway Beach Branch route

Image 37: Current state of the abandoned Rockaway Beach Branch rail tracks

Extension of A Train

The A train extension just like the Hybrid AirTrain would be quite expensive. A new rail connection would need to be built at Howard Beach as well as a track upgrades along the current AirTrain right of way. This would also likely result in a lengthy construction period. The trip length would increase but would benefit from being a one seat ride. There would be a need for agency cooperation between the MTA and the PA which in the past has proven to be somewhat difficult. The fare would likely be the same as all MTA trains with a possible addition of an airport fee depending on funding levels. The line would not increase access to any new communities but would ease the ride to the airport for residents along the current A train line.



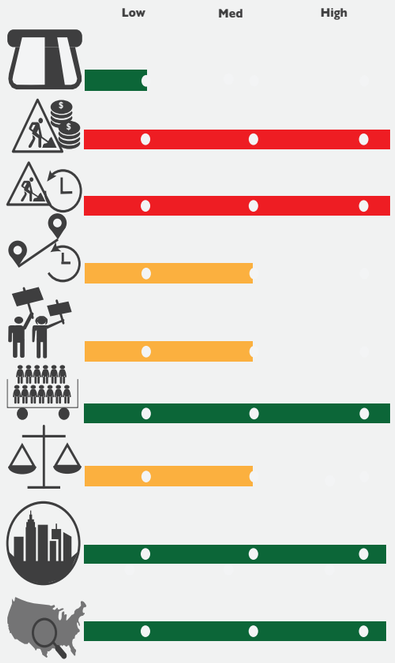


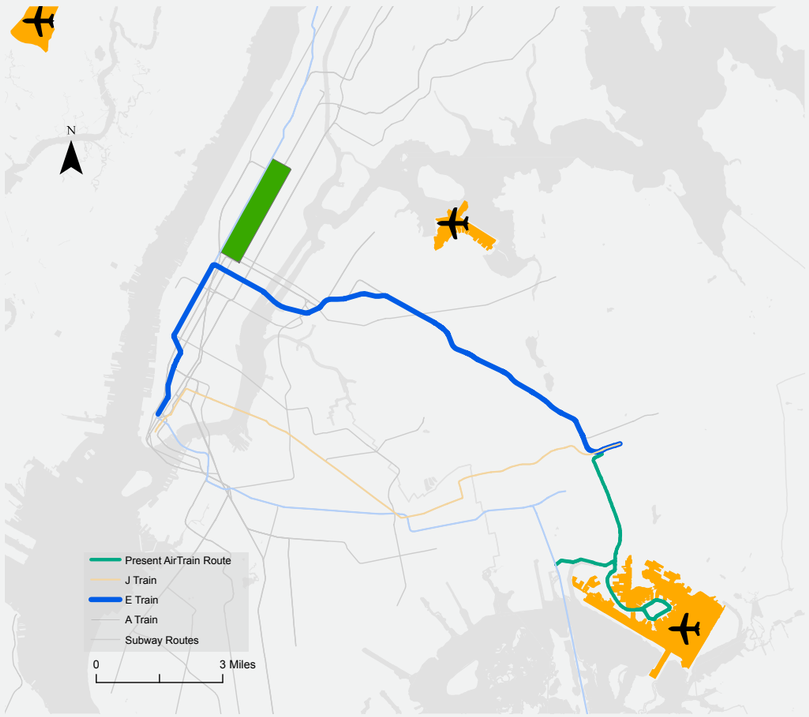
Map highlighting MTA Subway A Train route

Image 38: MTA Subway A Train

Extension of E Train

The E train runs underground for the entirety of its route. This would pose extra costs in attempting to connect it to the AirTrain right-of-way, although doing so would provide a one-seat ride to Midtown and Lower Manhattan. Currently the E stops at the Port Authority Bus Terminal, Penn Station and World Trade Center. Additionally, the E operates as an express train in Queens, providing a quick ride. As part of the subway service, the fare would be low. Construction cost and time would be significant as the route would have to rise above ground in the densely-built environment of Jamaica Queens. It currently takes approximately 45 minutes to travel on the E from Jamaica to the Port Authority Bus Terminal at 42nd Street. Operating to the airport would add approximately 10 minutes to that trip. There would be a need for agency cooperation between the MTA and the PA which in the past has proven to be difficult.





Map highlighting MTA Subway E Train route

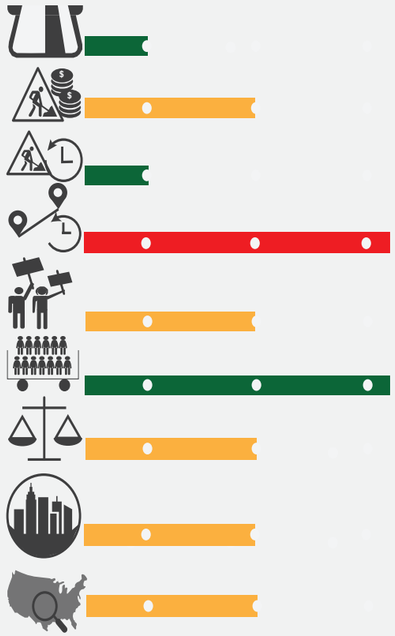
Image 39: MTA Subway E Train

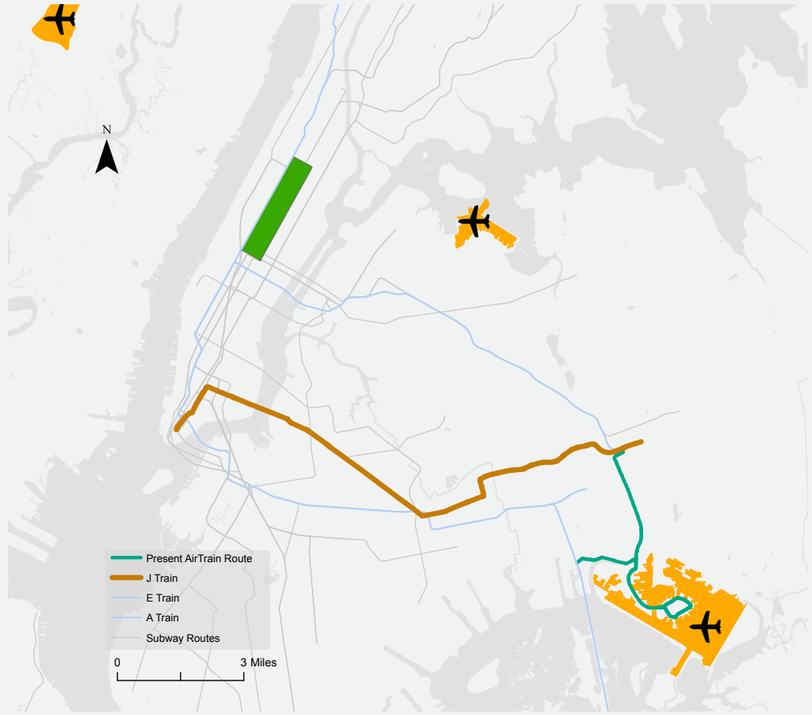
Extension of J Train

This option has a high carrying capacity. Trips from Midtown would not be improved, but it would provide good service from Lower Manhattan. Though this option could improve trip times to JFK, it would slightly worsen service in Jamaica and other communities served by the J train. There would be a need for agency cooperation between the MTA and the PA which in the past has proven to be somewhat difficult. There would also be the need for upgrades to the AirTrain infrastructure and trains.

The J train or extension would be quite expensive. There would need to be a rail connection added at Sutphin as well as a track upgrades along the current AirTrain track. This would also likely result in a lengthy construction period. The trip length would only increase but there would be the benefit of having a one seat ride and not having to change trains. That ride would not reach the most populous areas in Manhattan for business travelers.

The fare would likely be the same as all MTA train with a possible additional airport fee. This option does provide many connections to other rail and bus operations that would allow for a number of people throughout the city to use the new access to JFK.





Map highlighting MTA Subway J Train route

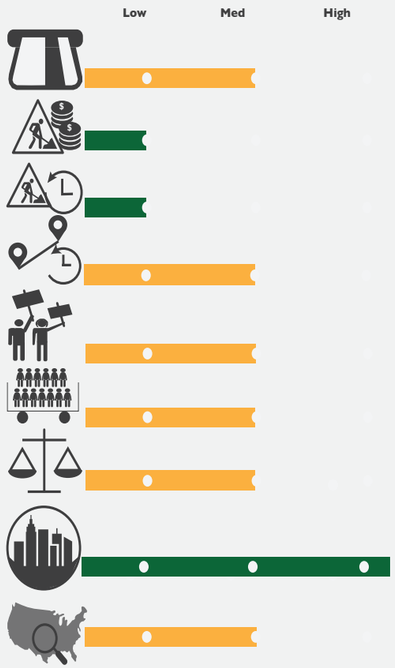
Image 40: MTA Subway J Train

There are multiple options of where the route would operate:

- Through the Queens-Midtown Tunnel onto the Long Island and VWE
- Over the Queensboro Bridge onto Queens Boulevard and the VWE
- Over the Manhattan or Brooklyn Bridges onto Atlantic and Conduit Avenues

BRT/SBS

Since 2008 New York City has expanded its bus service to include what they brand as "Select Bus Service" or SBS. SBS utilizes features typical of Bus Rapid Transit or BRT. Routes are often, though not exclusively on fixed rights of way and often travel on lanes that are converted to bus-only lanes. They use off-board fare collection, all door boarding and signal prioritization. Stops are limited compared to typical City buses. SBS service can be expanded to include a non-stop route from Midtown or Lower Manhattan to JFK.



SBS routes operated by the MTA have the same fare as local buses, although our proposed route may necessitate a slightly higher fare due to the cost of implementing a managed lane. We do not believe that a higher cost (perhaps $5.00) would inhibit travelers from utilizing the bus to the airport. Construction cost would be relatively low as the only infrastructure required are new fare machines, additional buses and the installation of managed lanes on the previously mentioned routes. The project would require commuter buses rather than local MTA buses so that all passengers will be able to sit down and have adequate space for luggage on the bus. The installation of the managed lane on the VWE would ideally occur after the VWE is expanded in order to minimize congestion. The installation of the other bus lanes would likely face public scrutiny as it would take away space from cars although the goal of the lanes would be to allocate traffic more efficiently.

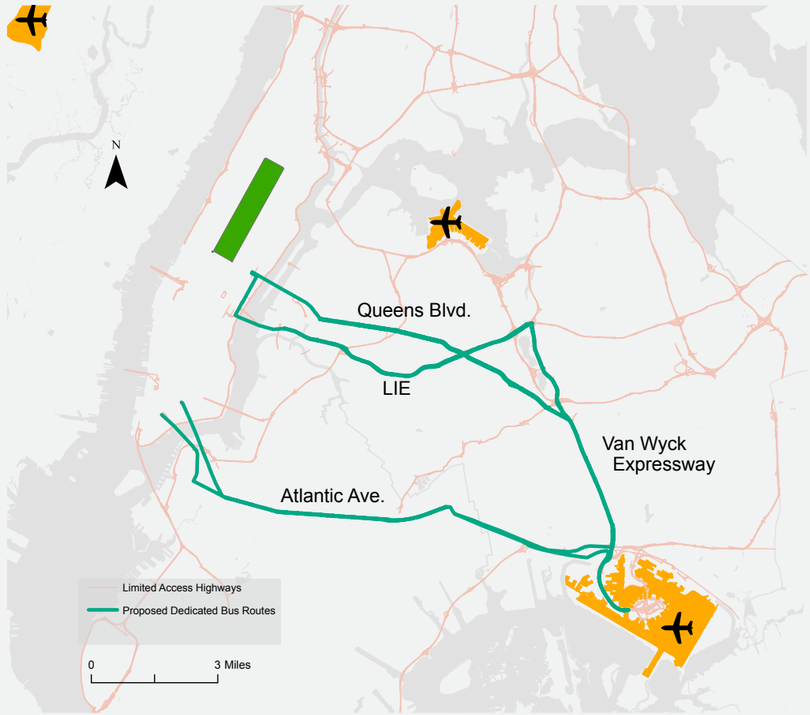


Image 48: Map Highlighting Bus routes

Image 41: bus-only lane

The project would require commuter buses rather than local MTA buses so that all passengers will be able to sit down and have adequate space for luggage on the bus. The installation of the managed lane on the VWE would ideally occur after the VWE is expanded in order to minimize congestion.

The installation of the other bus lanes would likely face public scrutiny as it would take away space from cars although the goal of the lanes would be to allocate traffic more efficiently. The simple installation of lanes would not take long, but waiting for the expansion of the VWE would.

Any new mechanism that decreases space for automobiles would face political and bureaucratic challenges. With adequate managed lanes and tolls, the trip time from Midtown would be under thirty minutes along the LIE and slightly longer along the surface streets although priority signal timing would increase speeds.

The presence of multiple routes and no local stops allows the vehicles to take any of the routes so as to avoid congestion. With low headways this mode is able to transport a high number of people, assuming that the managed lanes are moving efficiently.

The ideal route would be the via the Queens-Midtown Tunnel which operates along the highway for its entirety providing the fastest service although it would be slowed down by general traffic on the LIE. Non-stop routes would be ideal for providing the fastest service from Manhattan, though if routes operated on surface streets, some local or express service would improve access from these neighborhoods. Fares could be adjusted based on the route taken so that passengers have more options.

A route along Atlantic Avenue would have similar considerations as Queens Boulevard although it is not as heavily traveled. Operating from Lower Manhattan, service would face high levels of congestion. A dedicated bus lane is not feasible on the Manhattan or Brooklyn Bridges.
Passenger Fare: low to mid, may be slightly higher than current SBS fare, $2.75-$6.50
Construction Cost: minimal, SBS treatments, bus lanes, purchase of new buses, 2 million dollars
Construction Time: requires addition of lane on VWE which will take time, but aspects of this proposal alone are minimal.

Image 42: BRT rendering

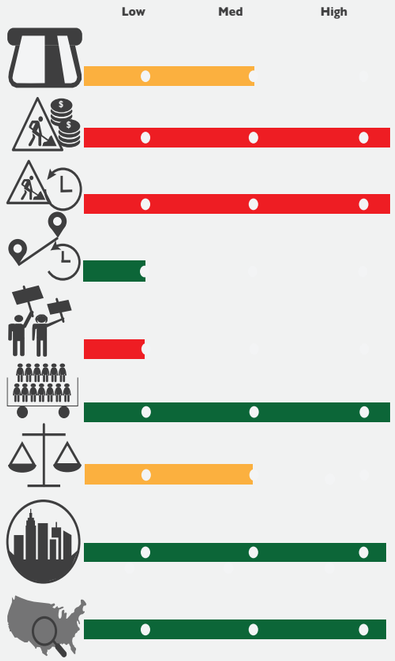
Service would operate from JFK Airport to Jamaica or Howard Beach and further onto the Long Island Rail Road tracks to Penn Station/GCT or from Howard Beach to the Rockaway Beach Branch and Atlantic Branch.

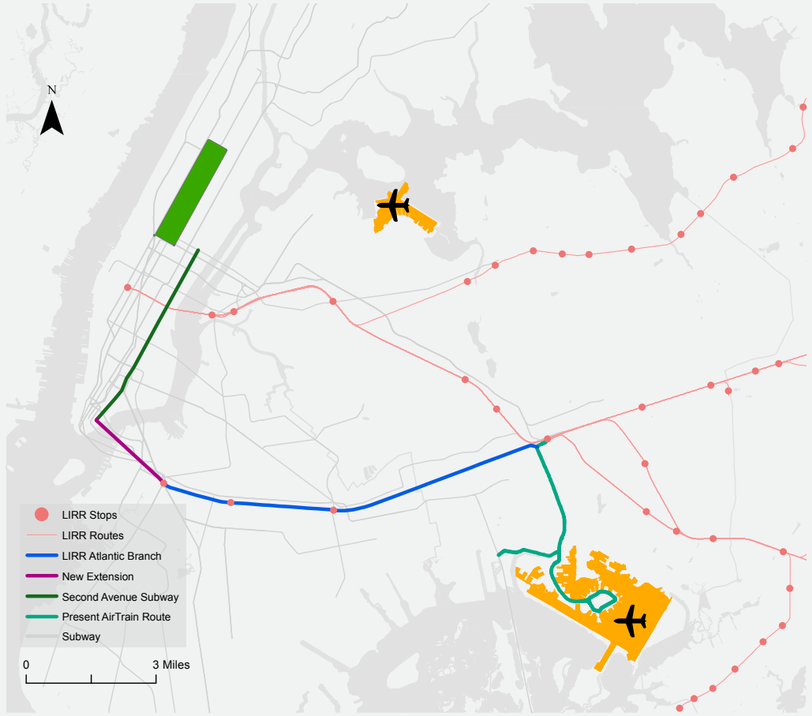
Hybrid AirTrain
(Recommended, Long-Term)

This option involves creating a new vehicle that is able to operate on the AirTrain, Long Island Rail Road and NYCT tracks. The AirTrain tracks were designed to allow for future accommodations to be made that would allow subway or commuter rail vehicles to operate on it.

The passenger fare for this option would be dependant on construction cost but would likely be similar to the cost of the current commuter transit trip. This one-seat ride option would have a high carrying capacity, though it would have to compete for space with Main Line LIRR and A Trains. It would offer a fast trip from Midtown's Grand Central Terminal to JFK. There is a possibility that this option could increase transit accessibility in underserved Queens neighborhoods along its route. The route would eliminate the possibility of the proposed Queensway, which might limit this option's political feasibility.

Additionally, the option would require cooperation between the PA and MTA, who have had issues collaborating in the past. The construction time is likely in the mid-range and the construction cost would include rehabilitating the RBB, creating connections between the Main Line LIRR and the RBB as well as between the RBB and the AirTrain. New vehicles would also be required, depending on availability and type of stock in order to meet both FTA and FRA regulations.





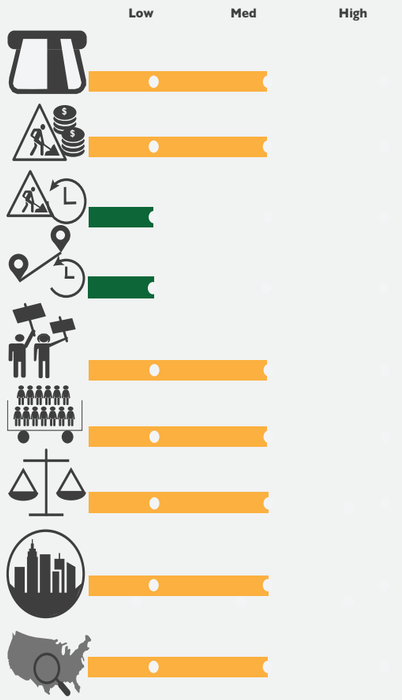
AirTrain in JFK

AirTrain Improvements
(Recommended, Near-Term)

The JFK AirTrain currently operates a two-car system with each car carrying up to 97 passengers. Our proposal for AirTrain improvements include adding two cars to each train in order to increase capacity, decreasing headways and reducing the price of the AirTrain to equal that of the subway. The PA has allocated funds in their current budget to study such a proposal although we believe that it should be implemented on a pilot basis prior to the study.

The AirTrain improvements we are proposing will only work to better serve all of the individuals traveling by transit to JFK. Adding additional signage and providing additional cars would be low cost in comparison to the other major projects as there no large infrastructure elements. Trip time in not applicable because there would likely be no difference. The improvements would be in trip ease.

We think there would be little political opposition to moving this proposal forward since it only serves to help an already popular



mode of airport access with no real negative aspects. The carrying capacity of the AirTrain could be doubled with the addition of new rail cars. Signage improvements can be made at a low cost and have immediate improvements for the flow of passengers. The mode is fast and AirTrain headways could be improved, but service from the CBD would not be improved, drastically limiting the impact on passengers' total trip time.

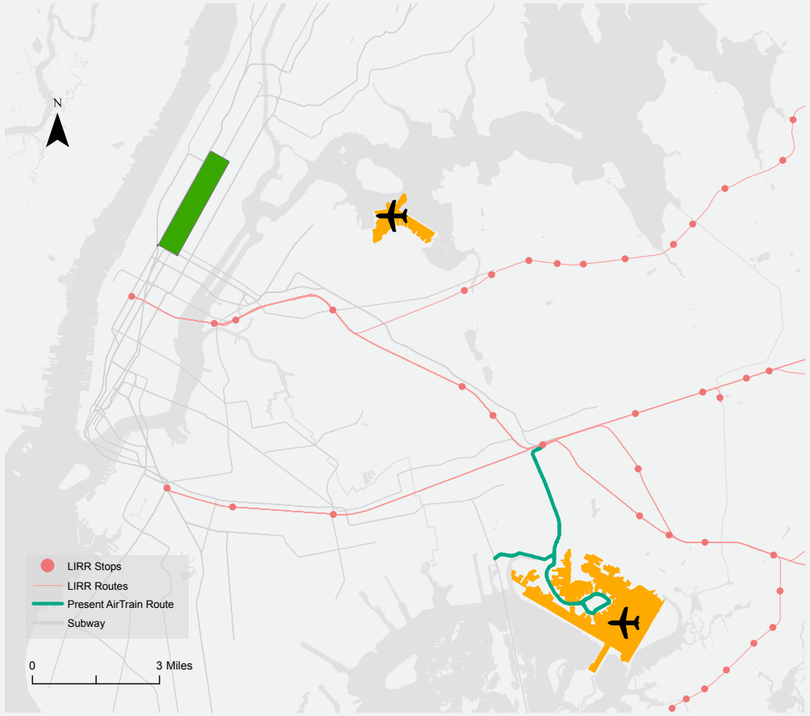


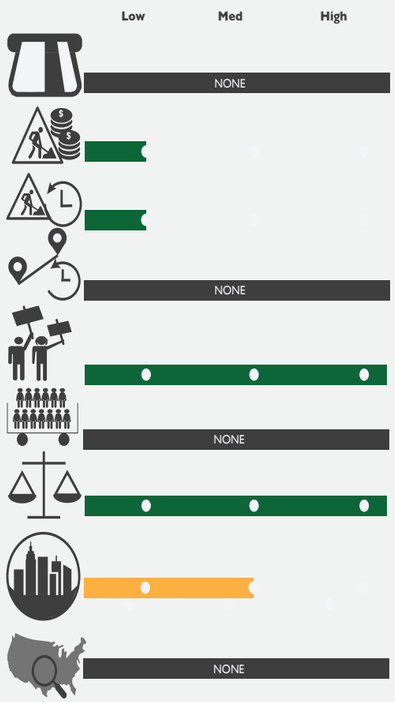
Image 43: AirTrain in JFK

Signage Improvements
(Recommended, Near-Term)

For those unfamiliar with New York City's transit system, traveling to or from JFK may be daunting. People are familiar with New York City taxi's and have used FHV services in other services so may opt to those out of comfort. Signage can be improved to have multiple languages within the airport as well as locations such as the Port Authority Bus Terminal or Penn Station where a train travels to connect to the AirTrain. Signs can be installed clearly and boldly state which trains go to the airport as well as how to reach the AirTrain.

These improvements would be complemented by the ability for passengers flying into JFK to receive ground access information upon purchasing their ticket so that they are aware of the costs and time of each option before arriving at the airport. JFK is the most used international gateway in North America, but signage does not reflect this diversity.

Though signage improvements would not provide new ground access service it will allow current service to be better utilized.



Due to its simplicity, there would likely be little to no opposition to such improvements. Signs can be installed at a relatively low cost and are easily maneuverable. Due to this ease, signage improvements are a near-term option.

Travel the Faster Way المسار السريع 便捷路线 Voyager le plus rapidement तेज मार्ग की यात्रा करें	Connection المواصلة عبر 转车 connexion सेवेच	Estimated Time and Cost الوقت المتوقع و 预计时间和预算 Temps et coût estimés अनुमानित समय और y costo
Midtown Manhattan New York Penn Station W. 34 St محطة بنسلفانيا في وسط مانهاتن 曼哈顿中城宾州车站 Station Midttowm Manhattan Pensylvania मिडटाउन मैनहट्टन से पेनसिल्वेनिया स्टेशन ミッドタウンマンハッタン ペンシルバニア駅 맨해튼 미드타운 펜실베니아역 Midtown Manhattan Pennsylvania Estacion	**Long Island Rail Road at Jamaica Station** سكة الحديد لونق ايلاند محطة جامايكا 长岛铁路 牙买加车站 Chemin ferroviaire Long Island Station Jamaica लाग आईलैंड रेल रोड जमैका स्टेशन ロングアイランド鉄道 ジャマイカ駅 롱 아일랜드 레일 로드 자메이카 역 Long Island Ferrocarrill Jamaica Estacion	**35 minutes $15** 35 دقيقة 35分钟 35 minutes पैंतीस मिनट 35分 35분 Minutos 35

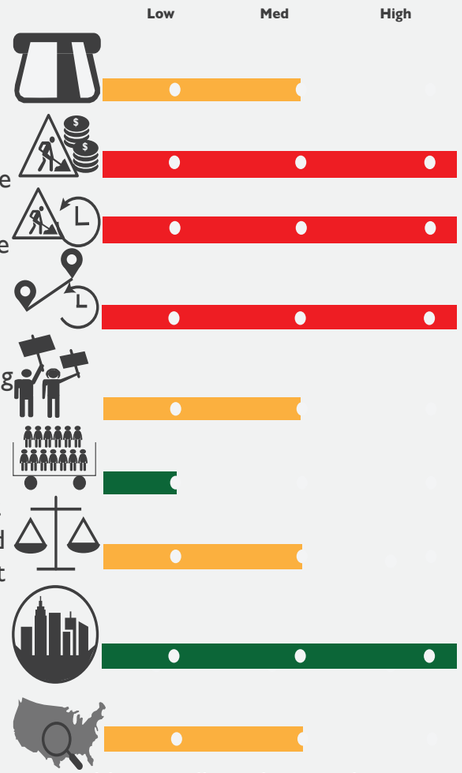
Signs in the Airport and along the AirTrain are only in English and Spanish. Signage can be installed in the most common languages spoken by JFK passengers to insure that all travelers are aware of ground access options.

To further ease reaching transit to and from the airport, passengers should be able to purchase a combined LIRR/ Subway/AirTrain ticket rather than need one for each mode. This will increase the attractiveness of public transit. The MTA is currently moving toward a new ticketing system that replaces the Metrocard. This time of transition is the perfect opportunity to update the intermodal purchase of tickets.

The income from the HOT lane will be used to maintain the lane and its technology and any extra revenue will be dedicated toward transit along the VWE. The project will also improve travel times for those not traveling from the central business district.

Lane Management and Widening

(Recommended, Long-Term)



The VWE is the main thoroughfare for airport users. We propose expanding the roadway from three to four lanes and designating the additional lane as a High Occupancy Toll lane for vehicles with three or more users including buses. The HOT lane would be enforced through overhead sensors and the toll would vary based on demand and time of day. The cost of the toll would depend on congestion and time of day, but may reach up to eight dollars. It would be balanced so that traffic in the managed lane is moving steadily.

Highway widening is very costly, especially in a densely-populated area such as Queens. Project cost will likely be very high. An efficient HOT lane would improve trip times for those within the lane and encourage carpooling and bus ridership, decreasing congestion in non-managed lanes. The NYSDOT predicts trip time reductions of 23 mins NB and 14 mins SB. There may be some community resistance depending upon the final roadway configuration. A reduction in the number of free travel lanes will not be popular. Roadways have relatively low capacity compared to public transit, but a managed lane and widening would encourage public transit which will substantially increase carrying capacity. The project will also improve travel times for those not traveling from the central business district.

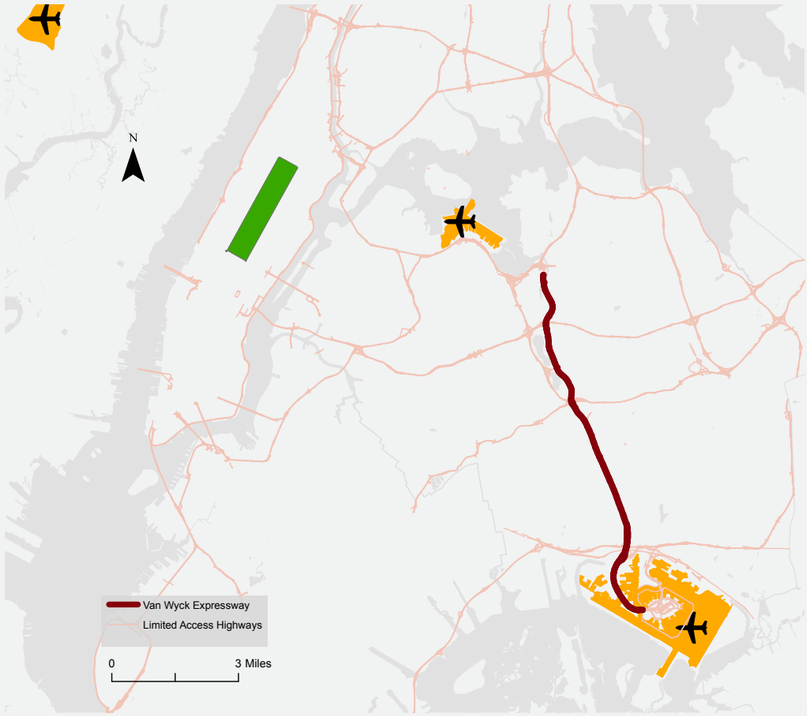


Image 44: Example of a Maneged Lane

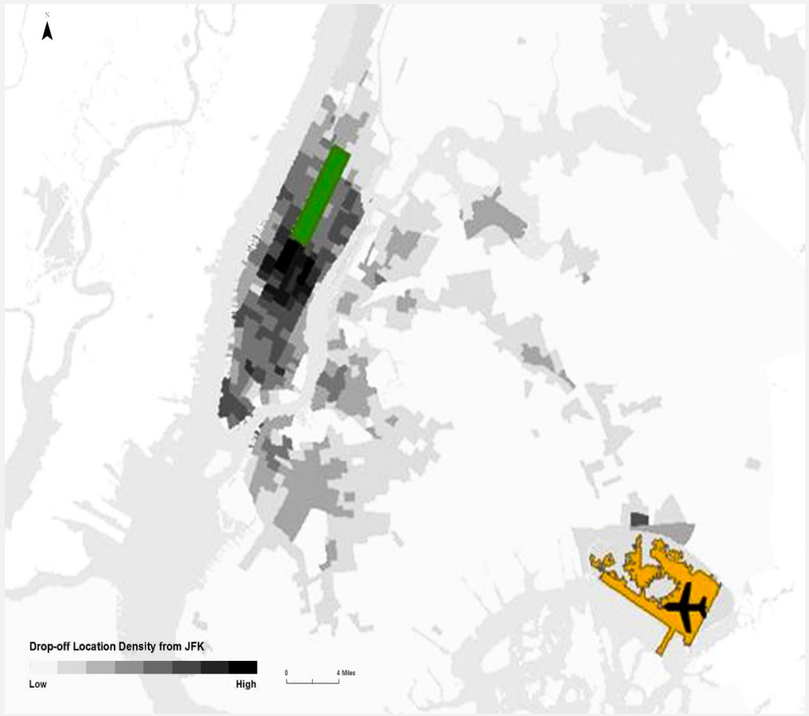
this improvement is contingent on the widening and installation of managed lanes on the Van Wyck. The project would go against for-hire vehicle (FHV) services like Uber although FHV carpools may also utilize the lanes. The project would require the cooperation of the Taxi and Limousine Commission, NYCDOT and PA

Taxi Carpool Stations
(Recommended, Near-Term)

The majority of JFK passengers arrive at the airport by automobile. 27% are dropped off by car, 9% as a driver/passenger in a private vehicle and 41% by taxi, black car, limo or shared van (Port Authority 2016). (INCLUDE THIS CHART EARLIER) Many of these trips cater to transportation of lone individuals.

To combat this we propose implementing taxi carpool stations in high density trip areas and at JFK Airport to facilitate shared use of taxis. Stations would initially be placed in spots of high concentration in Midtown Manhattan: namely Grand Central Terminal, Penn Station, the Port Authority Bus Terminal and Bryant Park. Stations would be located on the streets and have parking regulations and signage that limit the curb space to taxi's coming to and from the airport.

Taxi fares are already significantly higher than the cost of a transit trip to the airport. This would continue with the taxi carpool but they would be lower; likely between $20-$35 instead of over $50. Construction cost would be low, as only signage would need to be purchased. Taxis could be reallocated from the general pool of taxis so that new taxis would not need to be utilized. The more efficient travel to JFK through carpooling may decrease the number of taxis needed overall. If more taxis were necessary, money could be gained from the selling of medallions. With an adequate number of managed lanes, carpool taxis would move very quickly to JFK.



Carpool Station in San Fransisco

3.11 Autonomous Vehicles

Five main components that are necessary for a vehicle to be considered autonomous:

•Radar sensors - monitor the position of nearby objects (vehicles, people, or obstructions). Sensors can not detect color.

•Video cameras - detect traffic lights, road signs, other vehicles. Cameras are often able to detect different colors.

•LiDAR sensors - detect the edge of roadway, identify the lane markings, and make other precise measurements through the use of lasers. LiDAR sensors create a detailed three-dimensional navigational map of the vehicle's surroundings.

•Ultrasonic sensors - detect the position of the curb and other vehicles when parking through sensors in the vehicle's wheels.

•Central computer system - analyzes all sensor data to manipulate the steering, acceleration, and braking.

The combination of some or all of these systems comprise AV technology.

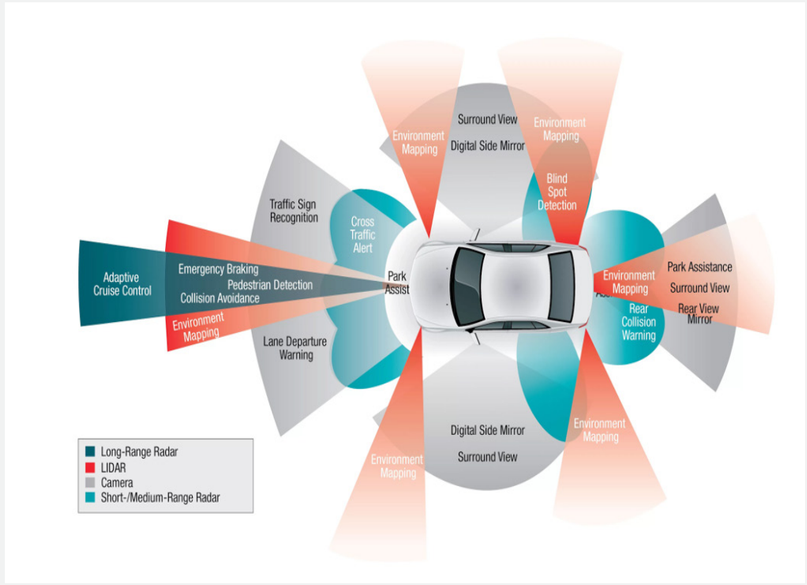


Image 45
Image 46

Autonomous vehicles (AVs) signal a huge transition in transportation technology, and there is potential for them to provide many transportation benefits. It's important for planners to anticipate future changes and direct this trend in ways that maximize benefits of this new technology by making plans that secure the gains in automotive efficiency and safety that AVs make possible.

Benefits

There are several potential benefits to the proliferation of AV technology. Firstly, the need for and form of parking will change dramatically. Parking lots and parking could be potentially replaced with more efficient land uses as shared autonomous vehicles may be on the road more en route to passengers.

Some parking would still be required, but much less so in a society with mostly autonomous vehicles. Mechanical parking structures that save space and money compared to current leveled garage could become more widespread in order to accommodate the parking that would still be required. Parking structures are presently designed for the ease of drivers, but without the driver these structures could be designed very differently.

Parking lots could also serve the dual purpose of providing parking spaces as well as charging stations for electronically powered AVs. Secondly, traffic fatalities should decrease as deployment of AVs eliminates driver error and makes automobile travel safer. Thirdly, ride-sharing could be improved through more efficient route-planning and decreased consumer cost, due to not having to pay a driver. Fourth, AVs' will likely have lower emissions due to them being electronically powered. These lowered emissions will diminish the negative effects of vehicular traffic on the environment.

United Kingdom: Heathrow Airport

Heathrow Pods started operation in May of 2011. The Pods are autonomous electric vehicles that produce zero-emissions. They run between the airport's business car parking and Terminal 5. Currently, 21 vehicles operate on a fixed 2.4 mile route. The Pods operate at an average speed of 25 mph and can fit four passengers per vehicle. The pods provide a five minute ride from end to end.. Passengers reserve the ride on a touchscreen at the station before the Pod arrives in fewer than twenty seconds. Pods can operate for up to 13 hours before requiring recharging. The project cost £23 million ($29 million). Since 2011 the Pods have carried 1.5 million passengers and eliminated the need for 700,000 bus trips along with their associated emissions.

Image 47
Image 48
Image 49

New Zealand: Christchurch International Airport

The first test run was on January 12, 2017. The AVs carry passengers between the airport gates and airplanes and can carry 15 passengers (ten seated, five standing). The vehicles are electrically powered and have a top The vehicles have a top speed of 40 mph. However, for safety the average operating speed is 25 mph. Because of the frequent earthquakes in New Zealand, extra sensors were installed in the vehicles to aid in adjusting to and detecting earthquakes.

Singapore

NuTonomy, a company in Singapore, began running the world's first self-driving taxis on August 25, 2016. Using a smartphone application, nuTonomy customers can hail these autonomous taxis as they would an Uber or Lyft. For now, these taxis only operate in a 2.5 square mile business and residential district called "one-north," but future expansions have been proposed. This type of vehicle could be implemented in the closed environment of airside operations or as an airport shuttle service at other airports.

Image 50: parking infrastructure in New York City

Image 51

Infrastructure Influence at JFK

We believe the the biggest infrastructure change at JFK brought upon by autonomous vehicles will be the reduction in required parking spaces. JFK currently has over 15,000 parking spaces. This land could be repurposed for new buildings, circulation roads or cargo storage.

Additionally pick-up and drop-off locations will need to replanned because of the potential for more vehicles to be hailed for pick and drop-off. Lastly autonomous vehicles can provide changes to how cargo and luggage are processed at the airport. These vehicles will not need drivers and therefore can work longer shifts and could potentially lead to a fully autonomous baggage handling process.

Drawbacks of AVs

While autonomous vehicles have benefits such as potentially eliminating overworked drivers and accidents caused by driver error, there are drawbacks as well.

According to the American Trucking Association, autonomous trucks could cost the U.S. millions of jobs. In London, transparent policies were adopted to gradually introduce autonomous trains so that drivers can prepare for job losses. In the UK, the first autonomous train line will be introduced in 2020 and automation will slowly dominate the system. This way, current and prospective drivers can try to take the necessary measures to change careers and find a secure income.

Chapter 4:
Final Remarks

4.1 Recommendations to Client

4.1 Recommendations to Client

Image 52 Flooded TEB airport after Hurricane Sandy

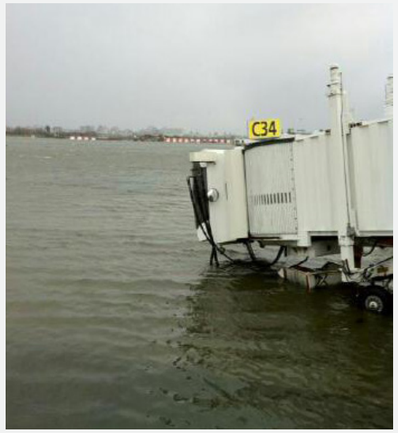


Image 53: Flooded LGA airport after Hurricane Sandy

Storm surge planning should be the immediate focus at LaGuardia Airport. The airport should invest in more green stormwater infrastructure to mitigate storm surges and to mitigate greenhouse gas emissions.

The implementation of a flip-up flood barrier could protect the airport during storms, but eventually the airport will need to invest heavily in a flood protection system such as a levee to maintain the functionality of the airport in anticipation of when sea level rises beyond the capacity of a flip-up flood barrier to protect the airport.

Teterboro Airport will eventually have to close since the airport's current operations do not warrant the amount of investment protection would require, but in the meantime plans should be made to facilitate the smooth transition of the airport's operations to other airports or travel modes.

More aggressive greenhouse gas emission standards should be adopted at both LaGuardia and Teterboro Airports.

Image 54: AirTrain Jamaica Queens Station

To improve ground access we recommend instituting a number of near and long-term improvements.

The first is to improve AirTrain service, signage and access to transportation information. The second is to create taxi carpool stations at JFK and Midtown. Third, we recommend widening the VWE to handle two high-occupancy toll lanes in each direction.

Finally, we recommend creating a hybrid AirTrain that could operate on the current AirTrain tracks as well as subway and commuter rail tracks to Midtown. JFK should also begin to prepare for autonomous vehicles to be used for ground access and airport operations.

Studio Team

Back, From Left: Mai Uchida, Ramya Ramanathan, Justin Romeo, Mohammed Alkahifa, Rebecca Noble, Charles Romanow, Qigao Wang, Kaiqi Zhang, Ruoran Lin, Lina Yin; Front, Center: Professor Floyd Lapp

Under the invaluable guidance of our indefatigable Studio Faculty Advisor, Professor Floyd Lapp, and our teaching assistant, Lina Yin, our team had the privilege of working together to investigate climate change adaptations and ground access improvements for our regional airports. We hope that this report can be useful in recommending practicable next steps to increase the resiliency of our transportation network for years to come.

Acknowledgments

BRT Planning International
Annie Weinstock

International Association of Public Transport
Andrew Bata

New York City Department of Transportation
Matt Kroneberger
Aaron Sugiura
Dan Wagner

New York Institute of Technology
Nicholas Bloom

New York State Department of Transportation
Harold Fink

Port Authority of New York and New Jersey
Patty Clark
Josh DeFlorio
Ben Engle
Daniel Garten
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Andrew Lynn

Queens College
Scott Larson

Glossary of Abbreviations

CBD:
Central Business District
EWR:
Newark Liberty International Airport
JFK:
John F. Kennedy International Airport
LGA:
LaGuardia Airport
LIRR:
Long Island Rail Road
MNR:
Metro North Rail Road
MTA:
Metropolitan Transportation Authority
NYC/the City/New York:
New York City
NYCDOT:
New York City Department of Transportation
NYSDOT:
New York State Department of Transportation
PA/PANYNJ:
Port Authority/Port Authority of New York and New Jersey
RBB:
Rockaway Beach Branch
VWE:
Van Wyck Expressway

Appendix

EWR Access

Newark International Airport was the first major airport in the New York City metropolitan region when it began operation in 1928. Newark Airport was at one point the busiest airport in the world before JFK opened in 1948 and the PANYNJ become responsible for maintaining both airports.

Newark Airport's ground transportation is similar to that of JFK as they both have a commuter rail – AirTran link. Passengers at both airports are more likely to get to the airport via a taxi or for-hire vehicle than by public transportation.

A taxi or car service from Manhattan to Newark Airport costs approximately $60-70, and the journey takes roughly an hour from Midtown. Bus and shuttle services operate between Newark Airport and the Port Authority Bus terminal as well as other locations in Manhattan. These services take an hour to reach the airport and cost $15-30 (NYC By Natives 2016).

Passengers may reach the Newark Airport rail station from Penn Station via Amtrak or New Jersey Transit. They must then transfer to the Newark Airport AirTrain. This combination costs $15 and takes 30 to 40 minutes from Penn Station (NYC By Natives 2016).

Newark Airport opened in 1928 and is located 14 miles west of Manhattan. There are three types of public transit connect between Midtown Manhattan and Airport.

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